MEMO

TO: Danielle Osborn Mills, Director, AWEA California Caucus

FROM: Caitlin Liotiris, Partner, Energy Strategies

DATE: March 2018

SUBJECT: Additional Analysis on the Relative Value of the Production Tax Credit for Wind Resources

In August of 2017, Energy Strategies delivered a memo to the AWEA California Caucus (ACC) which outlined the relative value of the federal Production Tax Credit (PTC) for wind energy.[1] The PTC is currently scheduled to phase out over the next several years; though, if timely procurement decisions are made, opportunities remain for California's load-serving entities (LSEs) and, ultimately, ratepayers to capture the benefits associated with these federal tax credits.

Energy Strategies previous analysis focused on the impacts on the levelized cost of energy (LCOE) for wind facilities that obtained the full (100%) PTC, compared to wind projects that did not receive these federal tax incentives. This subsequent analysis focuses on the relative cost savings of wind facilities that capture 80% of the federal PTC, compared to those facilities built at a later date which do not receive the PTC (though the relative cost of 100% PTC wind is also shown for illustrative purposes). The results of the analysis, described in more detail below, demonstrate the continued value of wind energy that receives 80% of the PTC. This analysis also evaluates cases with significant declines in capital costs and other technological advancements in wind and finds that projects with the 80% PTC are still expected to deliver significant savings to ratepayers compared to wind resources built at a later date that do not receive the PTC.

The PTC is currently scheduled to phase out over the next several years, with varying deadlines for resources to achieve 100%, 80%, 60% and 40% PTC. We point readers to the previous memo which explains, in more detail, how wind generation built in the coming years can capture the PTCs under Internal Revenue Service (IRS) guidelines.

The previous analysis focused on wind projects that achieve commercial operation in two timeframes: 2020 and 2026. As some wind projects achieving commercial operation in 2020 will be able to capture 100% of the PTC, while projects reaching commercial operation in 2026 are

[1] The memo was subsequently updated with additional information on potential ratepayer savings in October 2017.

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unlikely to be eligible for any amount of PTC. Similarly, certain projects reaching commercial operation in 2021 will be eligible to receive 80% of the federal PTC. This analysis focuses on comparing the costs of wind projects coming online in 2021, and receiving 80% of the PTC, and wind projects coming online in 2026, without PTCs.[2]

A number of both 100% and 80% PTC-eligible projects are expected to be available to California ratepayers, though they will require near-term contracting in order to achieve 100% or 80% PTC eligibility.

The analysis summarized below compares the relative LCOEs associated with procuring 80%-tax benefit eligible wind to procuring wind at a time when these tax benefits have expired, demonstrating the economics of the tax-eligible resources, even at a reduced level. Since the cost of renewable resources has been falling for many years now, several parties have suggested that decreasing capital costs and technological advancements will continue to decrease the costs of renewable resources, which may more than make up for any federal tax benefits that are currently available. To help illustrate the relative value of the PTCs, we added additional scenarios, including a more extreme capital cost decline scenario and a case with *both* further capital cost declines and higher capacity factors (which could result from further technological advancements).

As with the prior assessment, this assessment focuses on high-capacity-factor wind from New Mexico and Wyoming. In order to perform this analysis, Energy Strategies utilized version 6.2 of the California Public Utilities Commission (CPUC) Renewable Portfolio Standard (RPS) Calculator[3] with updated assumptions on capital cost and capacity factor taken from the July 2017 RESOLVE documentation of the inputs and assumptions for the CPUC 2017 Integrated Resource Plan (IRP).[4] Specifically, the RPS Calculator's pro forma cash tool was used to calculate the LCOE of wind resources in several scenarios, while using the average capital cost of Wyoming and New Mexico wind from the RESOLVE IRP inputs and assumptions. Although the LCOE values produced by the RPS Calculator may not reflect actual, confidential prices contained in PPAs, the RPS Calculator has been widely vetted in various CPUC proceedings and provides a sound platform for analyzing the *relative change* in the cost of wind energy with and without federal tax incentives.[5]

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[2] 2026 also aligns with the procurement timeframes being evaluated in RESOLVE and would, almost certainly, be past the time wind resources might qualify for reduced PTCs (such as 60% or 40%).
[3] Version 6.2 of the RPS Calculator was used, as version 6.3 has not been made available on the CPUC's website.
[4] RESOLVE documentation for capital cost and capacity factors used in the analysis is available here: http://www.cpuc.ca.gov/uploadedFiles/CPUCWebsite/Content/UtilitiesIndustries/Energy/EnergyPrograms/ElectPowerProcurementGeneration/irp/17/RESOLVE_CPUC_IRP_Inputs_Assumptions_2017-07-19_redline.pdf
[5] Note that while interconnection costs were assumed for these wind projects, no additional transmission costs were added for any of the wind projects evaluated. While transmission costs would likely be necessary for delivery

The analysis considered several scenarios. Each scenario is designed to compare the relative changes in LCOE between a wind project that can achieve commercial operation in 2021, and obtains 80% PTCs, and a wind project that achieves commercial operation with no PTCs. For illustration purposes, we have also included the costs of wind projects that achieve the 100% PTC (which have been assumed to come online in 2020). The wind project scenarios are described below and summarized in Table 1.

(1) Scenario 1A (Default RESOLVE/RPS Calculator Inputs): This scenario uses the default assumptions from the RPS Calculator, including updated capacity factors and capital cost assumptions from the RESOLVE documentation for inputs and assumptions used in the 2017 CPUC IRP. Capital costs reflect the simple average between Wyoming and New Mexico costs, which were sourced from RESOLVE inputs.

(2) Scenario 2A (Higher Capacity Factor): Scenario 2A uses the same inputs and assumptions as Scenario 1A, except that a higher capacity factor (52%) is used to align with the capacity factor of recent a wind project in New Mexico.[6]

(3) Scenario 3A (Higher Capacity Factor and Cost Reductions): Scenario 3A uses the same inputs and assumptions as Scenario 2A, except the project that comes online in 2026 has a lower capital cost to reflect potential cost reductions. The capital cost has been reduced from the 2020 value by 7.7%, which is in line with the largest proportional capital cost reductions seen between 2020 and 2030 under a single "case" in the U.S. Department of Energy's Wind Vision analysis.[7]

(4) Scenario 4A (Further Capital Cost Reductions in 2026): Scenario 4A uses the same inputs and assumptions as Scenario 2A & 3A, except the project that comes online in 2026 is assumed to experience even greater reductions in capital costs, even more than are anticipated in any case in Wind Vision. In this scenario, the wind coming online in 2026 experiences roughly a 22% reduction in capital costs compared to the 2020 case. This cost decline represents the greatest percentage decline from one of Wind Vision's "high" cost cases in 2020 to a "low" cost case in 2030.

(5) Scenario 5A (Further Capital Cost Reductions and Higher Capacity Factor in 2026): Scenario 5A uses the same inputs and assumptions as Scenario 4A, except the project that comes online in 2026 not only experiences significantly lower capital costs, but *also* experiences increased capacity factors due to technological advancement. For this scenario, wind coming online in 2026 was assumed to have a 61% net capacity factor

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of significant amounts of regional wind energy, the analysis is focused on isolating the relative value of the PTC. Excluding transmission costs from all projects evaluated allows for a comparison of the relative value of the PTC.

[6] See testimony seeking approval of PPAs for the Sagmore Wind project in New Mexico here: https://www.xcelenergy.com/staticfiles/xe-responsive/Company/Rates%20&%20Regulations/Regulatory%20Filings/NM-Filings-Riley-Hill-NM-Direct.pdf

[7] See *Wind Vision: A New Era for Wind Power in the United States*, U.S. Department of Energy, March 12, 2015, Appendix H, Table H-4, available here: https://energy.gov/eere/wind/maps/wind-vision

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(compared to 52% assumed in 2021). A 61% net capacity factor is the highest net capacity factor modeled under Wind Vision's 2030 assumptions.

TABLE 1: SCENARIO SUMMARY

	Commercial Operational Date (COD)	PTC Eligible?	Capacity Factor	Capital Cost (2016 $/kW)	Other Financial Assumptions[8]
Scenario 1A: Default RESOLVE/RPS Calculator Inputs	2020	100%	44%	Based on RESOLVE (July '17)	Consistent with CPUC documentation for RESOLVE and RPS Calculator 6.2/6.3
	2021	80%			
	2026	NO			
Scenario 2A: Higher Capacity Factor	2020	100%	52%	Based on RESOLVE (July '17)	
	2021	80%			
	2026	NO			
Scenario 3A: Higher Capacity Factor and Cost Reductions	2020	100%	52%	2026 only reduced 7.7% from 2021 RESOLVE value	
	2021	80%			
	2026	NO			
Scenario 4A: Further Capital Cost Reduction in 2026	2020	100%	52%	2026 only reduced 22% from 2021 RESOLVE value	
	2021	80%			
	2026	NO			
Scenario 5A: Further Capital Cost Reduction and Higher Capacity Factor in 2026	2020	100%	52%	2026 only reduced 22% from 2021 RESOLVE value	
	2021	80%	52%		
	2026	NO	61%		

[8] The RPS Calculator includes functionality to optimize the debt-equity ratio. Because the goal of this assessment was to isolate the relative value of the PTC, the debt-equity ratio for each project was held constant at 50/50.

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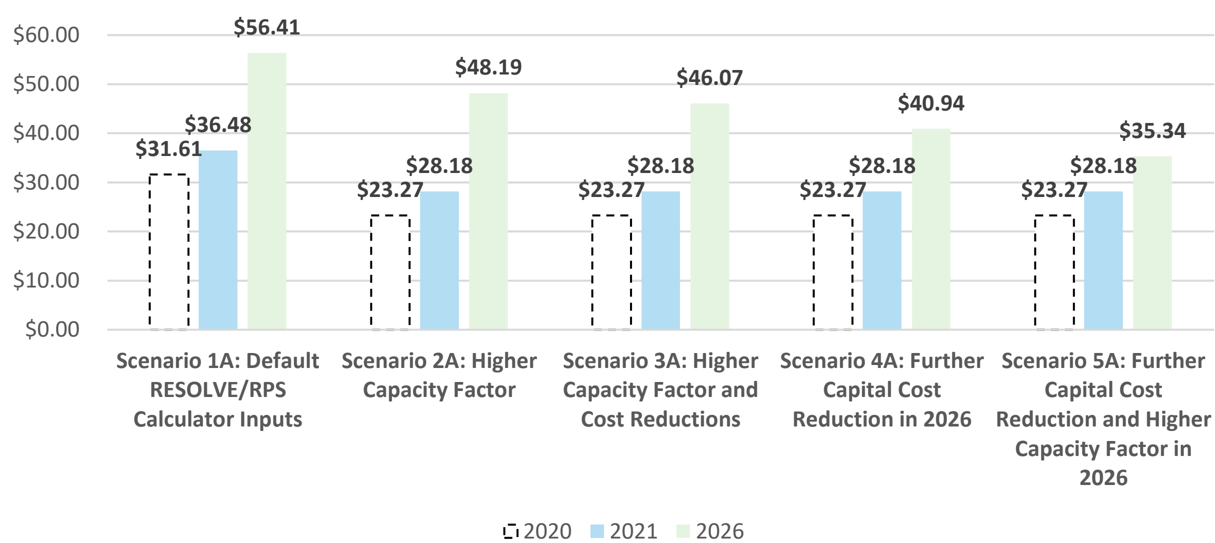
The relative impact on the LCOEs in each scenario were compared. Table 2 summarizes the results of the assessment. Figure 1 illustrates the savings that can be achieved by securing the full benefit of the PTC.

TABLE 2: LEVELIZED COST OF ENERGY (2016 $/MWH) AND RELATIVE SAVINGS ACROSS SCENARIOS[9]

COD Year	Scenario 1A: Default RESOLVE/RPS Calculator Inputs	Scenario 2A: Higher Capacity Factor	Scenario 3A: Higher Capacity Factor and Cost Reductions	Scenario 4A: Further Capital Cost Reduction in 2026	Scenario 5A: Further Capital Cost Reduction and Higher Capacity Factor in 2026
2020	$31.61	$23.27	$23.27	$23.27	$23.27
2021	$36.48	$28.18	$28.18	$28.18	$28.18
2026	$56.41	$48.19	$46.07	$40.94	$35.34
Delta (2026-2021)	*$19.92*	*$20.01*	*$17.89*	*$12.75*	*$7.16*
Relative savings (%) 80% PTC vs. no PTC	**35%**	**42%**	**39%**	**31%**	**20%**

FIGURE 1: LEVELIZED COST OF ENERGY (2016 $/MWH) COMPARISON



[9] The delta in the LCOE in Table 2 results from comparing LCOEs, as calculated by the RPS Calculator, of the two projects in each scenario. The RPS Calculator calculates LCOE using the net present value of the cash flows and the net present value of the energy and, among various other assumptions, the LCOE is grossed up for taxes. Note that the LCOE from the RPS Calculator may differ from actual PPA prices.

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This analysis demonstrates that the LCOE savings of the wind resources that receive 80% of the PTC can be between $7-20/MWh or 20-42% lower than the LCOE of wind energy that comes online in 2026, even when significant cost savings and increased capacity factors are assumed for wind coming online in 2026. While these values may not be reflective of actual, confidential PPA prices, they demonstrate the relative value of securing the 80% PTC.

The total value that can accumulate to ratepayers will vary depending on the specifics of the PPAs that might be signed. But if the LCOE values in this analysis are used as a proxy for relative and levelized PPA prices, then the total ratepayer savings associated with 1,000 MW of wind that receives 80% of the PTC over twenty-years can be estimated to be between $1.5 and $1.8B for scenarios 1A-3A. And, even if by 2026 there are significant reductions in capital costs and/or increases in capacity factors over the coming years, securing wind with 80% of the PTC would still result in relative LCOE savings of $650M - $1.2B over twenty-years. These results demonstrate the substantial value of the PTC and the potential cost savings ratepayers could see by securing wind that receives the 80% PTC compared to purchasing wind energy at a later date.

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BEFORE THE PUBLIC UTILITIES COMMISSION

OF THE STATE OF CALIFORNIA

Order Instituting Rulemaking to Develop an Electricity Integrated Resource Planning Framework and to Coordinate and Refine Long-Term Procurement Planning Requirements.	Rulemaking 16-02-007 (Filed February 11, 2016)

INFORMAL COMMENTS OF THE CALIFORNIA WIND ENERGY ASSOCIATION ON THE DRAFT SOURCES FOR 2019-20 IRP SUPPLY-SIDE RESOURCES

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April 23, 2018

BEFORE THE PUBLIC UTILITIES COMMISSION

OF THE STATE OF CALIFORNIA

Order Instituting Rulemaking to Develop an Electricity Integrated Resource Planning Framework and to Coordinate and Refine Long-Term Procurement Planning Requirements.	Rulemaking 16-02-007 (Filed February 11, 2016)

INFORMAL COMMENTS OF THE CALIFORNIA WIND ENERGY ASSOCIATION ON THE DRAFT SOURCES FOR 2019-20 IRP SUPPLY-SIDE RESOURCES

Pursuant to the March 27, 2018, email from Patrick Young, Energy Division, and the April 13, 2018, email of Karolina Maslanka, Energy Division, the California Wind Energy Association ("CalWEA") submits these informal comments on the Draft Sources for 2019-20 IRP Supply-Side Resources, addressing a subset of the questions posed by staff. We also comment on available transmission capacity, although none of the questions were directed at this topic, and reiterate two important issues that we have raised in the past.

Question 7: How should high- and low-cost trajectories for future battery costs be developed?

CalWEA encourages staff to ensure that the cost of battery disposal is properly accounted for, given the potentially hazardous materials involved.

Questions 10/11: Are there any new resource types … that Energy Division should prioritize including as a candidate resource in the 2019 IRP? Are there data sources … that should be considered for modifying the candidate resource potential assumed in IRP?

In CalWEA's initial IRP comments, we urged staff not to assume (as it did) that existing renewable resources will continue to operate indefinitely. This is a particular concern for renewable energy projects installed in the 1980s, including approximately 1,100 MW of wind energy projects that have not recently been repowered with new technology. See Attachment A for a list of these projects.[1] Further, the model should consider that repowering these resources with new technology can dramatically improve capacity factors and extend project life.

CalWEA is not aware of any publicly available data sources for the operating costs of these existing, aging wind projects. Moreover, costs will vary depending on turbine type, age, and wind regime (e.g., wind turbulence) of the project, among other factors. However, in general, essentially all turbines installed in the 1980s that remain operational[2] are mechanically sound, although their electronic control systems are dated.[3] Most of these turbines continue to operate past 30 years of age, albeit with relatively high operations and maintenance costs, relative to modern turbines, and capacity factors ranging from the high teens to 30%-range. These "work horse" turbines are generally continually repairable to the extent that replacement parts can be found or fabricated. However, it would be unreasonable to assume more than a 45-year life.

In contrast, beginning in the 1990s, turbines began to be designed with lifetimes to match expected contract lengths of 20-25 years with a five-year margin beyond that (25-30 years in total). These variable-pitch machines, with smaller gears and bearings, are more difficult to repair. Against this backdrop, based on input from CalWEA member companies that own and operate many of these vintage resources, CalWEA believes that the following average figures would be reasonable for use in the RESOLVE model:

- A reasonable assumption for the average cost of operating a 1980s-vintage wind project is $0.05/kWh (with a range of $0.04-$0.065/kWh). Costs would be lower where capital costs have been paid off and/or capacity factors are higher, and higher where debt remains (many projects have been purchased from their original or later owners within the past decade) and capacity factors are lower.
- A reasonable assumption for the average cost of operating 1990s-vintage wind projects is perhaps 25% less than that the above, given higher capacity factors.

The cost of repowering pre-2000-vintage California wind projects should be presumed to be the same as the cost of building new, greenfield wind projects. On the one hand, these projects do not incur the early-stage risk-capital outlays associated with a new project, including siting,

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[1] CalWEA submitted this same list as part of its October 26, 2017, IRP comments.

[2] These are Danish-made turbines; nearly all, if not all, U.S. Windpower machines installed in the 1980s are no longer operating.

[3] CalWEA is supporting a UC Davis/DNV-GL project funded by the Energy Commission (EPC-16-019) to research, develop and demonstrate cost-effective communications and control systems for aged turbines that will enable these turbines to be remotely dispatched and controlled in response to real-time and forecasted market prices, curtailment orders, forecasted wind production and other factors.

permitting and interconnection-deposit costs. On the other hand, the very small size of these projects, as indicated in Attachment A, creates a lack of economies of scale.[4] Therefore, many fixed costs (e.g., re-permitting, transactions, certain construction costs and, potentially, interconnection costs) must be spread over many fewer megawatts. While there are many site/project-specific factors that create variability in the costs of both greenfield and repower projects,[5] in general, the model should assume the same cost for small repowers as assumed for new greenfield projects. A reasonable assumption for the average operating cost of a repowered project would be 105% of the operating cost of a new, larger greenfield wind project. This, again, is due to fixed and non-scalable costs associated with small projects, such as service trucks, buildings and personnel.

Comment on Available Transmission Capacity

The staff document describes the source for available transmission capacity as "CAISO supplemental analysis based on the current year's TPP work." This analysis needs to be updated to reflect the ELCC-based RA values for wind and solar that have been adopted by the Commission.

CAISO's analysis estimates the amount of full capacity deliverability service ("FCDS') that is available from each CREZ. In very broad terms, this estimation consists of three steps:

1. Calculate total FCDS transmission capacity from the CREZ;

2. Calculate, based on CAISO's exceedance methodology, FCDS transmission capacity reserved to transmit the RA capacity of CREZ resources that are either operating or contracted; and

3. Calculate remaining available FCDS transmission capacity from the CREZ by subtracting the reserved FCDS transmission capacity calculated in Step 2 from total FCDS transmission capacity calculated in Step 1 plus any FCDS transmission capacity that may become available from planned retirement of resources in the CREZ.

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[4] A large majority of these wind projects (representing about half of the total capacity) is under 30 MW in size. Some 20 projects are under 10 MW in size.

[5] For repowers, these factors include substation conditions and interconnection requirements, terrain, project size, and impacts on neighboring projects.

For example, if CAISO determines that the total FCDS transmission capacity from CREZ-1 is 12,000 MW and the amount of reserved FCDS transmission capacity for existing and contracted resources in CREZ-1 is 8,000 MW (say, 100 solar projects with nameplate capacities of 100 MW and RA capacities of 80 MW each), the available FCDS transmission capacity from CREZ-1 should be 4,000 MW (=12,000-8,000). For reasons CalWEA cannot explain, CAISO adds a margin on the RA capacity – for example. for solar resources whose RA capacity is about 80% of their nameplate based on the exceedance method, CAISO reserves FCDS transmission capacity for 100% of nameplate capacity. In the simple example noted above, the reserved FCDS transmission capacity for CREZ-1 is calculated to be 10,000 MW, rather than 8,000 MW, and thus the available FCDS transmission capacity from CREZ-1 is calculated to be 2,000 MW (=12,000-10,000).

With the advent of the ELCC methodology for calculating the RA capacity value of wind and solar resources, Step 2 in the above calculation will be heavily impacted since the RA capacity of existing and contracted resources under the ELCC methodology is significantly different than the RA capacity under the exceedance method. For example, the Commission-approved RA capacity of a solar resource is now about 40% of its nameplate capacity. This means that the reserved FCDS transmission capacity from a solar-heavy CREZ will be significantly smaller than the value calculated under the exceedance method. In the above example for CREZ-1, the reserved FCDS transmission capacity calculated in Step 2 under ELCC should be 4,000 MW (100 solar resources with 100 MW nameplate capacity each and 40 MW RA capacity each). Even with the CAISO adjustment of RA capacity, the reserved capacity from CREZ-1 would be 5,000 MW (100 solar resources with 100 MW nameplate capacity each and 50 MW RA capacity each). That means that the available FCDS transmission capacity under ELCC will be 7,000 MW (=12,000-5,000) which is significantly higher than the 2,000 MW calculated under the exceedance method.

Therefore, the Commission should work with the CAISO to update its analysis of available transmission capacity in order to account for the Commission's adopted ELCC values.

Comments on Additional Issues

We are not clear whether or not reiterating some of our past comments is appropriate at this juncture, but just in case, we want to flag the following:

- **BTM PV –** The IRP model should have behind-the-meter ("BTM") PV compete with other resources in developing the IRP reference plan, as opposed to being placed as an input number. (The same is true for energy efficiency.) If this is not possible, then, for BTM-PV, the baseline should not assume levels of BTM PV that the IRP results clearly show to be grossly non-cost-effective. The RESOLVE results for the initial IRP cycle showed that reducing BTM PV to 9 GW would save ratepayers $682 million/year in the 42 MMT case. While location-specific transmission and distribution ("T&D") deferral benefits (net of specialized distribution upgrades needed to accommodate high BTM penetrations) are not considered in RESOLVE, the RESOLVE model also does not consider the ratepayer impact of NEM, since the assumed cost of BTM PV was the estimated installation cost only; the ratepayer impact is likely to be far higher than any T&D net benefits associated with BTM PV. Therefore, no more than 9 GW of incremental BTM PV should be included in the baseline for 2030 in the Reference case until the Commission determines the successor NEM tariff in view of any location-specific values determined in the Distributed Resources Plan proceeding, and the full ratepayer impact of NEM should be reflected.

- **Import-Export Limits.** The limit on import and export resources should be based on either historical figures or west-wide production simulation studies. The assumptions used in Staff's 42 MMT Reference case arbitrarily assumed a net export level of 5,000 MW out of the CAISO footprint, which is nearly 5,000 MW over the highest amount that has ever occurred. The "low export" sensitivity assumes 2,000 MW of exports. However, the current figure is near-zero even though there are no institutional, regulatory, or technical barriers to exporting energy out of the CAISO. If there are limits, they are economic limits resulting from neighboring Balancing Authorities' valuation of energy from the CAISO footprint (due to cost of the energy, the wheeling-out cost, or the neighboring area's own minimum generation limits or other operating considerations).

  For future studies, a more appropriate limit should be established using WECC-wide production simulation studies.[6] Meanwhile, the Commission should use CAISO's recommended level of 2,000 MW for the base case and should use zero exports for the "low-export" sensitivity. As CalWEA has shown in its own runs of the RESOLVE model,[7] a lower and more realistic export level will show that wind resources further reduce ratepayer costs.

Respectfully submitted,

/s/ Nancy Rader

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[6] As stated in CalWEA's January 13, 2017, informal comments in this proceeding, these limits could be reasonably established by performing a WECC-wide study with proper hurdle rates for inter-BA transactions to determine maximum expected export values from California to neighboring BAs. One such value should be established for each study year and interpolation could be used to determine the maximum expected export value for non-study years. The maximum expected export values, thus determined, would then become export limits for the IRP studies.

[7] See CalWEA's October 26, 2017, IRP comments --Question 5, part (b).

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April 23, 2018

CalWEA Attachment 1: Estimated California Wind Projects Likely To Be In Need of Repowering

Primary data sources: Expiring Contracts Shown in 2014 CPUC RPS Compliance Filings of PG&E, SCE & SDG&E
Spreadsheet available at: http://www.calwea.org/public-filings

Name	Utility RPS Compliance Filing	Technology	Contract Expiration Year	Nameplate Capacity (MW)	Location	PCC Classification or Contract Type
Altamont Power LLC (4-4)	PG&E	Wind	2015	19	Altamont Pass, CA	Qualifying Facility (QF)
Altamont Power LLC (6-4)	PG&E	Wind	2016	19	Altamont Pass, CA	Qualifying Facility (QF)
Patterson Pass Wind Farm LLC	PG&E	Wind	2015	22	Altamont Pass, CA	Qualifying Facility (QF)
Altamont Power LLC (3-4)	PG&E	Wind	2015	4.05	Livermore, CA	Qualifying Facility (QF)
International Turbine Research	PG&E	Wind	2018	34	Pacheco Pass, CA	Qualifying Facility (QF)
Subtotal - Altamont				**98**		
BNY Western Trust Company	SCE	Wind	2016	5.93	North Palm Springs, CA	PCC 0
Energy Development & Const. Corp.	SCE	Wind	2015	11.66	North Palm Springs, CA	PCC 0
EUI Management PH Inc.	SCE	Wind	2015	25.54	North Palm Springs, CA	PCC 0
Painted Hills Wind Developers	SCE	Wind	2015	19.27	North Palm Springs, CA	PCC 0
Difwind Farms Limited V	SCE	Wind	2016	7.9	Palm Springs, CA	PCC 0
Difwind Partners	SCE	Wind	2015	15.06	Palm Springs, CA	PCC 0
Dutch Energy	SCE	Wind	2020	8	Palm Springs, CA	PCC 0
FPL/WTE Acquisition	SDG&E	Wind	2019	16.5	Palm Springs, CA	
FPL Energy Cabazon Wind, LLC	SCE	Wind	2014	40	Cabazon, CA	PCC 0
NAWP Inc. (East Winds Project)	SCE	Wind	2015	4.17	Palm Springs, CA	PCC 0
Section 16-29 Trust (Altech III)	SCE	Wind	2015	32.87	Palm Springs, CA	PCC 0
Section 20 Trust	SCE	Wind	2015	13.51	Palm Springs, CA	PCC 0
Section 22 Trust (San Jacinto)	SCE	Wind	2015	18.95	Palm Springs, CA	PCC 0
Westwind Trust	SCE	Wind	2015	22.5	Palm Springs, CA	PCC 0
Iberdrola Renewables	SDG&E	Wind	2018	24.9	Riverside County, CA	
Mesa WindPower	SDG&E	Wind	2014	29.9	White Water, CA	
Alta Mesa Power Purchase Contract Trust	SCE	Wind	2018	27	Whitewater, CA	PCC 0
Subtotal - San Gorgonio Pass				**324**		
Cameron Ridge LLC (III)	SCE	Wind	2014	47.12	Mojave, CA	PCC 0
Cameron Ridge LLC (IV)	SCE	Wind	2015	12.76	Mojave, CA	PCC 0
CTV Power Purchase Contract Trust	SCE	Wind	2016	14	Mojave, CA	PCC 0
Desert Wind I PPC Trust	SCE	Wind	2019	48	Mojave, CA	PCC 0
Desert Wind II Power Purchase Trust	SCE	Wind	2020	75	Mojave, CA	PCC 0
Desert Wind III PPC Trust	SCE	Wind	2019	40.5	Mojave, CA	PCC 0
Oak Creek Energy Systems Inc.	SCE	Wind	2016	27.9	Mojave, CA	PCC 0
Oasis Power Partners	SDG&E	Wind	2019	60.0	Mojave, CA	
On Wind Energy, LLC	SCE	Wind	2017	2.4	Mojave, CA	PCC 0
Ridgetop Energy LLC (I)	SCE	Wind	2015	65	Mojave, CA	PCC 0
Ridgetop Energy LLC (II)	SCE	Wind	2018	28	Mojave, CA	PCC 0
Tehachapi Power Purchase Contract Trust	SCE	Wind	2016	56	Mojave, CA	PCC 0
Wind Resource I	PG&E	Wind	2022	8.71	Tehachapi, CA	RPS
Wind Resource II (1)	PG&E	Wind	2023	19.955	Tehachapi, CA	RPS
Aero Enery, LLC	SCE	Wind	2015	4.5	Tehachapi, CA	PCC 0
AES Tehachapi LLC 85-A	SCE	Wind	2015	17	Tehachapi, CA	PCC 0
AES Tehachapi LLC 85-B	SCE	Wind	2015	22.5	Tehachapi, CA	PCC 0
Coram Energy, LLC	SCE	Wind	2015	3	Tehachapi, CA	PCC 0
Mogul Energy Partnership I, LLC	SCE	Wind	2019	4	Tehachapi, CA	PCC 1
Sky River Parnership (Wilderness I)	SCE	Wind	2021	36.78	Tehachapi, CA	PCC 0
Sky River Parnership (Wilderness II)	SCE	Wind	2021	19.8	Tehachapi, CA	PCC 0
Sky River Parnership (Wilderness III)	SCE	Wind	2021	20.93	Tehachapi, CA	PCC 0
Terra-Gen 251 Wind, LLC (Monolith X)	SCE	Wind	2017	5.31	Tehachapi, CA	PCC 0
Terra-Gen 251 Wind, LLC (Monolith XI)	SCE	Wind	2017	4.99	Tehachapi, CA	PCC 0
Terra-Gen 251 Wind, LLC (Monolith XII)	SCE	Wind	2017	6.72	Tehachapi, CA	PCC 0
Terra-Gen 251 Wind, LLC (Monolith XIII)	SCE	Wind	2017	5.67	Tehachapi, CA	PCC 0
Victory Garden Phase IV Partner - 6102	SCE	Wind	2020	6.98	Tehachapi, CA	PCC 0
Victory Garden Phase IV Partner - 6103	SCE	Wind	2020	6.98	Tehachapi, CA	PCC 0
Victory Garden Phase IV Partner - 6104	SCE	Wind	2020	6.98	Tehachapi, CA	PCC 0
Wind Stream Operations LLC (Northwind)	SCE	Wind	2016	6.45	Tehachapi, CA	PCC 0
Wind Stream Operationss, LLC (VG #2)	SCE	Wind	2014	6.93	Tehachapi, CA	PCC 0
Wind Stream Operationss, LLC (VG #3)	SCE	Wind	2014	6.02	Tehachapi, CA	PCC 0
Wind Stream Operatos LLC (VG #4)	SCE	Wind	2015	6.77	Tehachapi, CA	PCC 0
Windland Inc. (Boxcar II)	SCE	Wind	2015	5	Tehachapi, CA	PCC 0
Subtotal - Tehachapi				**709**		
TOTAL REPOWER CANDIDATES (MW)				**1130**		

Note: A small fraction of these projects were repowered in 1998, before the federal tax credit was amended to discourage repowers. Even these facilities would be over 30 years old by 2030.

Projects Already Re-Contracted/Repowered/New (Assumed based on CPUC RPS Contract Database, public info or industry knowledge)

Buena Vista Energy	PG&E	Wind	2017	43	Byron, CA	RPS
Diablo Winds	PG&E	Wind	2016	18	Altamont Pass, CA	RPS
EDF Renewable Windfarm V, Inc.	PG&E	Wind	2017	10	Montezuma Hills	Qualifying Facility (QF)
EDF Renewable Windfarm V, Inc.	PG&E	Wind	2018	6.5	Benicia, CA	Qualifying Facility (QF)
Edom Hills Poject 1, LLC	SCE	Wind	2015	20	Palm Springs, CA	PCC 0
Green Ridge Power LLC	PG&E	Wind	2015	43.1	Tracy, CA	Qualifying Facility (QF)
Green Ridge Power LLC	PG&E	Wind	2018	15	Tracy, CA	Qualifying Facility (QF)
Green Ridge Power LLC	PG&E	Wind	2015	144.1	Livermore, CA	Qualifying Facility (QF)
Green Ridge Power LLC	PG&E	Wind	2016	10.8	Tracy, CA	Qualifying Facility (QF)
Green Ridge Power LLC	PG&E	Wind	2018	5.9	Tracy, CA	Qualifying Facility (QF)
Green Ridge Power LLC	PG&E	Wind	2015	54	Tracy, CA	Qualifying Facility (QF)
Mountain View Power Partners, LLC	SCE	Wind	2021	66.6	North Palm Springs, CA	PCC 0
San Gorgonio Westwinds II, LLC (partial)	SCE	Wind	2015	10	Palm Springs, CA	PCC 0
Shell-Cabazon-Whitewater	SDG&E	Wind	2013	102.4	Palm Springs, CA	
Shiloh I Wind	PG&E	Wind	2021	75	Birds Landing, CA	RPS
Windland Inc. (Boxcar II) (Partial)	SCE	Wind	2015	3	Tehachapi, CA	PCC 0
Total Assumed Repowered (MW)				**627.4**		

BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF CALIFORNIA

Order Instituting Rulemaking to Develop an Electricity Integrated Resource Planning Framework and to Coordinate and Refine Long-Term Procurement Planning Requirements.	Rulemaking R.16-02-007

INFORMAL COMMENTS OF CALIFORNIA BIOMASS ENERGY ALLIANCE ON THE DRAFT SOURCES FOR 2019-20 IRP SUPPLY-SIDE RESOURCES

April 17, 2018

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INFORMAL COMMENTS OF CALIFORNIA BIOMASS ENERGY ALLIANCE ON THE DRAFT SOURCES FOR 2019-20 IRP SUPPLY-SIDE RESOURCES

Pursuant to the March 27, 2018, email from Patrick Young, with attached documents, in Proceeding R-16-02-007, the Order Instituting Rulemaking to Develop an Electricity Integrated Resource Planning Framework and to Coordinate and Refine Long-Term Procurement Planning Requirements, the California Biomass Energy Alliance (CBEA), the trade organization of California's biomass energy industry provides: Informal Comments of California Biomass Energy Alliance on the Draft Sources for 2019-20 IRP Supply-Side Resources. CBEA's Comments are focused on the treatment of biomass in the IRP modeling process, including in the model's database.

The CBEA's June 28, 2017, Comments in this proceeding, made the case that some of the data in the Resolve database pertaining to biomass were inaccurate, with the result that biomass was not adequately represented in the modeling that led to the determination of the Reference System Plan, which was memorialized in D.18-02-018. We reiterated and reinforced our case for updating the biomass specifications in the Resolve database in our October 26, 2017, Comments on the Proposed Reference System Plan. With respect to renewable resources, the *Draft Sources for 2019-20 IRP Supply-Side Resources* (Draft Sources) document is clearly focused on solar and wind resources. Nevertheless, the time is now to update and correct the biomass data in the Resolve model database, in addition to updating solar and wind data.

We address below questions 10 and 11 in the Draft Sources document.

10. Are there any new resource types (not described in your responses to Questions 1 – 9) that Energy Division should prioritize including as a candidate resource in the 2019 IRP?

As the CBEA pointed out in our June 28, 2017, and October 26, 2017 Comments, there are approximately 200 MW of idled but operable biomass facilities in the state that could be brought back into service at considerably lower cost than the development of a new, greenfield plant. We are unaware of a public source of information that contains cost data on refurbishing and restarting idled power plants, but we believe that reasonable estimates can be added to the model's database based on discounting from the cost of new facilities (see answer to question 11 below re cost of new facilities).

The capital cost for the restart of an existing biomass facility can be assumed to be at least fifty percent lower than the cost of developing a new facility. As discussed below in our answer to question no. 11, the CBEA believes that publicly-available cost data from the EIA should be used in place of the data currently in the Resolve model's database for biomass power production. Using the EIA data, and adding in property taxes, which are in the Resolve database but not in the EIA data, produces a total levelized cost for new biomass power of $105 /MWh. If the capital cost factor used by EIA is cut in half in order to represent the cost of a restart of a idled facility, the total levelized cost of biomass from a restart of a idled facility would be $83 /MWh, a reduction of more than twenty percent. These "opportunity" facilities should be added to the Resolve model database. We repeat below the table of idled but operable biomass facilities in the state from our June 28, 2017, Comments.

Facility	**MW**	**Non-Op after 2014?**
Blue Lake	10	Yes
Buena Vista Biomass Power	18	Yes
Covanta Burney	10	No
Covanta Delano	48	Yes
Covanta Mendota	25	Yes
Covanta Westwood	11	No
Dinuba Biomass	12	Yes
Madera Biomass	25	No
Shasta Renewable Energy	6	No
Tracy Biomass	20	No

11: Are there data sources (not described in your responses to Questions 1 – 9) that should be considered for modifying the candidate resource potential assumed in IRP?

Biomass cost data in the Resolve model database are in strong need of updating. The current data are based on a 2013 study performed by Black & Veatch (B&V) for the Commission in the RPS proceeding. The B&V study produced design and cost data for a small (3 MW) and a large (20 MW) biomass generator. The table below shows the capital cost data ($/kW) in the B&V study for the two unit sizes, inflated to 2018 values.

	Low	Medium	High
3 MW	5,650	6,780	8,475
20 MW	5,810	6,520	7,695

These numbers show almost no difference in cost between a 3 MW biomass generator and a 20 MW biomass generator, whereas it is well known that there are very significant economies of scale to be had in this size range. Based on the experience of CBEA members, it is our opinion that the cost data for the 3MW facility are reasonable, while the cost data for the 20 MW facility are much too high. The problem is that the too-high capital-cost numbers for the 20 MW facility form the basis for the cost specifications in the Resolve database for large biomass generators.

The Resolve database is populated with levelized cost data for candidate generators, with levelized fixed costs expressed in $/kW-yrs, and levelized variable costs expressed in $/MWh. The RPS Calculator V6.3 Data Updates document, which is cited as a source document for Resolve, includes a capital cost for biomass of $5,869/kW, and a capacity factor of 85 percent. Assuming that this is the source for the capital cost specification for biomass in the Resolve database, this translates into a levelized capital cost for biomass of $556/kW-yr.

The most authoritative source of public information that we know of on the cost of electricity production is the Dept. of Energy's Energy Information Administration (EIA).

In March, 2018, the EIA published, *Levelized Cost and Levelized Avoided Cost of New Generation Resources in the Annual Energy Outlook 2018*.[1] Tables 1a and 1b (pgs. 5, 6) of the document present the levelized capital cost of biomass at $39.2-40.3 /MWh, which translates into a range of $295-300/kW-yr, assuming a capacity factor of 85 percent. The table below compares the full set of costs between the Resolve database and the EIA:

Levelized Fixed Costs ($/kW-yr)	Resolve	EIA
Capital	556	300
Interconnection	19	11
Property Tax	37	0
Fixed O&M	186	115
Total Fixed	798	426
Levelized Variable Costs ($/MWh)		
Variable O&M	9	45
Fuel	34	inc. above
Prod. Tax Credit	-28	0
Total Variable	15	45
Total Levelized Cost ($/MWh)	122	102
Corrected TLC (see disc. below)	150	105

As the raw data in the table show, there are two inconsistencies between the Resolve and the EIA datasets. First, the Resolve dataset includes a $28/MWh production tax credit for biomass, which, as we pointed out in our June 28, 2017, Comments, has long-since expired. Second, the EIA dataset does not include an estimate of property taxes. Removing the production tax credit from the Resolve dataset, and adding property taxes to the EIA dataset at the same rate as in the Resolve dataset, leads to the corrected values for total levelized cost shown on the last line of the table above in red.

[1] https://www.eia.gov/outlooks/aeo/pdf/electricity_generation.pdf

The CBEA urges the Commission to update the Resolve model database's biomass specifications with publicly-available information from the EIA.

Conclusion

CBEA requests that the biomass dataset being used for the IRP analysis be updated in time for the next round of the IRP, both with regards to the cost of new biomass generators, and with respect to including operable but currently idle biomass generators in the state as candidates for satisfying future resource needs.

Dated April 17, 2018

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BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF CALIFORNIA

Order Instituting Rulemaking to Develop an Electricity Integrated Resource Planning Framework and to Coordinate and Refine Long-Term Procurement Planning Requirements.	Rulemaking 16-02-007 (Filed February 11, 2016)

INFORMAL COMMENTS OF THE CALIFORNIA ENERGY STORAGE ALLIANCE ON THE DRAFT SOURCES FOR 2019-2020 IRP SUPPLY-SIDE RESOURCES DOCUMENT

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April 23, 2018

BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF CALIFORNIA

Order Instituting Rulemaking to Develop an Electricity Integrated Resource Planning Framework and to Coordinate and Refine Long-Term Procurement Planning Requirements.	Rulemaking 16-02-007 (Filed February 11, 2016)

INFORMAL COMMENTS OF THE CALIFORNIA ENERGY STORAGE ALLIANCE ON THE DRAFT SOURCES FOR 2019-2020 IRP SUPPLY-SIDE RESOURCES DOCUMENT

As follow-up to the Modeling Advisory Group ("MAG") webinar on March 1, 2018 and in response to the March 27, 2018 email from the California Public Utilities Commission ("Commission") staff soliciting comment on the draft *Sources for 2019-2020 IRP Supply-side Resources* ("Draft Sources") document, the California Energy Storage Alliance ("CESA")[1] hereby submits these informal comments.

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[1] 8minutenergy Renewables, Able Grid Energy Solutions, Advanced Microgrid Solutions, AltaGas Services, Amber Kinetics, American Honda Motor Company, Inc., Axiom Exergy, Brenmiller Energy, Bright Energy Storage Technologies, BrightSource Energy, Brookfield Renewables, Centrica Business Solutions, Consolidated Edison Development, Inc., Customized Energy Solutions, Demand Energy, Doosan GridTech, Eagle Crest Energy Company, East Penn Manufacturing Company, Ecoult, EDF Renewable Energy, ElectrIQ Power, eMotorWerks, Inc., Energport, Energy Storage Systems Inc., EnerNOC, ENGIE Energy Storage, E.ON Climate & Renewables North America, Fluence Energy, GAF, Geli, Greensmith Energy, Gridscape Solutions, IE Softworks, Ingersoll Rand, Innovation Core SEI, Inc. (A Sumitomo Electric Company), Iteros, Johnson Controls, Lendlease Energy Development, LG Chem Power, Inc., Lockheed Martin Advanced Energy Storage LLC, LS Power Development, LLC, Magnum CAES, Mercedes-Benz Energy, NantEnergy, National Grid, NEC Energy Solutions, Inc., NextEra Energy Resources, NEXTracker, NGK Insulators, Ltd., NRG Energy, Inc., Ormat Technologies, Parker Hannifin Corporation, Pintail Power, Qnovo, Range Energy Storage Systems, Recurrent Energy, Renewable Energy Systems (RES), Sempra Renewables, Sharp Electronics Corporation, SNC Lavalin, Southwest Generation, Sovereign Energy, Stem, STOREME, Inc., Sunrun, Swell Energy, True North Venture Partners, Viridity Energy, Wellhead Electric, and Younicos. The views expressed in these Comments are those of CESA, and do not necessarily reflect the views of all of the individual CESA member companies. (http://storagealliance.org).

I. INTRODUCTION.

CESA appreciates the opportunity to provide informal input to the MAG as it works in parallel tracks to enhance the production cost modeling in the 2017-2018 Integrated Resource Planning ("IRP") cycle and to update assumptions for initial modeling for the 2019-2020 IRP cycle. CESA agrees that this is a prudent and wise use of the Commission's time to prepare for the next round of RESOLVE modeling beginning in January 2019 while the load-serving entities ("LSEs") prepare their IRP filings for the 2017-2018 IRP cycle based on Decision ("D.") 18-02-018. CESA plans to continue its active participation in this important proceeding.

In these informal comments, CESA provides responses to the questions posed in the Draft Sources document but first offers its comments on the data source criteria, which requires that data sources to be used in IRP modeling must be publicly available, technically credible, reflective of future costs, usable to develop all-in technology costs, and geographically specific, if needed.[2] CESA generally agrees with this criteria, but adds that certain credible proprietary data and actual cost data from real-world competitive solicitations may be used to inform which publicly-available data sources and ranges to use. CESA understands the challenge for any public proceeding is around the ability to use publicly available data, which eliminates the use of perhaps more informative confidential data from competitive solicitations and/or the use of proprietary data due to licensing barriers. However, such datasets that are unusable for citing in public proceedings may still be useful to benchmark the publicly available data sources and inform the adoption of low-end or high-end cost ranges from the publicly available data source for different resources. Overall, we should not use inaccurate data knowingly, and should find a way to use realistic going-forward cost data.

[2] Draft Sources document, p. 11.

Furthermore, CESA believes that there should be some criteria around the process or triggers for updating resource cost inputs. Especially for energy storage, where costs are on a rapid downward trajectory, the use of one primary data source at this stage of the IRP modeling process may soon become stale by the time that the actual modeling efforts are underway in early 2019 and the modeling results are completed by late 2019, possibly early 2020. In instances where the primary data source is not updated annually or frequently enough, it may be reasonable to utilize certain proprietary data sources and/or actual costs from recent competitive solicitations to inform whether the high-, mid-, or low-end costs of the resource is reasonable for adoption in the 2019 or 2020 Reference System Plan. The Commission already proposes a criteria to justify changes to model functionality and run-time, where the magnitude of potential impact on future portfolio costs and composition must be sufficient. However, in this case, CESA believes that cost assumption updates as CESA proposes above do not require a significant re-work of the model functionality or create extra run-time, and thus a consideration of some threshold criteria or a streamlined process by which to update cost assumptions may be reasonable and prudent to ensure more accurate model outputs.

II. RESPONSE TO QUESTIONS.

Below, CESA provides our select responses to the questions posed by Commission staff from the Draft Sources document.

Question 4: Do parties have recommendations on how to distinguish between specific battery technologies in an emerging market?

CESA appreciates the Commission's consideration of emerging battery storage technologies. There are a number of battery storage technologies on the market today or are in the early stages of commercialization that each offer its own unique advantages and disadvantages in terms of power/energy density, lifetime, performance, safety, recyclability, among other traits. New advancements are frequently occurring, but rather than modeling every specific battery technology, CESA believes it may be more reasonable to model and price the different capabilities of battery (and other energy storage) technologies, with some differentiation across the major sub-classes of battery storage technologies – *i.e.*, lithium-ion, flow, advanced lead-acid, and flywheel battery storage – as it has been done in the IRP modeling to date and as it is usually reported in publicly-available industry sources. Ultimately, CESA views the role of the procurement process to select the specific battery technology, whereas the IRP modeling should identify the higher-level capabilities needed from energy storage resources to meet identified grid needs. For example, energy storage costs can be differentiated by duration levels to guide the authorization of procurement for specific energy storage capabilities.

<u>Question 5</u>: What sources should be considered in developing recommended battery costs for use in IRP?

CESA supports the Commission's approach of using Lazard's *Levelized Cost of Storage 3.0* (or whatever subsequent version of the study comes out)[3] as a primary data source that can be benchmarked or revised with a literature review of other proprietary industry market research from

[3] *Lazard's Levelized Cost of Storage Analysis – Version 3.0*, published in November 2017. https://www.lazard.com/media/450338/lazard-levelized-cost-of-storage-version-30.pdf

sources such as Bloomberg New Energy Finance ("BNEF"),[4] GTM Research,[5] Navigant Research,[6] IHS,[7] and potentially others.[8] CESA finds Lazard to be a generally credible and technically sound public industry data source that breaks out the various cost drivers of different energy storage technologies and takes a use-case perspective to determine costs that take into account the operational parameters of different energy storage technologies.

Lazard as a primary data source also has the advantage of representing a broader range of technologies, which many other data sources lack. In addition to Lazard's study, CESA points to

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[4] BNEF conducts an annual *Lithium-Ion Battery Price Survey* that provides valuable insights into the trajectory of lithium-ion cell and pack prices, primarily those used for electric vehicles and stationary storage. This proprietary resource is limited for focusing on the storage module costs and not incorporating the balance of system, power conversion, or engineering, procurement, and construction costs of a grid-connected energy storage system. However, this resource is useful in tracking recent cell/pack capital cost trajectories as well as forward trajectories based on their calculated learning rates, though this is only useful for lithium-ion-based batteries. https://data.bloomberglp.com/bnef/sites/14/2017/07/BNEF-Lithium-ion-battery-costs-and-market.pdf

[5] See, for example, *Grid-Scale Energy Storage Balance of Systems 2015-2020*, published in January 2016. https://www.greentechmedia.com/research/report/grid-scale-energy-storage-balance-of-systems-2015-2020 or see *U.S. Front-of-the-Meter Energy Storage System Prices 2018-2022*, published February 2018. https://www.greentechmedia.com/research/report/us-front-of-the-meter-energy-storage-system-prices-2018-2022#gs.VhyGBzc

GTM Research conducts battery hardware and balance of system costs over a three- to four-year look-ahead period and is thus limited to its applications when looking out to 2030. Furthermore, GTM Research does not provide a cost model for alternative energy storage technologies, limiting its application to short-term lithium-ion battery prices and forecasts, but given its more project-by-project tracking of energy storage costs, it may serve as a useful benchmark for current and short-term cost assumptions for lithium-ion battery storage projects. https://www.greentechmedia.com/research/storage

[6] Navigant is a major industry market research firm, but this source may be less reliable for IRP modeling purposes given the lack of detail and infrequency of its energy storage cost reports. When these reports do come out, it may be useful to at least benchmark and review.

[7] The same points for Navigant apply to IHS as a data source. The latest IHS report that CESA could find was limited in scope to lithium-ion battery projects of a specific configuration with short-term look-aheads. https://www.utilitydive.com/news/ihs-grid-scale-lithium-ion-battery-storage-prices-will-decline-by-half-by/409822/

[8] There are a number of other services firms that may produce energy storage cost reports, including one from McKinsey. However, these reports are usually one-off reports and may not track industry cost trends as closely, though it may still be informative as part of the literature review.
https://www.mckinsey.com/business-functions/sustainability-and-resource-productivity/our-insights/the-new-economics-of-energy-storage

a peer-reviewed, publicly-available analysis of current energy storage costs as well as projections through 2030 from the International Renewable Energy Agency ("IRENA").[9] Using a methodology that identified economic and materials-based factors that could drive down costs with scale and innovation, the IRENA report provided a comprehensive report on not just classes of energy storage technologies (*e.g.*, lithium-ion, flow batteries) but also specific chemistries and sub-classes of each type of technology. The report also covers a range of alternative energy storage technologies such as compressed air energy storage ("CAES") and flywheel energy storage that many industry data sources do not provide. The IRENA report may be helpful in benchmarking the Lazard's current and forecasted cost estimates.

Additionally, CESA recommends that the Commission consider the approach used by the New York State Energy Research and Development Authority ("NYSERA") in developing its *NYS Energy Storage Roadmap*, which aims to conduct an energy storage study to determine the energy storage deployment potential that would deliver net positive ratepayer benefits for the state of New York. As part of that study, NYSERDA generated 2018-2030 energy storage cost projections as inputs into their modeling runs by conducting a literature review of data from Lazard, GTM Research, Navigant Research, BNEF, and energy storage developers and creating a 'blended' cost number to calculate the installed cost per kW and per kWh of different durations of energy storage (see below table).[10] This is an approach that could be explored in lieu of modeling each and every energy storage technology (see response to Question 4) and that could be replicated in some manner here in California. It may be useful to coordinate between NYSERDA and the

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[9] IRENA, *Electricity Storage and Renewables: Costs and Markets to 2030*, October 2017. http://www.irena.org/menu/index.aspx?mnu=Subcat&PriMenuID=36&CatID=141&SubcatID=3879

[10] NYSERDA and New York Department of Public Service, *NYS Energy Storage Roadmap*, presented on March 16, 2018, p. 11. https://www.nyserda.ny.gov/-/media/Files/Programs/Energy-Storage/2018-03-09-energy-Storage-Roadmap-base-case-webinar.pptx

Commission to share their approach to using industry data sources. If this approach is used, it will also be important to make transparent to stakeholders how the Commission determined these blended cost numbers.

11

Energy Storage Technologies and Cost Declines

Duration and Installed Cost	2018	2020	2025	2030
Long (6 hrs)				
per kW	$2,270	$1,800	$1,200	$1,000
per kWh	$380	$300	$200	$165
Medium long (4 hrs)				
per kW	$1,600	$1,280	$840	$700
per kWh	$400	$320	$210	$175
Medium short (2 hrs)				
per kW	$1,080	$875	$600	$500
per kWh	$540	$435	$300	$250
Short (half hour)				
per kW	$630	$510	$350	$290
per kWh	$1,260	$1,020	$700	$580

All costs are in 2018 dollars and reflect bulk distribution or transmission system installed cost including a basic estimate for land lease cost and interconnection.

Add 1.25 multiplier for NYC Zone J installations and 1.10 multiplier for Long Island Zone K installations.

Add 40% multiplier for customer sited storage located behind a customer's utility meter.

Blended cost of technologies and sources including Lazard Levelized Cost of Storage 2017, GTM Research, Bloomberg, Navigant Research and storage developers

acelerex NEW YORK STATE OF OPPORTUNITY NYSERDA

Furthermore, in addition to Lazard and other industry data sources, CESA encourages the Commission to, with appropriate controls and protections for confidentiality, also look at confidential cost numbers reported as part of rate proceedings and applications for contract/project approval.[11] The use of actual cost data can serve as a very useful benchmark on the current or near-term costs used for energy storage assumptions, which can then be extrapolated using forecasts from industry data and forecasting reports. While CESA does not have access to these numbers, the Commission does have access and has the ability to adjust and adopt high-, mid-, or low-end cost estimates based on this actual cost data. The Commission has the discretion to select among the cost ranges from the publicly-available data sources, which can be guided by solicitation data from any number of energy storage applications in California – *e.g.*, biennial

[11] Comparative projects should be used. Importantly, CESA recommends *not* using projects that may not be reflective of normal development times, such as, for example, the 2016 Aliso Canyon Energy Storage (ACES) RFO projects. Such projects were needed and procured due to an emergency order stemming from the Aliso Canyon natural gas facility leak and subsequent moratorium on injections and withdrawals.

energy storage applications, local capacity requirement ("LCR") applications that selected energy storage contracts, etc. As an example, CESA points to Xcel Energy's all-source solicitation report that aggregated bid information by resource type and found surprisingly low cost data for standalone and paired energy storage resources.[12] A similar approach could be used to aggregate cost data across actual solicitations in California if possible – *i.e.*, sufficient number of bids to be able to aggregate bid prices and protect confidentiality – and be reported into the IRP. CESA encourages the Commission to explore this possibility given that we have seen reports of hundreds of bids submitted into energy-storage-related solicitations that could be used for IRP purposes.[13] In sum, this actual cost data can serve as a baseline against cost forecasts for energy storage resources as well as for other supply-side resources.

Another important consideration for supply-side energy storage assumptions is to reflect the investment costs for energy storage resources paired with generation assets. Hybrid energy storage resources have a significant advantage in potentially reducing the balance of plant and engineering, procurement, and construction ("EPC") costs, which factor into the capital costs reported by Lazard and will be used for supply-side cost assumptions of energy storage in the IRP modeling. One of the serious limitations of the 2017-2018 IRP modeling is that RESOLVE did not factor in the reduced cost impacts of coupling energy storage with solar resources, generating potential cost savings in terms of shared land, shared inverters (in the case of DC-coupled solar-plus-storage systems), and the Federal Investment Tax Credit ("ITC") when charging the energy storage resource by at least 75% from the paired ITC-eligible solar generator. In the next IRP

[12] Xcel Energy, *2016 Electric Resource Plan: 2017 All Source Solicitation 30-Day Report*, submitted on December 28, 2017. https://www.documentcloud.org/documents/4340162-Xcel-Solicitation-Report.html

[13] St. John, Jeff. "California Dreaming: 5,000MW of Applications for 74MW of Energy Storage at PG&E." Greentech Media, May 28, 2015. https://www.greentechmedia.com/articles/read/california-dreaming-5000mw-of-applications-for-74mw-of-energy-storage-at-pg#gs.em6QU2k

cycle, CESA believes it is important to properly model these potential capital cost savings as well as to get this functionality into RESOLVE where energy storage resources are not just selected independently but also coupled with either existing or new resources.

Understandably, this added functionality will require modeling generation and energy storage charge/discharge correctly, but robust modeling that accurately reflects the tools available for the grid should be the backbone to the IRP process. The National Renewable Energy Laboratory ("NREL") produced a study that could be referenced by the Commission on how pairing energy storage resources with solar plants can impact the costs and benefits of these hybrid assets, depending on the configuration and the charge profile of the resource. Notably, the study found significant balance of system and inverter cost savings as well as a major benefit in the ITC that boosted the viability of DC-coupled solar-plus-storage systems.[14] Similar type of work can be conducted in this IRP cycle, and in many ways, CESA believes that this functionality must be done since the Reference System Plan results demonstrated how the ITC has significant impacts on the resulting optimal resource portfolio, as evidenced by the more than 9,000 MW of utility-scale solar selected before 2026. To simplify modeling efforts, CESA suggests that the Commission consider modeling energy storage resources that can either charge 75% or 100% from the on-site solar resource as separate candidate resources, which can claim 75% or 100% of the ITC, respectively, against its investment costs.[15] For the 75% energy storage case, it may require further discussion on how the energy storage charging from the grid should be modeled, including

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[14] Denholm, Paul, Josh Eichman, and Robert Margolis. *Evaluating the Technical and Economic Performance of PV Plus Storage Power Plants*, National Renewable Energy Laboratory, published on August 2017. https://www.nrel.gov/docs/fy17osti/68737.pdf

[15] Though there is a range of energy storage charging cases between 75% and 100%, testing these two polar ends of ITC-eligible paired energy storage may be informative on the types of paired energy storage selected as well as the potential grid impacts of PV-only versus PV-majority charging.

how it should be sized in terms of capacity and durations and how it may be operationally constrained due to the 75% charge requirement.

In addition to storage paired with solar, CESA also recommends that the Commission consider other hybrid configurations where energy storage resources are paired with gas generation projects. For example, gas-plus-storage projects may also have similar capital cost benefits while providing the added benefit of reducing gas turbine starts and run time, thereby reducing the GHG emissions profile of the otherwise standalone gas plant. In both of these cases, adjustments to the capital and investment costs of the energy storage resource is needed when added to an existing or new generation resource in addition to adjustments to the modeled operating profile of the generation asset. Likewise, wind-plus-storage projects may have similar capital cost benefits as solar-plus-storage projects but have a different benefit where energy storage can firm generation, which reduces forecast uncertainty and/or load following requirements, generating cost and potential indirect greenhouse ("GHG") emission savings from not have to have other resources on standby to address those issues.

Understandably, the modeling of hybrid energy storage resources is a complex task, but CESA believes this is reasonable, if not essential, for the Commission to adapt its models to incorporate this functionality because of the potential ratepayer savings that could be generated by investing in new energy storage resources that can be paired with new or existing generation assets, rather than having the model make separate and potentially costlier investment decisions of generation and energy storage assets. Gas-hybrid resources may also have special applicability to address longer-term contingency conditions or local conditions, so they especially warrant representation in IRP models in this period of gas-plant attrition.

<u>Question 6</u>: How should Multiple Use Applications of battery storage by modeled?

CESA appreciates the Commission's consideration of multiple-use applications ("MUAs") of energy storage resources to be modeled in the IRP. In line with R.15-03-011 and ongoing work to effectuate MUAs in energy storage contracts and operations, CESA recommends exploration of MUA cost models that could be both prudent and reflective of real-word MUA capabilities. These resources can be modeled as new MUA storage resources into RESOLVE or other tools. Controls are needed to ensure MUAs are appropriately incremental to other resources, but the general concept here would be to model MUAs as resources that can be dispatched but that may have lower costs. Ultimately, modeling results should highlight system or grid needs and should be able to direct competitive solicitations wherein MUAs may be best evaluated via a procurement process using bids by third-party energy storage operators, who have the project- or fleet-specific optimization model for the energy storage resource to optimize revenues while managing financial risk, and by the distribution utility and the California Independent System Operator ("CAISO"), who have the visibility to key grid constraints and needs to ensure whether MUAs are viable from a single resource.

Additionally or alternatively, CESA recommends that the Commission adopt low-end cost assumptions for energy storage resources as an input into the model. CESA believes this is a minimally reasonable proxy for the MUA capabilities, which measures the added benefits of energy storage resources when evaluated for cost-effectiveness. In other words, if cost-effectiveness is a measurement of benefits over costs and the benefits are difficult to model in the context of MUAs, it is reasonable to assume lower costs for energy storage resources, with the intent to eventually tap into the MUA benefits of energy storage when these resources are procured and contracted.

Question 7: **How should high- and low-cost trajectories for future battery costs be developed?**

See CESA's response to Question 5-6. In general, CESA believes that it is reasonable to use low-end energy storage cost numbers from Lazard, supported by benchmarking from other industry resources. If actual cost data can be used as a basline for the current year, the aggregate average of the actual cost information should be used as the mid-point estimate. If actual aggregated and anonymized cost data cannot be reported publicly in the model, it could inform whether the Commission should use the high-, mid-, or low-end estimates from public industry data sources for use as the mid-point estimate in 2020-2030. Low- and high-cost trajectories for battery costs can be informed by literature reviews as well as learning rate estimates of cost reductions based on the scale of MW deployment.

Question 8: **How should pumped storage costs be represented given that they are highly site-specific and difficult to estimate on a generic basis?**

Given that pumped storage projects are site specific and fewer in number and are thus difficult to estimate on a generic basis, CESA recommends that differentiated categories of pumped storage projects could be used to model their costs. For example, "PHS 1" could represent pumped storage sites on brownfield sites while "PHS 2" could represent pumped storage projects on greenfield sites. Due to the confidentiality of site-specific information, CESA believes that a PHS 1, PHS 2, PHS 3, etc. type of approach is needed, similar to how the 2017-2018 RESOLVE model represented different gas generation units. Categories of specific capabilities, size, and project characteristics may be used to model pumped storage in this way.

CESA also suggests IRP staff have conversations with pumped storage developers to explore cost structures for specific sites. The goal of these conversations would be to have a more accurate and informed IRP outcome. Large pumped storage solutions should be available to the

IRP model for selection. IRP should also recommend how cost-sharing for resources larger than any single LSE's procurement appetites can be supported, if it is in the interests of ratepayers.

<u>Question 9</u>: To what extent are new pumped hydroelectric facilities able to contribute to primary frequency response?

In addition to having significant total inertia, ternary pumped storage facilities have the ability to contribute to primary frequency response ("PFR") due to the ability of the pumped storage plant to pump and generate at the same time. In other words, ternary pumped storage facilities are capable of acting like a fast-acting system that can transition quickly from pumping to generating in response to frequency deviations. There are a number of studies highlighting the capabilities of ternary pumped storage units, including one from Argonne National Laboratory on how these systems should be modeled in production cost and revenue analyses.[16]

CESA recommends the RESOLVE model or alternative IRP model also solve for grid needs such as PFR. A constraint such as this may highlight how resources with actual or synthetic inertia and PFR capability are needed in the grid of the future. The provision of PFR from any resource requires headroom, so model inputs should reflect this real-world operational requirement.

<u>Question 10</u>: Are there any new resource types (not described in Questions 1-9) that Energy Division should prioritize including as a candidate resource in the 2019 IRP? Describe how the new resource type satisfies the new candidate resource criteria listed above. List the data sources available for quantifying the cost and potential of the proposed resource type and describe how the data sources satisfy the data source criteria listed above.

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[16] *Modeling Ternary Pumped Storage Units*, Argonne National Laboratory, published in August 2013. https://ceeesa.es.anl.gov/projects/psh/ANL_DIS-13_07_Modeling_Ternary_Units.pdf

Yes, CESA believes that there are several new resource types that should be prioritized for inclusion in the 2019-2020 RESOLVE model as candidate resources. Using the criteria set forth by the Commission to justify their inclusion as well as some recommended data sources, CESA has outlined the case for each in the below table.

Resource	CAES	Gas + Storage
Criteria 1: Resource must have plausible trajectory to commercial availability within planning time horizon	Yes, there are two CAES plants in operation today in Germany[17] and one CAES plant in Alabama[18] that has been in operation for decades.	Yes, SCE contracted with Wellhead Electric and GE to procure energy storage integrated with a simple-cycle combustion turbine – *i.e.*, the new Hybrid EGT technology.[19]
Criteria 2: Magnitude of potential impact on future portfolio costs and composition must be sufficient to justify changes to model functionality and run-time	Yes, RESOLVE model economically selected approximately 1,200 MW of PHS as being optimal in the 30 MMT scenario and economically selected significant levels of PHS in 2034 to achieve the 2038 GHG emissions target in the limited post-2030 sensitivity for the 42 MMT scenario. D.18-02-018 then added that PHS benefits can be generalized to other bulk storage types, which includes CAES.	Yes, SCE reported to the Commission on the GHG emission reduction benefits from higher capacity factor, lower fuel usage, and fewer gas turbine starts and runs by having the paired energy storage resource optimize gas turbine operations.[20]
Potential Public Data Sources	Lazard's LCOS 2.0[21] and PacifiCorp's 2017 IRP Study Report[22]	Informed estimates based on informational interviews and data reported from SCE's procurement with GE and Wellhead

[17] See E.ON's Huntorf CAES Plant: http://www.solarplan.org/Research/BBC_Huntorf_engl.pdf

[18] See the McIntosh Plant from PowerSouth Energy Cooperative: http://www.powersouth.com/wp-content/uploads/2017/07/CAES-Brochure-FINAL.pdf

[19] "GE and Southern California Edison Debut World's First Battery-Gas Turbine Hybrid." BusinessWire, published on April 17, 2017. https://www.businesswire.com/news/home/20170417005741/en/GE-Southern-California-Edison-Debut-World%E2%80%99s-Battery-Gas

[20] Application of Southern California Edison (U 338-E) for Approval of its 2018 Energy Storage Procurement and Investment Plan, filed on April 13, 2018. http://www3.sce.com/sscc/law/dis/dbattach5e.nsf/0/E02F51B6FDDADE36882582430079252O/$FILE/A1803XXX-SCE-Various-2018%20Energy%20Storage%20Procurement%20and%20Investment%20Plan%20Testimony-SCE-01.pdf

[21] *Lazard's Levelized Cost of Storage Analysis – Version 2.0*, published in December 2016. https://www.lazard.com/media/438042/lazard-levelized-cost-of-storage-v20.pdf

[22] Black & Veatch, *Bulk Storage Study for the 2017 Integrated Resource Plan*, prepared for PacifiCorp, August 19, 2016. http://www.pacificorp.com/content/dam/pacificorp/doc/Energy_Sources/Integrated_Resource_Plan/2017_IRP/Black_Veatch_PacifiCorp_Bulk_Storage_IRP_Study_Report-final_20160819.pdf

For each of the above, CESA believes that they are already commercially available and present significant potential to support the state's renewable and GHG goals at least cost. CESA recommends the Commission explore these candidate resources.

III. CONCLUSION.

CESA appreciates the opportunity to submit these comments to the Ruling and looks forward to working with the Commission going forward in this proceeding.

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Date: April 23, 2018

BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF CALIFORNIA

Order Instituting Rulemaking to Develop an Electricity Integrated Resource Planning Framework and to Coordinate and Refine Long-Term Procurement Planning Requirements.	Rulemaking 16-02-007

COMMENTS OF CONSERVATION PARTIES ON THE 2019-2020 IRP SUPPLY-SIDE RESOURCES

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BEFORE THE PUBLIC UTILITIES COMMISSION
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Order Instituting Rulemaking to Develop an Electricity Integrated Resource Planning Framework and to Coordinate and Refine Long-Term Procurement Planning Requirements.	Rulemaking 16-02-007 (Filed February 11, 2016)

COMMENTS OF CONSERVATION PARTIES ON THE 2019-2020 IRP SUPPLY-SIDE RESOURCES

Defenders of Wildlife, The Nature Conservancy, and Sierra Club ("Conservation Parties") respectfully submit these comments pursuant to the California Public Utilities Commission ("Commission") Energy Division request for stakeholder input dated March 27, 2018, in the Integrated Resource Plan ("IRP") proceeding (R.16-02-007), requesting review and comment on the document called "Draft Sources for 2019-20 Supply-Side Data Sources."[1]

In the "Draft Sources" document, the Energy Division outlines the proposed data sources to be used in an update of the supply curve. The supply curve is the list of candidate renewable resources that are used as inputs to the RESOLVE model, for the statewide Integrated Resource Plan proceeding. These updates to the supply curve are to be incorporated into the modeling for the 2019-20 IRP planning cycle. With these comments, the Conservation Parties address Question 11 from the Draft Sources document, recommending additional environmental data sources for incorporation into the candidate resource potential.

Overall, we recommend that the Commission seek opportunities and methods to encourage and support renewable energy development in least-conflict zones which have been identified in stakeholder processes. This includes low-impact areas such as brownfields and the built environment.

[1] See CPUC Document "Draft Sources for 2019-20 Supply-Side Data Sources" http://www.cpuc.ca.gov/uploadedFiles/CPUCWebsite/Content/UtilitiesIndustries/Energy/EnergyPrograms/ElectPowerProcurementGeneration/irp/2018/CPUC%20Draft%20Sources%20for%202019-20%20IRP%20Supply-side%20Resources.pdf

Question 11: Data Sources on Candidate Resource Potential

In the IRP supply curve, the potential capacity for candidate wind and solar resource is characterized in zones. These zones are called Super Competitive Renewable Energy Zone (Super CREZ) within California, and Western Renewable Energy Zone Qualified Resource Areas (QRAs) outside of California.[2]

Pursuant to the Commission's request for stakeholder input, the Conservation Parties recommend updates to the renewable energy resource potential estimates (i.e. zones) that are used in the RESOLVE model. The candidate renewable resource potential for each zone (i.e. estimated MW per zone) should be updated to incorporate the latest ecological information. The Commission has periodically updated the ecological information in the supply curve in the past, every one or two years, since the creation of the original zones in 2008-2012.[3]

We recommend that the update for 2019-20 planning cycle should incorporate newly-available environmental information, which has not yet been incorporated into the planning process. The list below includes a description of each information source, and a recommendation for how the Commission should incorporate each source into the modeling:

- Bureau of Land Management Solar Energy Program (SEP)
    - Description: "As part of the Solar Energy Program, the BLM has categorized lands that are excluded from utility-scale solar energy development (about and has identified specific locations that are well suited for utility-scale production of solar energy (solar energy zones, or SEZs) where the BLM proposes to prioritize development. The program emphasizes and incentivizes development within SEZs and outlines a collaborative process for identifying additional SEZs." [4]
    - Recommendation: update renewable resource polygon boundaries (QRA boundaries) to capture SEP solar energy zones and exclusions per state, in AZ, NV, CO, NM, UT (note DRECP Development Focus Areas supersede in CA)
- BLM West-Wide Wind Mapping Project
    - Description: "Regional and state wind energy development exclusions and resource sensitivities maps and associated geospatial data developed as part of the West-Wide Wind Mapping Project are

[2] For background historic information on how these zones were developed, see the series of documents summarized in the appendix to this document.
[3] See appendix to this document for overview and timeline.
[4] http://blmsolar.anl.gov/program/

available... These maps depict areas on BLM-administered lands excluded from wind energy development, as well as areas with potentially developable wind energy resources where proposed wind energy projects would be expected to have a high level of siting considerations, a moderate level of siting considerations, or where there are no known environmental resources or land use restrictions that are likely to require more extensive consideration in siting reviews." [5]

    - Recommendation: Update or modify QRA boundaries to capture exclusions and wind energy zones per state
        - See geodatabase called Consol_BLM_wind_dev_sens
        - The following shape files are relevant:
            - Combined_exclusions_public.shp
            - Combined_high_level_siting_considerations_public.shp
            - Combined_moderate_level_siting_considerations_public.shp
            - The summary table in the WWWMP report describes what is included in each of these consolidated layers[6]
- U.S. Department of Energy Section 368 West-wide Energy Corridors
    - Description: "Section 368 of EPAct directed the Secretaries of Agriculture, Commerce, Defense, Energy, and the Interior to designate corridors for oil, gas, and hydrogen pipelines and electricity transmission and distribution facilities on federal lands in the 11 contiguous western states. Congress also directed the Agencies to perform any environmental reviews that may be required to complete the designation of the corridors and incorporate the corridors into land use plans." [7]
    - Recommendation: In particular note the Corridors of Concern[8] identified in the 2012 Settlement Agreement. We recommend applying a risk factor to proposed transmission routes that fall into these Corridors of Concern.
- California desert area information
    - Description of information source: "The Desert Renewable Energy Conservation Plan (DRECP) is a landscape-level plan that streamlines renewable energy development while conserving unique and valuable

[5] http://wwmp.anl.gov/
[6] http://wwmp.anl.gov/downloads/WWMP_Exclusions_Sensitivities_Table.pdf
[7] http://corridoreis.anl.gov/
[8] http://corridoreis.anl.gov/documents/docs/Settlement_Agreement_Package.pdf#page=29

desert ecosystems and providing outdoor recreation opportunities. It was a collaborative effort between the California Energy Commission, California Department of Fish and Wildlife, the U.S. Bureau of Land Management, and the U.S. Fish and Wildlife Service, also known as the Renewable Energy Action Team."[9]
    - Recommendation: No update needed. The DRECP has already been incorporated into supply curve updates as of 2016.
    - Recommendation for lands within the DRECP boundary, but not under the jurisdiction of the BLM LUPA (mostly private, City, or County lands): incorporate most recent County-level planning information.
    - Recommendation that extends beyond DRECP boundary: incorporate latest NatureServe Desert Tortoise Species Distribution Model[10]
- San Joaquin Valley (SJV) information
    - Description: "The main objective of the [2015] Solar and the SJV [stakeholder] process was to identify least-conflict areas in the Valley for solar PV development. The solar industry, agricultural farmland conservation, and environmental conservation stakeholder groups generated spatially explicit data to answer this single question."[11]
    - Recommendation: Update solar resource potential to include information from San Joaquin Valley Solar Convening.
- Environmental Information for Energy Planning from California Energy Commission
    - The CEC has made a significant investment into developing environmental information for energy planning. This information should be made available for use in the IRP proceeding.[12] The following tools are especially well-suited to help inform renewable energy portfolio selection.
        - CEC Energy Gateway[13]
        - Description: "The California Energy Gateway is an online, interactive platform that can support state and local planning by offering increased transparency and enabling users to

[9] https://www.drecp.org/
[10] https://databasin.org/datasets/4b1464c6c4d84a959ba442a58ba736ff
[11] https://databasin.org/datasets/b64959db3e694254818d97e51e2e6f42
[12] See August 2 2017 workshop: IEPR Staff Workshop on Environmental Information for Energy Planning http://www.energy.ca.gov/2017_energypolicy/documents/#08022017
[13] http://docketpublic.energy.ca.gov/PublicDocuments/17-IEPR-13/TN217682_20170522T143021_Policy_Perspectives_Using_Interactive_Data_Platforms_to_Support.pdf

collaborate through assembling, displaying, integrating, analyzing, and sharing data."[14]

        - Environmental Report Writer[15]
        - Description: This is an "interactive environmental report writer tool that could be used in future energy planning to identify and evaluate locations to site renewable energy generation and transmission, as well the environmental context of that location."[16]
    - Recommendation: continue working with CEC staff to identify methods to incorporate these tools into the IRP process.
- Brownfields and other low-impact areas
    - EPA Brownfields study
    - Description: "Through its RE-Powering America's Land Initiative, the U.S. Environmental Protection Agency (EPA) encourages renewable energy development on current and formerly contaminated lands, landfills, and mine sites when aligned with the community's vision for the site… EPA's RE-Powering Mapper, an online interactive web application, allows users to visualize EPA's information about renewable energy potential on contaminated lands, landfills and mine sites." [17]
    - Recommendation: prioritize candidate renewable resources on sites which have been identified for encouragement by the EPA, in a policy-preferred portfolio.
- CEC Offshore Wind Energy Gateway[18]
    - Description: "The Offshore Renewable Wind Energy Gateway assembles geospatial information on ocean wind resources, ecological and natural resources, ocean commercial and recreational uses and community values. This information will help identify areas off of California that are potentially suitable for wind energy generation."
    - Recommendation: Update the offshore wind resource potential to incorporate ecological and natural resource information. In particular

[14] See 2017 IEPR pg 156. http://docketpublic.energy.ca.gov/PublicDocuments/17-IEPR-01/TN223205_20180416T161056_Final_2017_Integrated_Energy_Policy_Report.pdf
[15] http://docketpublic.energy.ca.gov/PublicDocuments/17-MISC-03/TN220483_20170801T111642_Presentation_by_Scott_Flint_8217.pdf
[16] See 2017 IEPR pg 156. http://docketpublic.energy.ca.gov/PublicDocuments/17-IEPR-01/TN223205_20180416T161056_Final_2017_Integrated_Energy_Policy_Report.pdf
[17] https://www.epa.gov/re-powering/re-powering-mapper
[18] https://caoffshorewind.databasin.org/

see the California Marine & Coastal Ecology and Natural Resource Datasets in the Offshore Wind Gateway[19]

Each of the information sources in the above list is publicly available, technically credible, and geographically specific at the level of transmission zones used in RESOLVE. In addition, the magnitude of potential impact on future portfolio costs and composition is sufficient to justify changes to model functionality and run-time.

Independent studies have shown that "many undeveloped landscapes with high renewable resource potential also have high conservation value, creating the potential for conflict between renewable energy development and conservation goals. These potential conflicts matter. If renewable energy projects proceed in environmentally sensitive areas, they can unnecessarily degrade the habitat, biodiversity and other values of natural landscapes. Conversely, environmental concerns can seriously impede renewable energy development by subjecting projects to multi-year delays, major cost increases and in some cases abandonment."[20]

Applying the recommended updates will help develop a better "understanding of the environmental impacts and economic costs of potential renewable energy siting decisions to achieve ambitious renewable energy targets." This understanding is needed to minimize potential conflicts between conservation and development, and to better quantify potential cost impacts of doing so. The 2015 ORB study estimated potential cost impacts of the environmentally preferred portfolio as minimal (within 1 or 2 percent of the base case). Continual incorporation of the latest available information is necessary to investigate and confirm these initial results.

Methods

For the spatial data sources recommended above, the recommended method to incorporate this information is simple. The steps are as follows.

1. Start with the spatial data currently underlying the supply curve in the RESOLVE model.[21]

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[19] https://caoffshorewind.databasin.org/

[20] Integrating Land Conservation and Renewable Energy Goals in California: A Study of Costs and Impacts Using the Optimal Renewable Energy Build-Out (ORB) Model. The Nature Conservancy, 2015. Erica Brand, Laura Crane, Dick Cameron, Energy and Environmental Economics: Grace C. Wu, Nick Schlag

[21] Spatial data for the supply curve which is used as an input to the RESOLVE model is available online here: http://www.cpuc.ca.gov/General.aspx?id=6442453965
The specific links are as follows: Renewable Resources Cost and Potential Update:

2. Modify the polygons in this existing spatial data, to reflect additional exclusions and sensitivities represented in the data sources listed above. The geoprocessing term is called "clipping" the polygon. This modifies the amount of available resource per zone (MW) in proportion to the number of acres removed or added.

We describe above an easy way to update the estimates of available candidate renewable energy resource potential per zone. This will help produce more appropriate, informed, and relevant portfolios of future resources for transmission planning. In addition to updating the candidate resource list, we also recommend that the IRP proceeding seek further methods to encourage and support renewable energy development in least-conflict zones which have been identified in stakeholder processes, including other low-impact areas such as brownfields and the built environment.

Development of policy-preferred low-environmental risk portfolios can be done in multiple ways. The IRP team should investigate methods to favor or prioritize these least-conflict zones and other low-impact areas in the RESOLVE model portfolio selection process, in order to produce policy-preferred portfolios for consideration in directed procurement or transmission investment.

In the IRP proceeding, the Commission should consider whether to incorporate a land use or conservation metric for evaluating selected portfolios in the 2018-19 planning cycle. This has been done before, in the RPS proceeding. For an example approach, we recommend the Commission consult the methodologies presented in August 2015 Land Use Ruling and Staff Paper. In particular, Tracks 2a and 2b provide helpful illustrations. The following excerpt describes Tracks 2a and 2b:[22]

> Track 2a was intended to develop portfolios for use in the 2016 LTPP and policy-preferred portfolios for the 2016- 2017 CAISO TPP. Track 2b was intended to consider in greater detail several additional issues,

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http://www.cpuc.ca.gov/uploadedFiles/CPUC_Website/Content/Utilities_and_Industries/Energy/Energy_Programs/Electric_Power_Procurement_and_Generation/LTPP/RPSCalc_CostPotentialUpdate_2016.pdf
Renewable Resources GIS Data:
ftp://ftp.cpuc.ca.gov/resources/electric/zip/

[22] CPUC Ruling and Staff Paper: Land Use and Process Alignment Considerations (8/28/15)
http://www.cpuc.ca.gov/RPS_Calculator/
Ruling http://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M154/K287/154287797.PDF
Energy Division Staff Paper: Incorporating Land Use and Environmental Information into the RPS Calculator and Developing and Selecting RPS Calculator Portfolios
http://www.cpuc.ca.gov/WorkArea/DownloadAsset.aspx?id=5684

> including how best to incorporate environmental information into the RPS Calculator… There are two primary issues to be resolved in Track 2b: 1) how best to represent land use information in the RPS Calculator and whether; and 2) how to align generation and transmission planning with renewable procurement… Issue 2 of Track 2b, the alignment of planning and procurement, is not addressed here and will be visited at a later date.

The 2019-2020 IRP planning cycle is an ideal time to revisit this thinking. The 2017-18 planning cycle was necessarily kept simple, because it was the first instance of a new planning cycle, and it was necessary to design basic structures and a replicable path forward for implementing statewide IRP in California. Now that several decisions have been made and the planning cycle structure has been established, it is appropriate to re-introduce some of the nuance that had been lost when the RESOLVE model replaced the RPS Calculator functionality, designing plausible portfolios of renewable resources needed to meet the state's renewable energy and climate goals in future years for the purpose of generation and transmission planning.

The completion of these updates will enable the informed decision-making needed for California to meet its renewable energy and climate goals while balancing the protection of our natural and cultural resources.

We look forward to further collaboration with the Commission on this important topic. We are available to support the process of updating the supply side inputs and assumptions as needed, between now and the beginning of the IRP planning cycle in early 2019. We expect more detailed ecological information to become available over the coming months, and we will keep Commission Staff apprised of updates as information arises.

Conclusion

The Conservation Parties appreciate this opportunity to submit comments on supply-side resources for the 2019-2020 IRP. We applaud your leadership in this process, and we look forward to our continued work with you on this important effort.

Respectfully submitted,

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April 23, 2018

Appendix

This Appendix provides background and historic overview of the development of renewable energy "zones" currently being used in the RESOLVE model.

2008-2010: Renewable Energy Transmission Initiative (RETI)
In the Renewable Energy Transmission Initiative (RETI), lands were identified through a rigorous stakeholder process, and protected lands were organized into Category 1 (development prohibited) and Category 2 (development limited) (see the Final RETI Phase 1B report, beginning on page 333 at:
http://www.energy.ca.gov/2008publications/RETI-1000-2008-003/RETI-1000-2008-003-F.PDF

See also 2009 RETI report
http://www.energy.ca.gov/2009publications/RETI-1000-2009-001/RETI-1000-2009-001-F-REV2.PDF

It was through the elimination of protected and sensitive lands, as well as through the application of additional spatial and technical criteria, that the Competitive Renewable Energy Zones (CREZs) and Super CREZs (larger than the original CREZs) were identified.

Spatial (GIS) information for the RETI initiative is available online here:
http://www.energy.ca.gov/reti/documents/index.html
See GIS data for phase 2B, posted April 8, 2010

2010-2012: Western Renewable Energy Zones Initiative
Out of state candidate renewable resources were characterized through a similar screening process, under the WREZ initiative, facilitated by the Western Governors' Association. Protected and sensitive lands were identified through a similar method as was used in RETI. Category 1 and 2 lands were identified and screened out. The remaining renewable resource zones were called Qualified Resource Areas (QRAs).
https://westernenergyboard.org/crepc-spsc/wrez-3/

2010 - 2016: Renewable Portfolio Standard Calculator
The list of candidate resources identified in the RETI and WREZ studies took the form of a supply curve. A supply curve is a list of resources, with unique identifiers tying theeach resource to a spatial polygon, along with resource characteristics of that polygon(cost, estimated annual energy production, transmission cost, etc).

The RPS calculator was developed to use the supply curves from RETI (in California) and WREZ (out of state resources) as inputs. The supply curve is the list of candidate renewable resources from which the model selects the portfolio to meet future RPS targets. The selected portfolio (the output from the model) was submitted by the CPUC to the CAISO for use in the Transmission Planning Process.

The supply curve for the RPS calculator has been periodically updated over time, to incorporate new cost and environmental information as it became available. Documentation for these updates is provided below.

RPS Calculator v 6.0
http://www.cpuc.ca.gov/WorkArea/DownloadAsset.aspx?id=9366
RPS_CalcV60_ResourcePotentialandCost.pptx

RPS Calculator Version 6.2 release notes
http://www.cpuc.ca.gov/WorkArea/DownloadAsset.aspx?id=10346

CPUC Land Use Ruling and Staff Paper
http://www.cpuc.ca.gov/RPS_Calculator/
8/28/15

- Ruling
- Energy Division Staff Paper: Incorporating Land Use and Environmental Information into the RPS Calculator and Developing and Selecting RPS Calculator Portfolios

RPS Calculator v 6.3
Cost and Resource Potential Update
http://www.cpuc.ca.gov/General.aspx?id=6442453965

2016: RESOLVE Model for Integrated Resource Plan
The RESOLVE model has replaced the function of the RPS calculator in renewable energy planning at the CPUC. It continues to use the same input supply curve as its predecessors. This supply curve continues to need periodic updates to incorporate new information.
http://www.cpuc.ca.gov/irp/prelimresults2017/

Spatial data for the supply curve which is used as an input to the RESOLVE model is available online here:
http://www.cpuc.ca.gov/General.aspx?id=6442453965

The specific links are:
Renewable Resources Cost and Potential Update
http://www.cpuc.ca.gov/uploadedFiles/CPUC_Website/Content/Utilities_and_Industries/Energy/Energy_Programs/Electric_Power_Procurement_and_Generation/LTPP/RPSCalc_CostPotentialUpdate_2016.pdf
Renewable Resources GIS Data
ftp://ftp.cpuc.ca.gov/resources/electric/zip/

GRIDLIANCE

NOMAN L. WILLIAMS
Chief Operating Officer

April 17, 2018

To: Patrick Young

From: Noman Williams

Subject: 2019 - 2020 IRP Assumptions Input; Southern Nevada Solar Tracking Capacity Factor Update

GridLiance West appreciates the opportunity to provide comments on the CPUC's 2019 - 2020 IRP Assumptions. GridLiance West offers input at this time on one set of assumptions—that pertaining to the solar capacity factors in Southern Nevada captured in the RESOLVE modeling tool input files.

GridLiance West and its partner Valley Electric Association have participated actively in vetting the RESOLVE assumptions in the prior IRP cycle, primarily through our consultant representatives at Resero Consulting. We appreciate the efforts of the staff in the 2017 – 2018 IRP cycle to resolve significant aspects of the RESOLVE representation of the Southern Nevada CREZ areas.

At this time, GridLiance West requests only that the staff consider updating its assumption regarding the capacity factor of Southern Nevada solar resources. Currently the RESOLVE inputs show Tehachapi utility scale tracking solar facilities at approximately 35% and Southern Nevada-area resources at approximately 32%. Among the RESOLVE and RPS Calculator assumptions documentation, there is extensive documentation of the source(s) of the in-state (California) capacity factor values. For example, the 2017 RESOLVE Documentation: CPUC 2017 IRP Input and Assumption (DRAFT) dated July 2017, includes Table 21, California renewable resource cost & performance data, and it sources the data to Black and Veatch for the RPS Calculator v.6.3 as supplemented by additional analysis conducted by E3 on the cost and performance of new generation resources for the WECC (p. 34). The out-of-state capacity factors in the same July 2017 assumption document were included in Table 22. In this table, the Southern Nevada solar capacity factor is shown as 32%. For this table, however, there is no indication of the source of data. Release notes for RPS Calculator v6.1 and v6.2 do not indicate the source of the out-of-state solar capacity factor data. Similarly, while the RPS Calculator v6.3 Data Updates[1] provided updates to a lot of renewable cost and performance variables, no data or sources were noted regarding out-of-state solar capacity factors. In short, the source of data for the Southern Nevada region is unclear.

GridLiance West believes that the capacity factor for the Southern Nevada CREZ region should be the same as that used for the Tehachapi region. The National Renewable Energy Laboratory (NREL) shows comparable normal irradiance data for both the Tehachapi area of California and for Southern Nevada as shown below.[2]

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[1] http://www.cpuc.ca.gov/uploadedfiles/cpuc_website/content/utilities_and_industries/energy/energy_programs/electric_power_procurement_and_generation/ltpp/rpscalc_costpotentialupdate_2016.pdf

[2] https://www.nrel.gov/gis/solar.html.

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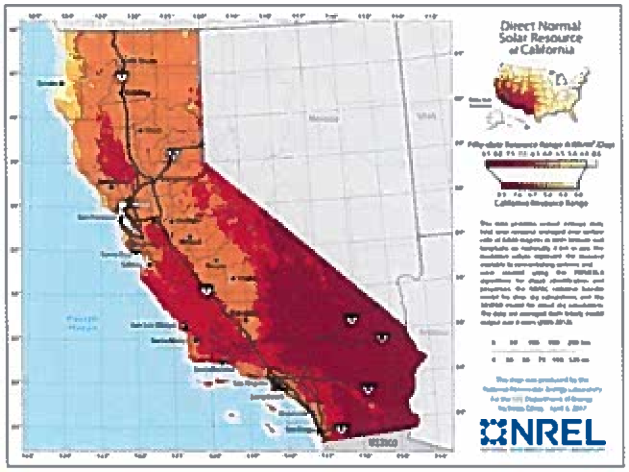

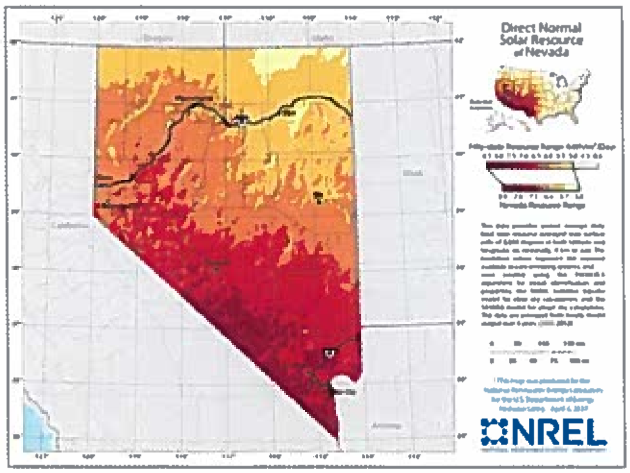

GridLiance West is not aware of any solar data source that shows differences in solar intensity or solar facility capacity factors between these two geographic regions.

The relative differences in net cost for renewable alternatives can be small. Ensuring the data does not artificially create a distinction in net cost per MWh of production will ensure the most economical selection of resources by Load Serving Entities. GridLiance West respectfully requests that the CPUC update the Southern and Western Nevada solar capacities to be equivalent to those of the Tehachapi area, currently set to 35.25%.

Thank you for your consideration.

Sincerely,

Noman L. Williams
Chief Operating Officer
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BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF CALIFORNIA

Order Instituting Rulemaking to Develop an Electricity Integrated Resource Planning Framework and to Coordinate and Refine Long-Term Procurement Planning Requirements.	Rulemaking 16-02-007 (Filed February 11, 2016)

THE OFFICE OF RATEPAYER ADVOCATES' INFORMAL COMMENTS ON DRAFT SOURCES FOR 2019-20 IRP SUPPLY-SIDE RESOURCES

XIAN MING (CINDY) LI
CHRISTIAN KNIERIM
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April 23, 2018

SUBJECT INDEX

I. INTRODUCTION

The Office of Ratepayer Advocates (ORA) submits the following informal comments in response to the March 27, 2018, Energy Division (ED) *Draft Sources for 2019-20 IRP* [Integrated Resource Planning] *Supply-Side Resources* document.

II. DISCUSSION

A. Solar Photovoltaic Question 2: Current assumptions of technology mix for solar PV are 25% fixed tilt and 75% single axis tracking, both with inverter loading ratio of 1.3. What assumptions should be made for the configuration and Inverter Loading Ratio (ILR) of future solar PV facilities?

Assumptions for the mounting-type and inverter load ratio of solar PV should continue to be based on the latest solar project development trends. For example, since 2015, what type of solar projects have the investor-owned utilities (IOUs) contracted with, fixed tilt and/or tracking? What is the ratio between fixed tilt and tracking? What are the latest trends in inverter load ratios?

B. Resource Potential Question 10: Are there any new resource types (not described in your responses to Questions 1 – 9) that Energy Division should prioritize including as a candidate resource in the 2019 IRP? Describe how the new resource type satisfies the new candidate resource criteria listed above. List the data sources available for quantifying the cost and potential of the proposed resource type and describe how the data sources satisfy the data source criteria listed above.

The *Draft Sources for 2019-20 IRP Supply-Side Resources* document[1] includes solar thermal as an "existing & planned resource" (along with biomass, geothermal, small hydro, solar PV, and wind). However, the document does not include solar thermal as a "candidate resource" that could be "potentially used to meet policy constraints and system needs, as well as resources identified as economic investments."[2] The candidate renewables are listed as biomass and biogas, geothermal, small hydro, solar PV, and

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[1] *Draft Sources for 2019-20 IRP Supply-Side Resources*, p. 3.

[2] *Draft Sources for 2019-20 IRP Supply-Side Resources*, p. 5.

wind.[3] Is there an explanation for the omission of solar thermal as a "candidate resource?"

C. Resource Costs Question 13: How should import tariffs on solar PV modules be represented?

As the modeling staff develops a methodology to account for solar PV module import tariffs and their effects on future solar PV project development costs in California, the staff should consider the following questions:

- Approximately how many future solar projects in California, for the years that the solar PV module import tariffs are in place, would continue to use imported materials as components for their projects? For example, Bloomberg reports that more than 80% of solar installations in the U.S. use imported materials.[4] Would a similar trend continue in California while the tariffs are in place? Since 2015, what percentage of California solar projects have used imported components, and how would the tariffs impact this trend?
- The solar PV module import tariffs last four years. How do typical solar PV project development timelines affect the likelihood that a project in development would face, or avoid, these import tariffs? For example, if a solar project started development in year 2 of the import tariffs, could the project delay its procurement of PV modules until after the tariffs expire so that the tariffs do not increase ratepayer costs for that project?

III. CONCLUSION

ORA looks forward to further discussion about inputs and assumptions for the 2019-20 IRP.

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[3] *Draft Sources for 2019-20 IRP Supply-Side Resources*, pp. 6-8.

[4] https://www.bloomberg.com/news/articles/2018-01-22/trump-taxes-solar-imports-in-biggest-blow-to-clean-energy-yet

Pacific Gas and Electric Company
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April 23, 2018

Mr. Paul Douglas
Supervisor, Energy Division
California Public Utilities Commission
505 Van Ness Avenue
San Francisco, CA 94102

Re: Informal Comments on Draft Sources for 2019-2020 Integrated Resource Plan Supply Side Resources Presented on March 27, 2018 (Rulemaking 16-02-007)

Dear Mr. Douglas:

In accordance with the direction provided by Energy Division of the California Public Utilities Commission (Commission or CPUC) on March 27, 2018, Pacific Gas and Electric Company (PG&E) respectfully submits these informal comments concerning the categories and sources of assumptions discussed during the March 1, 2018 Modeling Advisory Group (MAG), which Energy Division staff proposes to use in Integrated Resource Planning (IRP) capacity expansion modeling activities in 2019. PG&E's informal comments address three broad categories (data sources, resource potential, and resource costs) in the identical structure as the request presented by Staff in its document titled "Draft Sources for 2019-20 IRP Supply-Side Resources", which was served to parties in the R.16-02-007 CPUC docket.[1]

The following summarizes PG&E's comments:

A. PG&E provides specific recommendations for the CPUC for developing costs of

(1) retrofitting a power plant, which should be based on inputs from manufacturers for retrofitting an existing combined cycled (CC) or combustion turbine (CT), or converting an existing CC or CT;

(2) future solar photovoltaic (PV) projects, for high- and low-cost trajectories, that are based on a range of fundamental inputs that drive uncertainty around the levelized cost of energy (LCOE) for such projects; and,

(3) installed battery costs, financing costs, and operations and maintenance (O&M) costs should be consistent with the California Energy Commission's (CEC) cost of generation reports;

[1] Included on page 10 of the "Draft Sources for 2019-20 IRP Supply-Side Resources" document is a request for comments on Demand Response (DR) related data sources, even though this candidate resource type was inadvertently omitted from "Questions for Stakeholders" section on pages 12-13. PG&E provides a response as an addendum to the Data Sources section.

B. PG&E recommends the California Demand Response Potential Study should not serve as a formal forecast of the future of advance DR models (i.e., shift, shimmy, shape); and,

C. PG&E recommends how import tariffs on solar PV modules should be represented.

I. Data Sources

1. Do parties have recommendations on public data sources that capture the costs and operational characteristics of retrofitted power plants?

   Response: PG&E recommends CPUC develops costs of retrofitting a power plant based on inputs from manufacturers and power plant operators for retrofitting:

   - An existing CC or CT
   - Converting an existing CC to a CT

   Several factors impact the type and cost of retrofit for a power plant including its age and operational characteristics (e.g. number of starts). While retrofit cost is unique for a power plant, a reasonable assumption can be developed using typical cost for extending the life of a power plant and operational characteristics.

2. Current assumptions of technology mix for solar PV are 25% fixed tilt and 75% single axis tracking, both with inverter loading ratio of 1.3. What assumptions should be made for the configuration and Inverter Loading Ratio (ILR) of future solar PV facilities?

   Response: PG&E believes these values are roughly appropriate. Regarding the technology mix, PG&E notes that recent trends and projections have shifted more weight to single-axis trackers as part of the technology mix in recent years and may continue to do so. As a higher bound, up to 90 percent of new ground-mount installations could be single-axis trackers by the 2021 timeframe.

3. How should high- and low-cost trajectories for future PV costs be developed?

   Response: PG&E recommends developing high/low cost trajectories based on a range of fundamental inputs that drive uncertainty around the levelized cost of energy (LCOE) for solar PV projects. These include, but are not limited to: the extension and availability of tax credits, import tariffs, panel costs, balance of system cost, financing structures, etc. Benchmarking and supplementing these forecasts with public and/or private cost forecasts could also be beneficial.

4. Do parties have recommendations on how to distinguish between specific battery technologies in an emerging market?

   Response: PG&E does not have any comments at this time.

5. What sources should be considered in developing recommended battery costs for use in IRP?

   Response: PG&E recommends the CPUC develop installed battery costs, financing costs, and O&M costs using a methodology consistent with that deployed by the CEC's cost of generation reports for other technologies.

   Specifically, the installed cost of battery system cost can be obtained as the sum of battery pack costs and Balance of System costs for specified sizes. Battery pack costs can be developed by applying a specific learning rate and a forecasted demand for battery packs. The forecast demand for battery packs should recognize the forecasted demand for electric vehicles, as well as stationary batteries. For historical battery pack costs, PG&E recommends referencing the surveys done by BNEF and surveyed costs from battery pack vendors for specific sizes. PG&E also recommends the CPUC consider price differences between battery packs for stationary battery and electric vehicles due to order volume differences and economies of scale.

   PG&E recommends the CPUC break down Balance of System costs into four cost components: inverters (power control systems); balance of plants; installation (shipping and assembly), and Engineering, Procurement and Construction (EPC)); and development costs (developer overheads, developer margin, interconnection and permitting). PG&E recommends breaking down the components of battery system and individually developing the cost of each component to be based on its underlying cost driver (whether size-independent, kW-dependent, or kWh dependent).

   The source of such costs for individual component can be obtained from survey and industry report, such as BNEF and GTM Research. However, most sources lack thorough forecasts of battery system cost estimates up to the IRP horizon. Therefore, the CPUC needs to develop cost trajectory for individual component based on historical and projected cost estimate of individual component, and assuming certain observed (or assumed) learning rates, and/or inflation, and make it vary by kW or kWh of the assumed size of battery systems.

6. How should Multiple Use Applications of battery storage be modeled?

   Response: PG&E recommends the CPUC first determine an assumed description of common types of Multi Use Applications (MUA) of battery storage. For example, the CPUC could assume that a certain MW or percentage of battery storage will be for dual-use between distribution/transmission grid reliability and market services in which capacity during summer months is reserved for grid reliability and capacity during non-summer months can be used for market. Once such use cases for MUA of battery storage are specified, how to model such MUA battery systems follow.

7. How should high- and low-cost trajectories for future battery costs be developed?

   Response: PG&E recommends the CPUC develop low- and high-cost trajectories for future battery system costs by combining low- and high-cost trajectories for each component (battery pack, inverters, balance of plants, development, and installation) of battery system costs. PG&E recommends the CPUC use different learning rates and different battery pack volume growth trajectory in order to develop the low- and high-cost trajectories for battery pack costs. Since a significant cost decline for battery pack cost is anticipated (mainly driven from uncertain amounts of large growth in electric vehicles (EV)), it is necessary to assume different EV growth trajectories in order to develop high, mid and low trajectories for battery pack demand.

The low and high case for each component of balance of system can also be developed based on the range of the values observed and projected by different sources.

8. How should pumped storage costs be represented given that they are highly site- specific and difficult to estimate on a generic basis?

   Response: PG&E does not have any comments at this time.

9. To what extent are new pumped hydroelectric facilities able to contribute to primary frequency response?

   Response: PG&E does not have any comments at this time.

9A. Are there other data sources that should be considered for additional DR cost and potential, beyond the latest version of the California Demand Response Potential Study?

Response: PG&E observes that the 2025 California Demand Response (DR) Potential Study[2] dated March 1, 2017, may not be ripe for use as an input to the IRP. Consistent with PG&E's comments filed in this proceeding on the 2017 Reference System Plan,[3] we believe the DR Potential Study should not serve as a formal forecast of the future of advance DR models (i.e., shift, shimmy, shape) because core assumptions underlying the model include market and regulatory policy changes that have not been fully analyzed or realized, much less implemented and operationalized.

On the other hand, as it relates to conventional DR (i.e., shed), PG&E's latest Load Impact showing, filed on April 2, 2018, provides a reasonable projection of DR load reduction (impact) associated with DR programs administered at this time (these include Critical Peak Pricing (CBP), Base Interruptible Program (BIP), SmartAC).[4] The load impacts associated with PG&E's DR (and CBP) programs are provided through a rolling 10-year projection (2018-2028). PG&E cautions that these projections effectively assume status quo in the 10-year forecast cycle.

There are several uncertainties that could materially impact these projections. First, PG&E, along with SCE and SDG&E, currently have a DR program funding cycle that is

[2] Link: http://www.cpuc.ca.gov/General.aspx?id=10622

[3] *See*, PG&E's Opening Comments to ALJ's Ruling Seeking Comment on Staff Proposal on Process for Integrated Resource Planning (June 28, 2017), pp. 29-30.

[4] *See*, Notice of Availability of PG&E (U 39 E) for Load Impact Reports For Summary of Program Year 2017 Pursuant to Load Impact Protocols Adopted By D.08-04-050, As Modified By D.10-04-006 (April 2, 2018); hyperlink: http://pgera.azurewebsites.net/Regulation/ValidateDocAccess?docID=444844.

five-years (2018-2022), with an expected mid-cycle review occurring in 2020. Program offerings could be modified in 2020 with even greater changes possible beyond 2022. Second, the potential conversion of the DR Auction Mechanism (DRAM) from a pilot to a permanent program could impact the overall level of DR offered by third-parties, which may directly or indirectly affect IOU programs.[5] Third, significant load migration to Community Choice Aggregators (CCA) combined with Competitive Neutrality Cost Causation rules, will most likely impact the level of DR capable of being offered by LSEs.[6]

II. Resource Potential

10. Are there any new resource types (not described in your responses to Questions 1 – 9) that Energy Division should prioritize including as a candidate resource in the 2019 IRP? Describe how the new resource type satisfies the new candidate resource criteria listed above. List the data sources available for quantifying the cost and potential of the proposed resource type and describe how the data sources satisfy the data source criteria listed above.

    Response: PG&E does not have any comments at this time.

11. Are there data sources (not described in your responses to Questions 1 – 9) that should be considered for modifying the candidate resource potential assumed in IRP? Please describe and provide a link for any suggested data sources. Explain how the data source meets the data source criteria listed above.

    Response: PG&E does not have any comments at this time.

III. Resource Costs

12. Are there any additional sources of capital cost, operating cost, and performance projections (not described in your responses to Questions 1 – 9) that should be considered for solar PV or wind? Please describe and provide a link for any suggested sources. Explain how the data source meets the data source criteria listed above.

    Response: PG&E does not have any comments at this time.

13. How should import tariffs on solar PV modules be represented?

    Response: Imported solar modules represent the vast majority of solar PV installations. Therefore, it is critical to update RESOLVE's modeled prices. Import tariffs on solar PV modules can be represented in cost assumptions for solar PV between February 2018 and February 2022. The 30 percent import tariff,[7] which begins in 2018 and phases down

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[5] D. 16-09-056 called for a Resolution to be issued by June 1, 2018 regarding the future of DRAM.

[6] D. 17-10-017 set forth a path for the development of a mechanism for IOUs to unwind their DR program offerings to CCA and ESP customers when a Direct Access provider establishes a "similar" DR program.

[7] First 2.5 gigawatts of imported modules are excluded from the tariff.

five percent annually over the four-year period, will increase the cost of modules and therefore the cost of solar PV development overall.

To best reflect this cost increase, a dollar ($) per watt (W) adder can be incorporated into solar PV cost assumptions. For example, if the average price of an imported PV module is $0.33/W, in 2018 this adder would apply approximately $0.10/W to total module costs, stepping down to approximately $0.04/W in the final tariff year.[8,9]

Table 1:
Tariff levels and example cost premiums

	Year 1	Year 2	Year 3	Year 4
Tariff Level	30%	25%	20%	15%
Cost Premium (Modules)	$0.10/W	$0.08/W	$0.06/W	$0.04/W

14. Should any of the cost and financing assumptions in RESOLVE's LCOE calculations be modified, for example assumptions related to state and federal tax incentives, the cost of capital, and financing lifetime? Explain and support any recommended changes using publicly available information, to the greatest extent possible.

Response: PG&E does not have any comments at this time.

IV. Conclusion

PG&E appreciates Energy Division Staff's leadership to ensure that IRP modeling produces high quality analysis for the next IRP cycle, and thanks Staff for its efforts to ensure a transparent stakeholder process. We look forward to learning about Staff's findings resulting from these informal comments during future MAG sessions, and how party input on the supply-side resources will ultimately be used in IRP modeling.

cc: Service List R.16-02-007
Patrick Young, CPUC
Karolina Maslanka, CPUC

[8] https://www.greentechmedia.com/articles/read/breaking-trump-admin-issues-a-30-solar-tariff

[9] https://news.energysage.com/2018-us-solar-tariff-impact-prices/

BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF CALIFORNIA

Order Instituting Rulemaking to Develop an Electricity Integrated Resource Planning Framework and to Coordinate and Refine Long-Term Procurement Planning Requirements.	Rulemaking R.16-02-007

INFORMAL COMMENTS OF PACIFIC OCEAN ENERGY TRUST ON THE DRAFT SOURCES FOR 2019-20 IRP SUPPLY-SIDE RESOURCES

April 23, 2018

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INFORMAL COMMENTS OF PACIFIC OCEAN ENERGY TRUST ON THE DRAFT SOURCES FOR 2019-20 IRP SUPPLY-SIDE RESOURCES

Pursuant to the March 27, 2018, email from Patrick Young, with attached documents, in Proceeding R-16-02-007, the Order Instituting Rulemaking to Develop an Electricity Integrated Resource Planning Framework and to Coordinate and Refine Long-Term Procurement Planning Requirements, the Pacific Ocean Energy Trust (POET), a representative of California's floating offshore wind (OSW) sector, provides the following informal comments on the Draft Sources for 2019-20 IRP Supply-Side Resources. POET's Comments are focused on the treatment of offshore wind energy in the IRP modeling process, including in the model's database.

POET appreciates the opportunity to submit these informal comments in this proceeding in response to the March 27, 2018 letter from Patrick Young, and it is our position that the IRP process in California should include floating OSW, a new but promising source of clean energy for California. However, we must also emphasize that existing data regarding the current and projected cost of floating OSW is incomplete, and it is not possible to provide accurate and up-to-date data on the sector at this time. Nevertheless, the sector is committed to developing the data, and we agree the time is now to begin adding OSW data to the RESOLVE model database.

We address below question 10 in the Draft Sources document.

10. Are there any new resource types (not described in your responses to Questions 1 – 9) that Energy Division should prioritize including as a candidate resource in the 2019 IRP?

POET supports the preliminary investigation of floating OSW as a new supply-side resource. Due to the age of publicly-available cost data, however, formal consideration of floating OSW as a candidate resource should be deferred until the 2021-2022 IRP.

With 112 gigawatts of technical resource capacity in California from safe, reliable, clean, and locally available renewable generation, the opportunity for floating OSW in California is significant. Worldwide, the offshore wind sector has matured, the supply chain is competitive, and costs continue to fall. The installed capacity of offshore wind in Europe exceeds 15 gigawatts, and the strike prices for the most recent projects did not include subsidies; in other words, OSW in Europe is approximately at price parity with other sources of conventional and renewable energy generation.

While the United States has only recently brought online its first offshore wind project in Rhode Island, fifteen projects are now underway on the east coast, and two floating OSW projects have been proposed in California. Largely as a result of the maturation of bottom-mounted OSW technology, a growing and competitive supply chain, and efficiencies of scale, the cost of OSW has declined by sixty-five percent over the past ten years. While those cost reductions pertain to bottom-mounted OSW, several of the factors that have contributed to that decline also apply to the floating OSW sector.

In light of California's outstanding offshore wind resource and the progress of the offshore wind industry overseas, Governor Brown in May 2016 asked then Secretary of the Interior Sally Jewell to form an intergovernmental task force to evaluate opportunities for offshore renewable energy development off the California coast.[1] Governor Brown stated that California will need to "dramatically increase our share of renewable energy to meet long term climate objectives," and that offshore renewable energy resources "present important future opportunities." He also stated that there "are significant offshore wind resources along most of California's coast that complement the profile of onshore solar resources," and that "new developments in offshore wind technology – such as large facilities that are not visible from land and present little to no avian impacts – will likely make projects more viable."

A recent report by the National Renewable Energy Laboratory (NREL) has provided new insights into the cost and benefits of floating offshore wind in California. In 2016, NREL published a report called *Potential Offshore Wind Energy Areas in California: An Assessment of Locations, Technology, and Costs*.[2] NREL was commissioned by the Bureau of Ocean Energy Management

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[1] Letter from California Governor Jerry Brown to U.S. Secretary of the Interior Sally Jewell (May 12, 2016). http://docketpublic.energy.ca.gov/PublicDocuments/16-IEPR-03/TN211458_20160513T085713_51216_Letter_from_Gov_Brown_to_Honorable_Sally_Jewell.pdf.

[2] Musial, W., P. Beiter, S. Tegen, A. Smith.., National Renewable Energy Laboratory, BOEM OCS Study 2016-074, Potential Offshore Wind Energy Areas in California: An Assessment of Locations, Technology, and Costs (Dec. 2016). https://www.boem.gov/2016-074/.

(BOEM) in 2016 to conduct a cost and feasibility study for floating offshore wind in California. The study assessed possible siting options and cost trajectories for floating offshore wind in California out to a 2030 timeframe. The study indicated that the cost of floating offshore wind could drop below $100/MWh by 2030 at most viable sites in California, which now appears high relative to recent market trends. It also indicated that large-scale (up to 15 GW) deployment of offshore wind was possible in California. Finally, it showed that the corresponding day/night wind patterns along the coast could be complementary to the solar production curves, which sharply ramp down in the early evening just before peak demand. The study was conducted using the existing NREL spatial cost model, which is a detailed bottom-up cost estimator that takes into account geo-spatial siting differences and breaks down the wind plant into sub-cost elements that are aggregated over different years, from present day out to 2027 commercial operations date.

However, this study was conducted without the benefit of current market data which show a 65% drop in fixed bottom offshore wind winning auction prices in several European countries, and without a formal analysis to understand how much of the recent cost reductions can be attributed to floating wind systems. In addition, NREL based its 2016 floating foundation cost estimates and projections on specifications for one thoroughly studied design, even while recognizing that there are numerous other floating foundation designs at various stages of development, some of which show considerable promise for steeper cost reductions. A recent NREL presentation on floating foundation technology surveyed active and recently concluded demonstration projects and research efforts relating to floating offshore wind with budgets totaling nearly $500 million.[3] Floating wind has been modeled by NREL to have the potential for cost parity with fixed bottom systems by 2030 by exploiting the key advantages of offshore wind including higher wind speeds, fewer siting conflicts, less work at sea, potential for quayside assembly and commissioning, and multiple opportunities for mass production and site independence.

In addition, the initial study showed that diurnal wind characteristics may have some synergies with solar energy resources that may be beneficial to smoothing out the duck curve, but the analysis was not comprehensive enough to quantify the value of this effect to the grid under realistic deployment

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[3] Walt Musial, National Renewable Energy Laboratory, Presentation, Offshore Wind Energy Briefing to the California Energy Commission Integrated Energy Policy Workshop on Offshore Renewable Energy at 8 (May 25, 2016). at http://docketpublic.energy.ca.gov/PublicDocuments/16-IEPR-03/TN211749_20160608T080633_Offshore_Wind_Energy_Briefing.pdf.

scenarios. This aspect of offshore wind could also be investigated and the sensitivities of offshore wind deployment to the mitigation of large scale renewable energy deployment can be investigated to help further capture the costs and benefits of OSW.

We look forward to continuing to engage with NREL, CPUC, BOEM, CEC and other California industry experts to continue this cost analysis to develop more accurate cost data that can be used to inform California's IRP process, evaluate the economic potential of offshore wind, and improve upon the initial floating wind cost estimates.

Conclusion

POET requests that the California Public Utilities Commission continue its investigation of the costs and benefits of floating OSW energy for the California energy market. Over the course of the next year, POET and the floating wind sector will ensure that updated data will be developed that will more accurately reflect the current and projected costs of OSW. In addition, POET will seek to work with its regional and national partners to help develop the value proposition of floating OSW, reflecting the myriad facets of OSW that provide benefits to the state of California including, among others: lower grid integration costs relative to existing and available renewables; the effect of geographically western generation that will utilize existing but stranded grid assets and strengthen the state's grid with geographically balanced energy generation; and the potential to help address the "duck curve" problem.

Dated April 23, 2018

Respectfully Submitted,

Jason Busch, Executive Director

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BEFORE THE PUBLIC UTILITIES COMMISSION OF THE

STATE OF CALIFORNIA

Order Instituting Rulemaking to Develop an Electricity Integrated Resource Planning Framework and to Coordinate and Refine Long-Term Procurement Planning Requirements.	)))))) _)	Rulemaking 16-02-007 (Filed April 23, 2018)

CERTIFICATE OF SERVICE

I hereby certify that I have this day served a copy of the accompanying **INFORMAL COMMENTS OF PACIFIC OCEAN ENERGY TRUST ON THE DRAFT SOURCES FOR 2019-20 IRP SUPPLY-SIDE RESOURCES** on all parties of record to R.16-02-007 by transmitting a true and correct copy to the persons at the electronic notification addresses shown on the accompanying Service List.

Executed this 23rd day of April, 2018, in San Diego, California.

/s/ Jason Busch
Jason Busch

CALIFORNIA PUBLIC UTILITIES COMMISSION
Service Lists

PROCEEDING: R1602007 - CPUC - OIR TO DEVELO
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LIST NAME: LIST
LAST CHANGED: APRIL 23, 2018

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BEFORE THE PUBLIC UTILITIES COMMISSION OF THE STATE OF CALIFORNIA

Order Instituting Rulemaking to Develop an Electricity Integrated Resource Planning Framework and to Coordinate and Refine Long-Term Procurement Planning Requirements	Rulemaking 16-02-007

RANGE ENERGY STORAGE SYSTEMS COMMENTS ON MODELING ADVISORY GROUP DRAFT SOURCES FOR 2019-2020 IRP SUPPLY-SIDE RESOURCE MODELING

April 23, 2018

In accordance with the March 27, 2018 Energy Division request for comment, Range Energy Storage Solutions ("Range") respectfully submits the following comments on the Energy Division's Draft Sources for the 2019-2020 IRP Supply Side Resources ("Draft Sources").

I. INTRODUCTION

Range has been an active participant in the Integrated Resource Planning process since its inception in 2016. In January 2017, we discussed including supply side information specific to Compressed Air Energy Storage (CAES) in the first iteration of the IRP model. We have continued to advocate that diverse technologies, including multiple bulk storage technologies, should be made available as candidate resources in this model because CAES has a different cost profile, operational profile and is more scalable than pumped hydro storage.

We are encouraged that staff has taken the opportunity to consider updating assumptions and inputs in the model, including incorporating new types of resources. The next IRP cycle will commence in a matter of months and this is the right opportunity to incorporate new resource types into the model which were absent in the first iteration.

II. RESPONSE TO QUESTIONS

Question 10: Are there any new resource types (not described in your responses to Questions 1 – 9) that Energy Division should prioritize including as a candidate resource in the 2019 IRP? Describe how the new resource type satisfies the new candidate resource criteria listed above. List the data sources available for quantifying the cost and potential of the proposed resource type and describe how the data sources satisfy the data source criteria listed above.

Compressed Air Energy Storage (CAES) should be included as a candidate resource in the 2019 IRP. Decision 18-02-018 Conclusion of Law (COL) 18 directed the Commission to "continue to evaluate the need for long lead-time resources, including out-of-state wind (and other renewables), geothermal, and pumped hydro storage (and other bulk storage) resources in subsequent IRP" (*emphasis added).*[1] The Decision also suggests that CAES could be a new resource to include in the next IRP.[2] As discussed below, CAES is a commercially available technology today which could significantly impact and improve the next portfolio selected for the 2019-2020 Reference System Plan, especially as other variables (e.g., availability of gas resources, carbon reduction targets/ranges, etc.) change.

CAES is commercially available today. Two CAES plants have been in commercial operation for decades. E.ON Kraftwerke operates a 290 MW CAES plant in Huntorf, Germany, commissioned in 1978. The PowerSouth Energy Cooperative has had a 240 MW CAES plant in McIntosh, Alabama, commissioned in 1991. Lazard calls CAES, "a mature technology with a well-developed design and a proven track record which leverages existing gas turbine technologies."[3] There are multiple companies actively pursuing new CAES projects today, including Range ESS, Magnum CAES, and Apex CAES. Finally, the Southern California Public Power Authority is currently evaluating CAES proposals submitted in response to their January 2018 CAES

[1] Decision 18-02-018, http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M209/K771/209771632.PDF, p. 166.
[2] Decision 18-02-018, p. 51.
[3] Lazard LCOS V3.0 p. 11 https://www.lazard.com/media/450338/lazard-levelized-cost-of-storage-version-30.pdf.

solicitation.[4]

The absence of a recently completed CAES facility should not be viewed as an indication of technology readiness. There is no question about the commercial availability of CAES.

CAES could substantially impact future portfolio costs and composition. Given other changes in resource assumptions and targets which the Commission could implement for the 2019 IRP, it is much more likely that the model will select a bulk storage resource for the next Reference System Plan. First, the next IRP may implement a more stringent carbon target. While the Commission selected the 42 MMT reference system plan for the 2017 IRP, at higher RPS levels and carbon reduction levels (the 30 MMT scenario), bulk storage (PHS) was selected by the model as a cost-effective resource. Second, the value of bulk storage in the development of the Reference System Portfolio also hinges on assumptions about other resources in the portfolio, such as the existing gas fleet. As the Commission revises the model's assumption about which gas resources will be available in the future, allowing some to retire and some to compete, energy storage resources of all kinds are likely to become more competitive. The addition of CAES creates a more diverse set of bulk energy storage candidate resources (just as there are multiple forms of short-duration storage resources available) and will make the model more robust and useful to both the Commission and Load Serving Entities (LSEs).

Compared to other storage resources, CAES has the operating profile closest to that of a natural gas plant (while being much cleaner, more efficient, and more flexible than a simple cycle or combined cycle facility). CAES could therefore serve as the most suitable alternative to re-contracting gas-fired units in certain locations. By including all the best alternatives to natural gas resources in the model, the Commission will be well equipped to judge whether any new or re-contracted natural gas resources proposed in an LSE IRP are, in fact, justified, as required by Order number 8 in D 18-02-018. CAES is also less expensive than batteries and PHS on a levelized cost of storage basis and could therefore affect the cost effectiveness of the next resource portfolio.[5]

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[4] SCPPA RFP for Compressed Air Energy Storage Project, http://scppa.org/file.axd?file=/2017/11/UPDATED%20Compressed%20Air%20Energy%20Storage%2011-27-2017.pdf.

[5] Lazard LCOS v. 2 p. 11.

Despite the Commission's suggestion in D 18-02-018 that one bulk storage resource can act as a proxy for other bulk storage resources and that "pumped hydro storage can be generalized to include bulk storage of other types,"[6] there are in fact significant differences in the cost, scale, and operating characteristics between different technologies. Range understands that for the first IRP, including one bulk storage technology was a way to begin evaluating this type of long-lead time resource. However, PHS is not an appropriate proxy for CAES. No other resources in the model appropriately represent CAES's cost, performance, scalability and operating characteristics.

There are credible, public data sources available on CAES. Range recommends that Energy Division Staff examine and incorporate into the model data on CAES provided by the following sources:

1. **Lazard's Levelized Cost of Storage Version 2.**[7] Note that while staff stated a preference for Lazard LCOS Version 3 or later, Version 2 is the latest report which includes information on CAES.
2. **PacifiCorp IRP Storage Studies, by Black & Veatch (2017 and 2015).**[8] See especially data in Table 11 (pg. 26) of the 2017 Bulk Storage Study.[9]
3. **Western Electricity Coordinating Council (WECC) Transmission Expansion Planning Policy Committee (TEPPC) 2015 Priority Study Inputs,** prepared with Burbank Water and Power and Duke American Transmission Company.[10] Data inputs are provided in Attachment 1 of this comment letter.[11]

Each of these three data sources has been prepared and vetted by credible entities and in combination provide sufficient data on CAES capital costs, operating costs, and operating characteristics. Range has summarized the information in the following table, which generally

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[6] Decision 18-02-018 p. 78.
[7] https://www.lazard.com/media/438042/lazard-levelized-cost-of-storage-v20.pdf, p. 37.
[8] http://www.pacificorp.com/es/irp/irpsupport.html.
[9] http://www.pacificorp.com/content/dam/pacificorp/doc/Energy_Sources/Integrated_Resource_Plan/2017_IRP/Black_Veatch_PacifiCorp_Bulk_Storage_IRP_Study_Report-final_20160819.pdf.
[10] See study results: https://www.wecc.biz/Administrative/160208_PC26_Study_Results_IPP-Swap.pptx.
[11] OEM can also provide updated information to CPUC staff.

aligns with the data inputs used in the model for other storage inputs. Range team members also worked closely with WECC over several months to determine the right approach for modeling CAES and would be happy to work with staff and E3 to determine how to appropriately model CAES in RESOLVE.

We also recommend the Commission utilize the aggregate data received by SCPPA in their very recent solicitation to validate or improve upon CAES assumptions in the model.

Table 1: CAES Data Sources & Values

Data Need	Data Source	Value
Available potential capacity (MW)	WECC TEPPC inputs	150 MW (single train)
Storage duration (hrs.)	Lazard 2.0	8 hours average daily discharge
Round-trip efficiency (%)	a) WECC TEPPC inputs b) Lazard 2.0	a) 83% b) 75-79%
Point of interconnection	Active proposals	Intermountain Power Project (IPP) at Delta, UT. Multiple pathways from IPP to CAISO.
Ramping limitations, if applicable (MW/min)	a) WECC TEPPC inputs b) PacifiCorp IRP Study	a) 20% of full load per minute; 30 MW/min generation (per single train); 25 MW/min compression (per single train); b) 32 MW/min
Other operational limits such as minimum time to switch from charge to discharge.	OEM Dresser-Rand	None, can operate concurrently.
Spinning reserves	a) WECC TEPPC Inputs b) PacifiCorp IRP Study	a) Full capacity spinning reserve (150 MW of 150 MW facility) b) 156.7 MW on 320 MW net capacity facility
Ability to contribute to other reserve requirements	PacifiCorp IRP Study	Expected use-cases include: Energy, capacity, spinning, regulation, non-spinning, black start

Data Need	Data Source	Value
Current and future projections of cost, performance, and financing assumptions (used to develop forward-looking projections of PPA prices, $/MWh)	Lazard 2.0	CAGR 1%; 5 years = 5%
Capital cost, $/kW and $/kWh	a) Lazard 2.0 b) PacifiCorp IRP Study	a) $146-$210/kWh b) $1,740/kW base capital
Fixed O&M, $/kW-yr.	a) Lazard 2.0 b) PacifiCorp IRP Study	a) $1-2/kWh b) $18.9/kW-yr.
Financing inputs (WACC, capital structure, etc.)		Suggest using similar financing inputs to those used for CCGT or CTs.
Tax credits (PTC, ITC)	n/a	n/a
Heat Rate @Pmin/PMax	a) WECC TEPPC Inputs b) PacifiCorp IRP Study c) OEM Dresser-Rand Information[12]	a) 4.375 mmbtu/MWh (HHV) @Pmax b) 4.227 mmbtu/MWh (HHV) @Pmax c) 5.210 mmbtu/MWh (HHV) @Pmin
Design life	PacifiCorp IRP Study	30 years

III. SUMMARY AND CONCLUSION

CAES is a commercially available technology today which could significantly impact and improve the next portfolio selected for the 2019-2020 Reference System Plan, especially as other variables (available gas resources, carbon reduction targets) change.

The IRP is the state's central procurement vehicle in the electricity sector. Excluding a low-GHG, flexible resource like CAES essentially bars it from the consideration and restricts resource competition and portfolio optimization (both in terms of costs and flexibility). It is critical that the Commission include CAES in the model today so that the Commission, the

[12] http://www.dresser-rand.com/wp-content/uploads/2015/01/caes.pdf, p. 6.

CAISO, and LSEs can begin evaluating the potential for this resource to meet system needs and achieve 2030 GHG goals. If the Commission delays incorporating CAES into the model for another IRP cycle, it may not be possible for developers and LSEs to carry out the necessary evaluations, procurement processes, and construction activities to bring a facility on line by the time it is needed.

Respectfully,

/s/

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Molly Deringer Croll
California Environmental Associates
On behalf of Range Energy Storage Systems

Attachment 1

WECC Study
Gridview Input Parameters for CAES Units
DRAFT 5/5/14

Gridview CAES Entries	**Value**	**Comments**
Generator Name:	CAES Unit 1	Single CAES unit train. Total 1200 MW would be comprised of eight-150 MW units like this.
Long Name:	-	To be provided by modeler.
Long ID:	-	To be provided by modeler.
Bus ID:	-	To be provided by modeler.
Generator ID:	-	To be provided by modeler.
Initial Dispatch:	0	To be provided by modeler. Usually zero.
Maximum Storage (MWh):	5976	Maximum MWh of energy *input* to storage for *each* CAES unit, to support two days of generation at full, 150 MW output.
		150 MW * 48 hours * (0.83 storage input to generation output ratio) = 5976 MWh.
Minimum Storage (MWh):	0	Minimum level of working air available. Cavern would always contain additional cushion air.
Maximum Generation Capacity (MW):	150	Assumes storage operation at 2000 psi max, 950 psi min. Eight-150 MW CAES units = 1200 MW total.
Minimum Generation Capacity (MW):	17	Minimum generation of an eight-unit, 1200 MW facility in total would be that for only a single unit = 17 MW.
Maximum Pumping Capacity (MW):	150	Assumes multi-unit pumping MW for 1200 MW generation is 1200 MW (Same as generation MW).
Minimum Pumping Capacity (MW):	50	When pumping, maximum turndown of compressors is 67%. Two-50% (i.e., 75 MW) compressors per CAES unit.
		0.5* 67% * 150 = 50 MW.
Maximum Pumping Price ($/MWh):	See Comments	May need to be input as "IF-THEN" nomogram or formula to represent changing prices per then-current market pricing conditions.
		Example: 90% of average look-ahead price in next 24 hours?
Cost Benefit Ratio (%):	100	Establishes whether CAES will generate based on cost/price ratio in that hour.
Spinning Reserve Contribution (MW)	150	For fast-ramping resources like CAES, full capacity can spin within time requirement to qualify.
Pumping Requirement:	0.83	Ratio of (Storage MWh in)/(Net CAES Generation MWh out).
Heat Rate (MMBTU/MWh)	4.375	For natural gas input to CAES generator (Higher heating value, HHV).
		Gridview entry page currently erroneously specifies units as MWh/MMBTU.
Fuel Name	NGAS	Natural gas.
Ramping Rate for Generation (MW/hour):	1800	Ramp rate for generation: 20% of full load per minute = 150*0.2 = 30 MW/minute = 1800 MW/hour for *each* 150 MW CAES unit.
		In the future, Gridview entry page may be revised to use units in MW/minute.
Ramping Rate for Pumping (MW/hour):		
Ramping Up or Down	3000	25 MW/minute for each 50% (75 MW) compressor in each 150 MW CAES unit. Two compressors can ramp 50 MW/minute.
		2 compressors * 25 MW/minute = 50 MW/minute * 60 minutes/hour = 3000 MW/hour. Same rate ramp for ramping up or down.
		Compressors in eight-150 MW CAES units (1200 MW) working together can ramp 8*50 MW/minute = 400 MW/minute, which is 60 * 400 = 24,000 MW/hour.
Startup Cost ($)	0	Unlike a conventional CT, very little startup cost for CAES.
Emission:	See Comments	Coal: 0.9 metric tons CO_2/MWh.
		CCGT: 0.36 metric tons CO_2/MWh.
		CAES: 0.23 metric tons CO_2/MWh.
Scheduling Mode:	-	To be provided by modeler.
Schedule Area/Region	-	To be provided by modeler.

by: SA/RHS

Southern California Edison Company's Informal Comments on Draft Sources for 2019-20 IRP Supply-Side Resources

April 23, 2018

On Tuesday, March 27, 2018, Staff issued a request for informal input on the sources for supply-side technology costs and potential to be used in 2019 Integrated Resource Planning ("IRP") modeling. In the document, Staff outlined the various sources it currently considers when determining input assumptions in IRP modeling and listed several questions on which it invited parties to comment.

Southern California Edison Company ("SCE") appreciates Staff's willingness to update, improve, and gather party input on the supply-side resources used in IRP modeling and thanks Staff for its efforts to maintain and improve transparency. In their comments on the proposed Reference System Plan in the fall of 2017, several parties, including SCE, identified assumptions and inputs to the model that were inconsistent with observed market data or other industry-respected projections. In addition to those issues, technology and commodity costs change, sometimes rapidly. New use cases are also developing for selected technologies. It is essential that the IRP process incorporate updated assumptions as market conditions change.

SCE's comments on Staff questions are focused on two key themes. First, as valuable as publicly available sources can be for their transparency and accessibility, they sometimes lag behind observed market conditions. Supplementing these sources with selected proprietary information would improve IRP modeling and portfolio outcomes. Fuel prices are a good example of input assumptions to which the modeling outcome is highly sensitive, but the publicly available sources Staff uses do not well reflect observed market realities. SCE's previous comments have shown that the Reference System Portfolio's timeline for resource buildout changes significantly when natural gas prices are adjusted to reflect observed market prices.[1] Staff should be willing to make these adjustments using proprietary sources, especially where respected industry reports suggest public forecasts are not accurate, and where the model is highly sensitive to those inputs.

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1 Comments of Southern California Edison Company (U 338-E) on Administrative Law Judge's Ruling Seeking Comment on Proposed Reference system Plan and Related Commission Policy Actions, October 26, 2017, at 25.

Second, it is important that Staff recognizes the impact of key inputs to the financial modeling in RESOLVE, and that steps are taken to improve transparency and accuracy of those inputs. The goal of IRP modeling should be to reflect underlying market conditions in the most accurate way possible and then let resources compete for placement into an optimal portfolio that reaches the greenhouse gas ("GHG") emissions goals. There are several assumptions in the financial modeling engine that are unclear and others that are subject to policy change or uncertainty. These inputs can significantly affect the mix and amount of resources selected to fill the portfolio need. SCE further outlines these issues in its answer to question 14 below.

SCE thanks Staff for this opportunity to provide input and includes its comments on specific questions herein.

Questions from Energy Division Staff

1. **Do parties have recommendations on public data sources that capture the costs and operational characteristics of retrofitted [gas] power plants?**

   SCE supports the idea of including a plant improvement adder to represent natural gas plant retrofits and upgrades. The set of retrofits and upgrades would be modeled with a capital cost, just like other candidate resources. The IRP modeling results could then select a retrofit or upgrade if, for example, it could improve the existing power plant performance or operating characteristics, and it was more cost-effective than other candidate resources. Plant retrofits and upgrades can include physical or programing improvements that: reduce P_{min}, increase operational flexibility, including ramping; improve heat rate; or institute other performance enhancing or emissions reduction modifications.

   SCE is not aware of any publicly available source that specifically addresses the costs or generic characteristics of various forms of power plant retrofits and upgrades that may apply. This is partially because each natural gas plant is unique, and depending on the types of upgrades and improvements to each unique plant, these costs and characteristics could vary widely on a case-by-case basis. However, one possible alternative is to use a proxy value that represents the cost of generic upgrades and improvements. While there does not appear to be a pre-developed industry standard on a broadly applicable proxy value, one approach could be to use a percentage of the capital cost of a new plant. The capital cost of a new plant can be obtained from a public source[2] and then apply a factor of 10% of the cost of a new plant to represent the cost of a retrofit. Alternatively, a study could be performed to develop a more engineered proxy algorithm. In either case, SCE agrees that including retrofitted gas plants as a candidate resource represents an important potential enhancement to IRP modeling.

2. **Current assumptions of technology mix for solar PV are 25% fixed tilt and 75% single axis tracking, both with inverter loading ratios (ILR) of 1.3. What assumptions should be made for the configuration and ILR of future solar PV facilities?**

SCE recognizes the challenges of modeling resources that can be developed using multiple configurations and appreciates Staff attempts to acknowledge and model both the fixed and tracking configurations that may be utilized going forward. However, SCE's preferred method to identify the mix of these configurations is to let the model endogenously choose, based on the cost and performance of each type of plant. These assumptions are readily available for both fixed and tracking solar configurations of utility-scale solar plants. Therefore, the capacity expansion model should be able to evaluate each separately, so that the share of total additions for which each configuration accounts is an output of the model rather than a forced value. Market activity over recent years shows a shift toward single-axis tracking as the dominant configuration. However, as market conditions evolve and change, modeling both fixed and tracking solar as distinct resource types would eliminate the need for Staff to continually revise this assumption exogenously.

Regarding ILR parameters, SCE has observed ratios closer to 1.5 in recent years. We expect this ratio may continue to trend upward as solar paired with energy storage

[2] One example of a publicly available source is the Energy Information Administration's *Cost and Performance Characteristics of New Generating Technologies*, included in the 2018 Annual Energy Outlook. This source includes broad estimates of capital costs in the U.S. electric sector, as well as regional adjustments that provide California-specific estimates. Available at: https://www.eia.gov/outlooks/aeo/assumptions/pdf/table_8.2.pdf.

becomes more prevalent, therefore reducing the effects of inverter constraints on the solar installation's DC capacity.

3. **How should high- and low- cost trajectories for future PV costs be developed?**

SCE suggests that the high- and low- cost trajectories should represent a reasonable range of conservative and ambitious technology improvement projections and the cost reduction associated with those developments. SCE's recommended method to develop these trajectories is to establish the current year's cost from a source or sources and extrapolate high and low trajectories using different learning curves. SCE suggests validating publicly available cost estimates with proprietary sources which utilize specific expertise and resources to develop more targeted projections. SCE's preferred source for this purpose is the IHS *US Solar PV Capital Cost and Required Price Outlook.* It provides a reasonable estimate of current costs and defines a future cost trajectory on a regionally specific basis.

4. **Do parties have recommendations on how to distinguish between specific battery technologies in an emerging market?**

Future planning models should have the flexibility to identify the best battery technologies to use for various purposes. For example, one type of battery may be useful in replacing peaker plants by responding quickly to system needs, while other batteries may be more effective for shifting generation in low demand hours to high demand hours. Battery storage characteristics, from ramping limitations to the number of cycles per day to upfront costs, may change significantly between these different technologies used for different purposes. In addition to different characteristics, batteries may receive revenues from differing value streams, such as Resource Adequacy or distribution deferral. Resource optimization in planning models will be improved by including the characteristics and, eventually, value streams that distinguish different battery storage products used for specific purposes.

5. **What sources should be considered in developing recommended battery costs for use in IRP?**

   SCE agrees that Lazard's *Levelized Cost of Storage Analysis*, which Staff has indicated is already an input to the RESOLVE model, is a valuable, publicly available source to use in modeling storage technology cost and operational parameters. SCE uses this source in conjunction with proprietary sources, such as the IHS *US Battery Storage Costs, Drivers, and Market Outlook* report, to develop its internal perspectives on the state of the storage market and how it may evolve in the near- to mid-term.

   SCE recognizes and appreciates the challenge Staff faces, balancing a publicly available source's accessibility and transparency against a proprietary source that may provide more detailed or up-to-date information. However, SCE recommends that Staff considers utilizing proprietary sources where appropriate to validate, adjust, or supplement publicly available cost and operational data. This is particularly relevant for newer technologies where costs and technological improvements, and projections of future improvements, are not always adequately captured by publicly available research.

6. **How should Multiple Use Applications of battery storage be modeled?**

   SCE supports efforts to appropriately value and realize the multiple functions energy storage can provide to the grid. In the future, IRP modeling should be able to account for "value stacking" opportunities in modeling potential energy storage capacity expansion and SCE looks forward to continued engagement in IRP, the Multiple-Use Application ("MUA") Working Group, and other venues as the market develops. However, it would be premature to attempt to include MUAs in the current version of capacity expansion modeling in IRP, both because the market and rules governing it remain early-stage, and because the model requires additional work on single-use storage modeling before multiple uses are considered.

   Generally, SCE agrees that appropriately valuing MUA storage is a priority goal and that capacity expansion modeling will underestimate the optimal level, and contributions, of grid-connected storage as long as these uses are not modeled. The MUA Decision[3] provides interim rules that outline the benefits storage can provide at a given level of grid connection; however, more work is required to define the value of these benefits. Neither the market, nor the rules governing it, are well enough developed to provide substantial insight into appropriate modeling parameters or approaches at this time.

Further, the RESOLVE model, as a system-level model without deep geographic granularity, currently models only medium-duration load shifting and cannot account for all the various single-use applications in which a given battery can participate. For all these reasons, SCE supports continuing work within the MUA Working Group and with the Commission, California Independent System Operator ("CAISO"), and other stakeholders in other venues to define storage use cases and values. However, this work is ongoing, and SCE recommends continued monitoring rather than attempting to model MUA values at this time.

7. **How should high- and low-cost trajectories for future battery costs be developed?**

As previously stated, SCE agrees that Lazard's *Levelized Cost of Storage Analysis – Version 3.0* report is a valuable publicly available source that estimates energy storage technology costs and future projections. This report also provides low and high cost ranges. These ranges should be used in conjunction with proprietary sources to guide Staff in developing high and low battery storage ranges.

8. **How should pumped storage costs be represented given that they are highly site-specific and difficult to estimate on a generic basis?**

SCE agrees that pumped storage's cost is highly site-specific, and is difficult to represent on a generic basis. There are also relatively few observed, recent data points on which to build a reasonable forecast of pumped storage capital and operating costs. SCE does not have an existing, well-developed methodology to recommend for determining new pumped storage cost estimates. Instead, SCE offers one suggestion for a proxy method and two more general guiding principles.

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[3] D.18-01-003, Appendix A.

In terms of a proxy method, Staff could consider collecting observed capital costs from existing plants and using them as a guidepost for new development costs. In particular, if new sites are in close proximity to proposed capacity additions, these estimates may capture some of the site-specific cost drivers a new unit would face.

Regarding guiding principles, SCE recommends Staff takes into consideration two key aspects of pumped storage plants when developing estimates. First, internal analysis suggests that scale effects are particularly relevant for pumped storage. In other words, there is a theoretical minimum unit size below which pumped storage additions would not be considered economic or practical. Second, new pumped storage projects require long project development cycles, in many cases upward of ten years. Staff should consider this in the event IRP modeling selects any new pumped storage capacity, in particular if capacity is projected to be added within this ten-year window.

9. To what extent are new pumped hydroelectric facilities able to contribute to primary frequency response?

IRP modeling should consider pumped hydroelectric facilities as bulk storage assets and not frequency response assets, given the scale and operational profile of these projects. According to industry research presented by the Electric Power Research Institute ("EPRI") to the Commission in R.10-12-007, pumped hydro storage facilities have an optimal scale of many hundreds of megawatts and it is more financially beneficial for those assets to provide bulk shifting services than ancillary services. In the study, EPRI states that "[r]egulation service has lower priority than system electric supply capacity. To provide this service, the storage system must have at least 15 minutes of capacity available. Its dispatch is on the same priority level and co-optimized with other ancillary services and electric energy time-shift to maximize market profit."[4] Pumped hydro's scale and operational profile make it much better suited to providing higher priority system electric supply capacity services rather than frequency response.

[4] EPRI. *Cost-Effectiveness of Energy Storage in California*. June 2013, at 4-3 (PDF p. 45). Available at: http://large.stanford.edu/courses/2013/ph240/cabrera1/docs/3002001162.pdf

10. Are there any new resource types (not described in responses to Q1-9) that Energy Division should prioritize including as a candidate resource in the 2019 IRP? Describe how the new resource type satisfies the new candidate resource criteria listed above. List the data sources available for quantifying the cost and potential of the proposed resource type and describe how the data sources satisfy the data source criteria listed above.

The current set of supply-side candidate resources is reasonable for the 2019 IRP cycle.

11. Are there data sources (not described in responses to Q1-9) that should be considered for modifying the candidate resource potential assumed in IRP? Please describe and provide a link for any suggested data sources. Explain how the data source meets the data source criteria listed above.

SCE has no further comment on sources for candidate resource potential, other than the sources discussed in responses 1-9. However, SCE also provides its response to the question related to demand response ("DR") resources from the "Draft Sources for 2019-2020 IRP Supply-side Resources" document, per Staff's request in the March 30 Modeling Advisory Group webinar. The question is as follows:

> *Are there other data sources that should be considered for additional DR cost and potential, beyond the latest version of the California Demand Response Potential Study?*

SCE recommends using programmatic, market, and/or pilot data, where available, to ensure that reasonable and achievable DR potential is reflected for IRP planning purposes. For offerings being defined as "Shed," current DR programs will best serve to inform costs, availability, and other attributes. SCE can provide program data to Staff, which would help better define appropriate cost parameters for Shed offerings. SCE also recommends Staff supplements its analysis with the 2017 Load Impact Study[5] and SCE's

[5] Southern California Edison 2017 Demand Response Portfolio Executive Summary, available at: http://rims.sce.com/Proceedings/R.13-09-011/R1309011-SCE%20Compliance%20Filing%20Pursuant%20to%20Load%20Impact%20Protocol%20Filing%20Reqs%20(Public).pdf

prospective portfolio submitted as part of the approved 2018-2022 Demand Response Application.[6]

SCE recognizes there are limited sources of publicly available data, outside of the most recent DR Potential Study, for offerings that are defined as "Shift," "Shape," and "Shimmy." These offerings are currently being considered for new models of DR and are largely in the development phase. As they remain relatively nascent, with high uncertainty regarding their cost, value, market potential, and adoption rates, SCE recommends Staff refers to timing and sequencing considerations of ongoing activities in DR-specific proceedings that may help inform appropriate modeling parameters. SCE also expects that future updates to the DR Potential Study will capture additional market changes that affect appropriate values for these products.

Currently, Staff and stakeholders are developing a means of enabling new products and models for DR through the Load Shift Working Group. This Working Group is required to submit a final report to the Commission on January 31, 2019, outlining recommendations and positions on the parameters around a new load shifting product. Over the next few months, stakeholders will be work to clarify different product types, determine how to integrate the resources in the wholesale market, and address the necessary policy/operational barriers to enable the market to offer products such as Load Shift. Concurrently, CAISO's ESDER Phase III pilot will help inform these efforts, albeit limited to a specific technology during the first stage of development. The earliest these products could "go-live" in the market would be sometime in 2020 (i.e., following CAISO and Federal Energy Regulatory Commission approvals and CAISO systems updates to enable "go-live"). Until these offerings are better understood and clearly defined, SCE recommends limiting reliance on lesser known products and their values. As these new products are integrated into the market, lessons learned from their early adoption can inform the next DR Potential Study and future IRP efforts.

12. Are there any additional sources of capital cost, operating cost, and performance projections (not described in your responses to Q1-9) that should be considered for

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[6] Per D.17-12-003.

solar PV or wind? Explain how the data source meets the data source criteria listed above.

SCE recommends Staff considers two additional sources not discussed in previous questions, to further validate technology cost assumptions entered into RESOLVE.

The first is the NREL *Annual Technology Baseline*.[7] Staff documented utilizing this source only for conventional gas generators and did not look to this study for current and projected technology costs for wind, solar, and various other technologies. This data is both technically credible and publicly available, the two most important criteria for the assumptions used in RESOLVE.

Second, Staff should consider utilizing proprietary data to supplement its publicly available sources. SCE recommends using research from IHS, including the *US Wind and Capital Cost and Required Price Outlook*, and the *US Solar PV Capital Cost and Required Price Outlook*. IHS develops its current and projected cost analyses using proprietary models and input from industry participants. The reports are considered technically credible and are widely respected among industry professionals. They also include regional level data, which is another key criterion for assumptions used in IRP modeling.

13. How should import tariffs on solar PV modules be represented?

SCE appreciates that Staff is considering how to account for Section 201 import tariffs on solar crystalline silicon photovoltaic modules in IRP modeling given recent Federal policy changes. Given the ad valorem structure of the tariff, SCE recommends that Staff models an adjusted solar installed cost projection as a function of baseline (pre-tariff) installed costs, the share of installed cost accounted for by the modules, and the applicable tariff rate on modules for a given model year. Mathematically, this method would be calculated in the following way, where m represents the portion of total installed cost attributable to modules and t represents the tariff rate:

[7] Available at: https://atb.nrel.gov/.

$$New\ Solar\ Installed\ Cost = Old\ Solar\ Installed\ Cost * (1 - m) + Old\ Solar\ Installed\ Cost * m * (1 + tariff\ rate)$$

$$= Old\ Solar\ Installed\ Cost * (1 + mt)$$

To complete this analysis, Staff would need to develop a perspective on the percent of a given solar installation's price attributable to modules and recognize that this value varies by the type of installation considered (i.e., distinct m values exist for utility-scale, commercial, and residential solar PV installed costs). Various public and proprietary sources can provide this perspective. SCE recommends estimated values of approximately 33% for utility-scale, 20% for commercial distributed, and 15% for residential distributed.[8]

The tariff rate is established by the Presidential Proclamation 9693[9] and shown in the table below.

Year (Feb-Feb)	**1** (2018-19)	**2** (2019-20)	**3** (2020-21)	**4** (2021-22)
Module tariff rate (*t*)	30%	25%	20%	15%

This simplified methodology does not account for all the potential nuances of the Section 201 tariff administration. For example, it assumes all modules are imported and subject to the tariff, while in fact there are several countries producing small volumes of modules that may be exempt. While the simplification is directionally correct, given the broad nature of industry protection tariffs, some small quantity of crystalline silicon modules would likely be exempt from the duty. It should also be noted that thin-film solar modules are exempt from these tariffs, and the model does not provide a clear method of

8 These ratios are approximated, and derived from public reports estimating the impact of solar tariffs on the cost of installations, and average system cost estimates.

9 Proclamation No. 9693, 87 F. R. 17 (January 23, 2018). Available at: https://www.gpo.gov/fdsys/pkg/FR-2018-01-25/pdf/2018-01592.pdf.

accounting for the type of solar module chosen for a given project. One way to account for this issue could be to make a simplifying assumption that most fixed-tilt systems will use thin film technology and most single-axis tracking systems will use crystalline silicon modules. When combined with SCE's recommendation to model fixed and tracking system costs separately and let the capacity expansion model choose between them, Staff could allocate the tariff costs only to tracking systems for the purposes of planning.

The nature of this policy also raises the importance of utilizing opportunities to improve the time granularity of IRP modeling. Given RESOLVE currently only models every fourth year in the planning period, impactful policies that are instituted and/or expire in between those time periods are inherently obscured. Rather than attempting to capacity weight the tariff to account for this issue in specific modeled year, Staff should consider improving the model's time granularity to an annual or biennial period.

14. **Should any of the cost and financing assumptions in RESOLVE's LCOE calculations be modified, for example: assumptions related to state and federal tax incentives, the cost of capital, and financing lifetime? Explain and support any recommended changes using publicly available information, to the greatest extent possible.**

SCE appreciates Staff raising this question, given the sensitivity of the optimal portfolio to these assumptions. Testing has shown that it is possible to substantially alter the optimal portfolio's mix and timing by making reasonable changes to the financial model without changing any underlying technology or fuel cost data. This is particularly relevant for certain technology types, such as geothermal. SCE submits the following comments on factors related to capital structure, tax rates, tax incentives, and out-of-state transmission cost adders.

Capital structure

With regard to the capital structure, SCE suggests several key assumption adjustments or clarifications. First, SCE recommends either that all resources be modeled using the same capital structure, or that Staff conducts research and provide documentation with regard to differences in capital structure by technology type. In RESOLVE's current method, resources can differ not only in variable cost, fixed cost, construction cost, and incentives, but also equity share and discount rates. Without keeping the capital structure the same, different technology costs are not evaluated on a level playing field. For example, solar developers are assumed to use 52% equity whereas geothermal and battery developers are assumed to use 20-30% equity. In a model where only the cost data drives financial differences, rather than the financial modeling, the valuation would be more directly related to the information at hand rather than assumed calculations that may not bear out in future deployments. If these assumptions should vary by technology, Staff should consider reporting more thoroughly on the genesis of these assumptions. For example, developer capital structures might be studied using data on public companies.

SCE also suggests additional vetting and documentation around the discount rates used to levelize costs in worksheet “COSTS_Pro_Forma.” With the current range of discount rates ranging from 12% to 23%, it is difficult for SCE to determine how these values were selected and how they compare to discount rates used in independent power producers’ (“IPP”) financial models or other similar financial modeling on future capacity expansion estimates. Excessively high discount rates serve to underestimate renewable power purchase agreement prices as a seller would, in reality, be recovering investment costs at a faster rate than assumed in RESOLVE.

Further, the RESOLVE model’s use of cost of equity measures lacks transparency and SCE suggests two changes. First, as the model makes certain assumptions about the equity and debt shares for project finance, it may better reflect financial market conditions to use the Weighted Average Cost of Capital (“WACC”) as the discount rate for this purpose. WACC is a more accurate reflection of the opportunity cost of capital and therefore a more reasonable measure to include in investment calculations. Second, the cost levelization uses Cost of Equity in the numerator (net present value of payments) while the denominator (net present value of capacity) uses another rate (called “Discount Rate” in cell Costs_Pro_Forma C51). SCE believes that the two rates should be equal in order for future payments and future capacity to be valued in the same present value terms. It seems that the difference between Cost of Equity and Discount Rate may reflect some cost escalation; however, SCE notes that the escalation seems to be captured in the payment streams of Fixed Operations & Maintenance, Production Tax Credit, and Fuel. In this case, modifying Discount Rate to reflect escalation may result in double counting the escalation.

Finally, SCE requests Staff validates the use of a cost escalation calculation in Fixed Operations & Maintenance, Production Tax Credit, and Fuel. Costs are reported in constant 2016 dollars, and cost escalations typically reflect monetary, rather than real, changes in contracts. In general, no monetary effects should be modeled if the costs are stated in real terms. However, if a monetary effect were being captured, the exponent in the escalation should reflect the distance from the constant dollar year rather than only the lifetime year of the project.

Tax rates

With regard to tax rates assumed in RESOLVE, SCE makes two recommendations to bring modeling more in line with current policy. First, the California state corporate tax rate in RESOLVE should be set to the actual current rate of 8.84%, rather than the 7% figure currently used in RESOLVE. Differences in tax rates can result in different revenue requirements and total resource costs, but also affect the resources selected in the optimal portfolio.

Further, changes in Federal corporate tax policy should be reflected in the next cycle of IRP modeling. The "Tax Cuts and Jobs Act of 2017" (H.R. 1, 115^{th} Congress) institutes a much lower corporate tax rate, at 21%, than the 35% currently modeled in RESOLVE. According to SCE's sensitivity testing in RESOLVE, reducing the corporate tax rate to 21% over the full planning horizon increases modeled optimal geothermal additions by over 50%. As capacity additions are capital intensive and the tax rates affect capital costs through deductions for interest and depreciation, it also would be prudent to consider sensitivities around future uncertainty in Federal tax policy (for example, one in which the corporate tax rate starts at 21% in the base year, but returns to the previous 35% later in the planning horizon).

Tax incentives

SCE makes two recommendations with regard to how investment and production tax credits are modeled. First, the Investment Tax Credit ("ITC") and Production Tax Credit ("PTC") are modeled assuming developers/sellers can monetize the entire ITC benefit one-for-one, and that the full value is passed through to customers. In reality, these tax credits are generally distributed as a negative value in the company's future taxes. In order to harness the ITC as working capital, IPPs have historically entered into agreements known as tax equity financing wherein the future ITC value is sold to other, typically non-IPP companies. These agreements inherently put the ITC at a discount, and the full value is not passed through to customers in the form of cost savings. This should be better captured in the RESOLVE modeling.

Second, the RESOLVE model's current version assumes unlimited tax deductibility of interest payments on construction and interconnection. However, federal law places a cap on the level of the deduction based on a company's earnings before interest, taxes, and amortization ("EBITA").[10] Testing suggests that the interest deduction significantly affects the optimal portfolio and the path to 2030. In test scenarios SCE ran to adjust this assumption, geothermal capacity quadrupled, solar declined nearly 50%, and no wind was procured until the 2030 model year.

Out-of-state transmission cost adders

Finally, SCE asks that Staff provides additional transparency regarding the out-of-state transmission cost adders applied to relevant resource options in the RESOLVE model. Staff's Inputs and Assumptions document released in September 2017 notes that these values are "derived" from CAISO data. It is, however, unclear whether or not these values were included as reported by CAISO and if so, which reports produced them. Without additional transparency, it is difficult for parties to validate that the assumed

[10] For additional context, please see the following sources:
a) "Broad new limitation on business interest deductions." RSM US. 22 Dec 2017. Available at: http://rsmus.com/what-we-do/services/tax/lead-tax/broad-new-limitation-on-business-interest-deductions.html.
b) "Conference report limits on interest deductions." Tax Foundation. 17 Dec 2017. Available at: https://taxfoundation.org/conference-report-limits-interest-deductions/#_ftnref1.

costs reasonably reflect future cost of transmission additions required to deliver out-of-state renewables into the California market.

15. Other issues not addressed in questions.

There are several issues on which Staff did not specifically request input, but are important to mention in a thorough review of supply-side input assumptions. SCE addresses issues related to natural gas generating facilities and fuel costs, and recommends an additional source for transmission data.

Existing natural gas facilities

As SCE stated in its previous comments on the Reference System Plan, it is important that IRP modeling be able to identify natural gas plant economic shutdown conditions. To create this functionality, Staff should strongly consider integrating annual fixed costs along with the current profile of variable operating and maintenance costs for existing natural gas facilities. Without this information, there will potentially be errors in the planning reserve margin, and other important metrics.

Fuel prices

The RESOLVE model currently relies on gas price forecasts reported in the state's Integrated Energy Policy Report ("IEPR"), but as SCE previously noted, the gas prices provided by this report differ from both available data on gas prices in California, and from proprietary forecasts. As SCE highlighted in previous comments, the Reference System Portfolio's timeline for resource buildout changes significantly when natural gas prices are adjusted to reflect observed market prices.[11] Given this sensitivity, and the inaccuracy of publicly available data, Staff should strongly consider supplementing and validating existing publicly available sources with one or more additional proprietary sources that better reflect market realities.

[11] Comments of Southern California Edison Company (U 338-E) on Administrative Law Judge's Ruling Seeking Comment on Proposed Reference system Plan and Related Commission Policy Actions, October 26, 2017, at 25.

Further, the method IEPR uses to extrapolate seasonal changes in gas price may no longer be appropriate. The current methodology assumes all gas price hubs will have the same monthly shape as the Henry Hub. However, various fundamental market changes have occurred since this methodology originated that invalidate this assumption. For example, the significant diminution of gas storage capacity at Aliso Canyon makes California gas prices more seasonal than other North American hubs. The ascendance of Appalachia and Permian Basin as the two fastest growing gas production hubs also affects this assumption. Permian Basin is the nearest supply basin to California, and its gas is largely produced in conjunction with oil. This means the proximate supply to California has less supply elasticity than the drier gas plays of the Gulf Coast region. Until the IEPR's model is refined to reflect these changes, seasonality depicted in IEPR and transferred to RESOLVE will remain unreliable.

Transmission capacity and cost

When considering appropriate transmission capacity and cost assumptions, SCE recommends Staff considers the RETI 2.0 reports[12] in addition to those sources already mentioned in Section 3.3 of Staff's supply-side source documentation. RETI 2.0 can provide additional information on bulk transmission system capacity for new generation resources. Currently the only primary data source is listed as CAISO supplemental analysis based on the current year's Transmission Planning Process work. Adding an additional source would help validate Staff's current assumptions and identify potential opportunities for refinement.

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[12] Available at: http://docketpublic.energy.ca.gov/PublicDocuments/15-RETI-02/TN214168_20161025T091645_Transmission_Capability_and_Requirements_Report.pdf.

Schatz Energy Research Center

Memorandum

4/17/2018

To: California Public Utilities Commission Integrated Resource Plan Staff

From: Dr. Arne Jacobson, Director, Schatz Energy Research Center

Re: New Resource Type for IRP- Offshore Wind

Off-shore wind energy can play an important role in helping California meet its medium and long term renewable energy targets and greenhouse gas emission reduction goals and therefore should be included as a candidate resource in the 2019 Integrated Resource Plan (IRP). Offshore wind has a plausible trajectory to commercial availability within the planning time horizon as evidenced offshore wind technology deployment in Europe[i] and early stage activities in California such as a public-private partnership initiated by the Redwood Coast Energy Authority and partners with intent to develop an offshore wind project in the waters near Humboldt Bay.[ii]

An offshore wind industry along the California coast that has an estimated potential of up to 100 GW[iii] based on investment of $500 billion.[iv] At this magnitude, the potential impact on future portfolio costs and composition is sufficient to justify changes to model functionality and run time.

The following publicly available and technically credible data sources are available for quantifying the cost and potential of offshore wind.

A) Musial, Walter, Phillip Beiter, Suzanne Tegen, and Aaron Smith. (2016a) *Potential Offshore Wind Energy Areas in California: An Assessment of Locations, Technology, and Costs*. National Renewable Energy Laboratory and Bureau of Ocean Energy Management. Technical Report NREL/TP-5000-67414.

B) Musial, Walter, Donna Heimiller, Phillip Beiter, George Scott, and Caroline Draxl. (2016b) *2016 Offshore Wind Energy Resource Assessment for the United States*. National Renewable Energy Laboratory. Technical Report NREL/TP-5000-66599.

C) Draxl, Caroline, Andrew Clifton, Bri-Mathia Hodge, and Jim McCaa (2015) The Wind Integration National Dataset (WIND) Toolkit, Applied Energy, 151:355-366.

D) URL: http://maps.nrel.gov/wind_prospector

E) Wind Europe. (2018) *Offshore Wind in Europe: Key Trends and Statistics 2017*. Wind Europe: https://windeurope.org/wp-content/uploads/files/about-wind/statistics/WindEurope-Annual-Offshore-Statistics-2017.pdf

The California wind resource data for both of these Musial reports were collected from two sources: 1) AWS Truepower databases and 2) National Aeronautics and Space Administration's (NASA) Modern-Era Retrospective Analysis (MERRA) data. These data sets were combined into a hybrid data set. While the MERRA data is freely available from NASA, the AWS Truepower databases are proprietary, and the hybrid data set used by Musial et al (2016a) is not currently available. The MERRA data is based upon satellite observations - a dataset similar to the AWS database will need to be obtained to characterize wind resource.

Furthermore, NREL studies use NOAA buoy data as verification - an important step, as Musial et al (2016b) acknowledge that significant uncertainty still exists within AWS data. Currently, there is one buoy off of Humboldt coasts - the Eel River station - that collects wind speed data. If this dataset cannot serve as a reliable estimate for the project location, an additional buoy will need to be deployed near the target site.

NREL has also created the Wind Integration National Dataset (WIND) that is the largest publically available wind dataset. As described by Draxl et al. (1915), it provides up to seven years of 5-minute interval simulated wind speed data for the lower 48 States and offshore locations. The spatial resolution is on a 2 km x 2 km grid. Access to the dataset is free and facilitated by a convenient web interface (http://maps.nrel.gov/wind_prospector). The data has been validated based on measurements at over 100 locations.

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[i] https://windeurope.org/wp-content/uploads/files/about-wind/statistics/WindEurope-Annual-Offshore-Statistics-2017.pdf

[ii] http://www.times-standard.com/general-news/20180405/rcea-announces-partnership-for-offshore-wind-farm

[iii] https://www.boem.gov/2016-074/

[iv] https://www.nrel.gov/docs/fy17osti/66861.pdf

BEFORE THE PUBLIC UTILITIES COMMISSION

OF THE STATE OF CALIFORNIA

Order Instituting Rulemaking to Develop an Electricity Integrated Resource Planning Framework and to Coordinate and Refine Long-Term Procurement Planning Requirements.	Rulemaking 16-02-007 (Filed February 11, 2016)

INFORMAL COMMENTS OF THE SOLAR ENERGY INDUSTRIES ASSOCIATION AND THE LARGE-SCALE SOLAR ASSOCIATION ON DRAFT SOURCES FOR 2019-20 IRP SUPPLY-SIDE RESOURCES

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On behalf of
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Dated: April 23, 2018

BEFORE THE PUBLIC UTILITIES COMMISSION

OF THE STATE OF CALIFORNIA

Order Instituting Rulemaking to Develop an Electricity Integrated Resource Planning Framework and to Coordinate and Refine Long-Term Procurement Planning Requirements.	Rulemaking 16-02-007 (Filed February 11, 2016)

INFORMAL COMMENTS OF
THE SOLAR ENERGY INDUSTRIES ASSOCIATION
AND THE LARGE-SCALE SOLAR ASSOCIATION
ON DRAFT SOURCES FOR 2019-20 IRP SUPPLY-SIDE RESOURCES

Pursuant to the March 27, 2018 email from Patrick Young to the parties in Commission Rulemaking R. 16-02-007, the Solar Energy Industries Association (SEIA) and the Large-scale Solar Association (LSA) appreciate the chance to present the following informal comments on the draft sources (Draft Sources) that are proposed to be used for modelling supply-side resources in the 2019-2020 Integrated Resource Plan (IRP). The comments of SEIA and LSA are limited to the sources that the Commission should use to develop the costs for utility-scale solar resources in California. SEIA is the national trade association of the solar industry in the U.S. LSA is a trade association that represents the developers and operators of utility-scale solar facilities in California.

The capital costs for solar resources have declined substantially and consistently in recent years. As a result, it is important to use the most up-to-date information, including public, reputable forecasts, to develop a reasonable estimate for solar costs. The Draft Sources proposes to use utility-scale solar costs derived from the current version of the RPS Calculator, updated by E3 using unspecified “market data.” The Draft Sources also lists as sources the CEC’s Cost of Generation report, California Solar Initiative (CSI) data, and Lawrence Berkeley National Laboratory’s (LBNL) most recent reports on actual utility-scale and distributed solar costs in the

U.S.[1] SEIA and LSA observe that the CEC's available Cost of Generation report is dated (2015); we understand that an updated version is planned, but we are not aware that it has been published. CSI data also may be out-of-date given that CSI incentives are no longer available. Further, the CSI data is limited to distributed solar projects no larger than 1 MW. The LBNL report on utility-scale solar costs is an excellent source, but it is important to recognize that the LBNL reports on solar costs are backward-looking. For example, the LBNL reports published in 2017 are based on actual data through 2016.

There are publicly-available forecasts of utility-scale solar capital costs, for example, from Wood Mackenzie's Greentech Media (GTM).[2] Public forecasts also may be available from entities such as Lazard and Bloomberg New Energy Finance. Such forecasts can be used to extend recent historical data from sources such as LBNL on actual utility-scale solar costs, provided that care is taken to make certain that the historical and forecast data are consistent. For example, as discussed in LBNL's report, *Utility-scale Solar 2016*, at page 20, LBNL uses a "top down" cost reporting methodology that is more comprehensive than GTM's "bottom up" approach to costing and forecasting. To compensate for the possible costs that are not captured in GTM's forecasts, GTM's forecasts could be increased in all years by the observed ratios of LBNL's 2016 reported costs to GTM's 2016 reported costs. **Table 1** below shows an example of the application of this approach to forecasting solar capital costs, using the recent forecast from GTM cited above and LBNL's most recent report on utility-scale solar costs.

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1 See LBNL, *Utility-scale Solar 2016*, at p. 20, and LBNL, *Tracking the Sun X* (August 2017), at p. 41, available at https://emp.lbl.gov/publications/tracking-sun-10-installed-price.

2 See GTM Research, *PV System Pricing H1 2017: Breakdowns and Forecasts* (June 2017), at 7, 34, 41, and 43, available at https://www.greentechmedia.com/research/report/pv-system-pricing-h1-2017#gs.tHjJR6c.

Table 1: Exemplary Solar Cost Forecast				*Does **not** include solar tariff costs.*			
	2016	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Fixed - Utility-scale ($/Wdc)							
LBNL Cost	1.55						
GTM Cost	1.17	0.95	0.82	0.78	0.75	0.72	0.70
Ratio LBNL/GTM	*1.32*						
Forecast		1.26	1.09	1.04	0.99	0.95	0.93
Fixed - DG Commercial ($/Wdc)		*500 kW - 1 MW*					
LBNL Cost	2.50						
GTM Cost	1.74	1.50	1.29	1.20	1.13	1.06	1.03
Ratio LBNL/GTM	*1.44*						
Forecast		2.16	1.86	1.74	1.63	1.53	1.48
Tracking - Utility-scale ($/Wdc)							
LBNL Cost	1.73						
GTM Cost	1.31	1.08	0.94	0.89	0.85	0.81	0.80
Ratio LBNL/GTM	*1.32*						
Forecast		1.42	1.24	1.17	1.12	1.07	1.05

SEIA and LSA also recommend caution in estimating the impact on solar costs of the new tariff on imported solar cells and modules. The new tariff on solar imports starts at 30% of module costs in 2018 and declines by 5% (500 basis points) in each of the next three years. However, applying the full tariff to forecasts of solar costs will overstate its impact. Some imports are exempt from the tariff (all thin film modules and up to 9% of total imports from certain countries), others may receive exemptions, and there are ongoing activities with the potential to further mitigate the impact of the tariffs. Further, the history of similar tariffs on imports suggests that any adopted tariff may be in place for less than four years, due to retaliation from foreign countries that manufacture panels, retaliation that would be sanctioned as a result of legal action before the World Trade Organization.

The following analysis shows that the import tariffs levied by the U.S. on PV panels imported from select countries will have a minimal impact on the cost of utility-scale PV development. The analysis may be useful to the Commission to the extent that future forecasts of solar cell or module costs do not include tariff impacts. The tariffs, which were imposed in March 2018, will decline annually between 2018 and 2021, expiring completely in March 2022. The first 2.5 GW of panels imported from the specified countries annually are exempt from the tariff.

Safeguard Tariffs on Imported Solar Cells and Modules				
	Year 1	Year 2	Year 3	Year 4
Tariff increase	30%	25%	20%	15%

* First 2.5 gigawatt of imported cells are excluded from the additional tariff.

The tariff will increase panel prices but will have a nominal impact on the total installed costs of utility-scale PV development. There are several factors that mitigate the impact of the tariff on the industry, including:

- Tariffs are only levied on panels from specific countries. American manufactured panels, and panels from exempt countries, will be unaffected by the tariff. We can reasonably expect to see additional imports from exempt nations and there have been several announcements of increased American panel manufacturing, including from Jinko Solar and Sunpower.
- The first 2.5 GW of panels imported annually from the specified countries are exempt from the tariff.[3]
- Tariffs only apply to silicon-based panels. Thin-film PV technologies, which are a significant portion of utility-scale installations, were not part of the trade case and are exempt from the tariffs, regardless of the location of manufacture.[4]
- The U.S. Import Trade Commission has received applications for over 20 exemptions from the tariffs, which it is still reviewing. Approval of any of these applications will increase the quantity of imported panels that are exempt from the tariff.

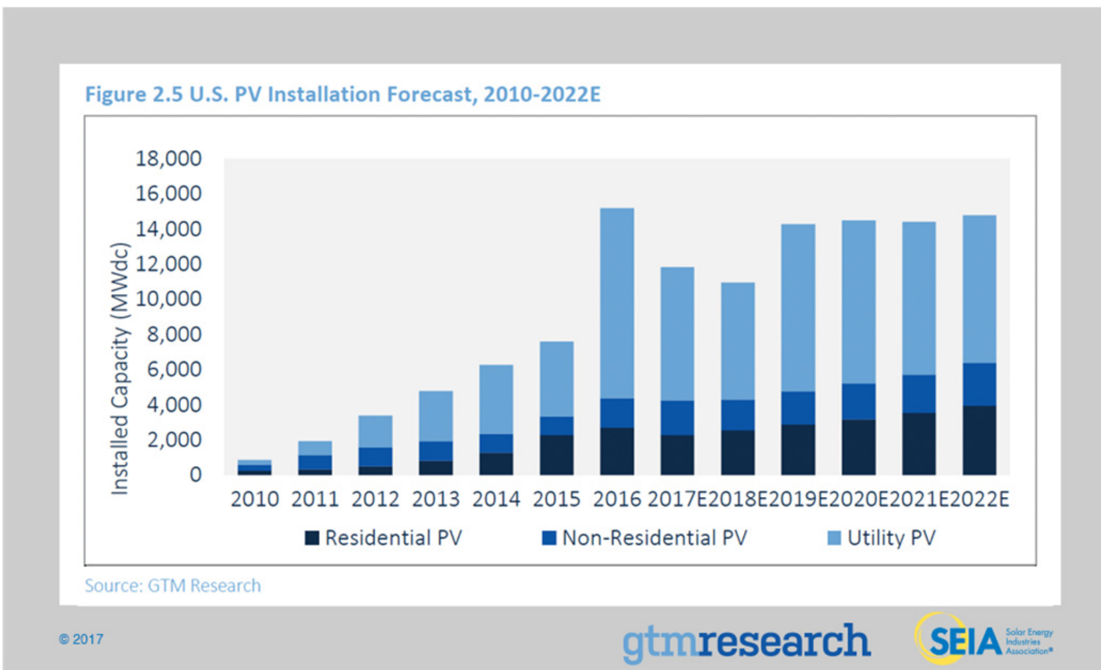
Greentech Media estimates the total U.S. market for solar PV will be approximately 12 GW in 2018, increasing to 14 GW in 2019 – 2022. Adjusting for American production, panels from non-impacted countries, the 2.5 GW per year of exemptions from tariff-subjected countries, and thin film PV, the tariff will impact approximately 42% of all PV panels in 2018, increasing to 50% in years 2019-2021, as shown in **Table 2** below.

[3] 2.5 GW of U.S. solar manufactured in 2017: news.energysage.com/u-s-solar-panel-manufacturers-list-american-made-solar-panels

[4] See www.eia.gov/todayinenergy/detail.php?id=34112 for information in thin film installations.

Table 2: PV Panels Impacted by U.S. Tariff

	2018	2019	2020	2021
Tariff Rate	30%	25%	20%	15%
U.S. Panel Demand (GW)	12.0	14.0	14.0	14.0
Sources exempt from tariff				
Tariff-country exemptions (GW)	-2.5	-2.5	-2.5	-2.5
Exempt-country imports (GW)	-1.0	-1.0	-1.0	-1.0
Thin-film PV (GW)	-1.0	-1.0	-1.0	-1.0
U.S.-made panels (GW)	-2.5	-2.5	-2.5	-2.5
Net: Panels subject to tariff (GW)	5.0	7.0	7.0	7.0
% of total PV	42%	50%	50%	50%



PV panel costs represent approximately 30% of total installed costs for a utility-scale PV facility. The remainder of the installation – including development costs, site preparation, inverters, racking systems or trackers, and electric interconnection – are not subject to the tariffs.

It is impossible to predict which facilities that will be impacted by import tariffs, making it difficult to assess the impact on the project's price. Ideally, one could develop a step function in the supply-cost curve for panels that distinguishes between affected and non-affected panels, but given the national nature of the PV market, it is impossible to determine where that step-function may occur when it comes to large-scale solar development in the western U.S.

In lieu of creating a step function for panel prices, we propose a weighted average tariff cost uplift based on year of installation. Since PV panels are a commodity and can be easily substituted for each other, this assumes that prices will continue to be uniform, and the total cost burden of the tariff apportioned to all panels, whether the individual panels are subject to the tariff or not. The impact on utility-scale facility costs is a function of the tariff rate, the percent of panels affected by the tariff, and the proportional cost of panels to the total facility installed cost. Discussed above and detailed on the table below, the annual impact on the total cost of utility-scale PV facilities will range between 3.8% in 2018 (when tariff rates are highest) to 2.3% in 2021, the last year of the tariff.

Table 3: Exemplary Impact of U.S. Solar Tariff

	2018	2019	2020	2021
Tariff Rate	30%	25%	20%	15%
% of total PV	42%	50%	50%	50%
% of facility cost	30%	30%	30%	30%
Tariff Uplift (% facility cost)	3.8%	3.8%	3.0%	2.3%

SEIA and LSA appreciate the Commission's consideration of these informal comments.

3326/032/X199111.v1

BEFORE THE PUBLIC UTILITIES COMMISSION OF THE STATE OF CALIFORNIA

Order Instituting Rulemaking to Develop an Electricity Integrated Resource Planning Framework and to Coordinate and Refine Long-Term Procurement Planning Requirements.	Filed Public Utilities Commission February 11, 2016 San Francisco, CA Rulemaking 16-02-007

INFORMAL COMMENTS OF THE CALIFORNIA ENVIRONMENTAL JUSTICE ALLIANCE AND SIERRA CLUB ON STAFF'S DRAFT SUPPLY-SIDE RESOURCES

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April 23, 2018

BEFORE THE PUBLIC UTILITIES COMMISSION OF THE STATE OF CALIFORNIA

Order Instituting Rulemaking to Develop an Electricity Integrated Resource Planning Framework and to Coordinate and Refine Long-Term Procurement Planning Requirements.	Filed Public Utilities Commission February 11, 2016 San Francisco, CA Rulemaking 16-02-007

INFORMAL COMMENTS OF THE CALIFORNIA ENVIRONMENTAL JUSTICE ALLIANCE AND SIERRA CLUB ON STAFF'S DRAFT SUPPLY-SIDE RESOURCES

The California Environmental Justice Alliance ("CEJA") and Sierra Club respectfully submit these informal comments in response to the Energy Division's Draft Sources for 2019-2020 IRP Supply-Side Resources ("Draft IRP Supply Resources"). CEJA and Sierra Club have some general observations related to this document, and then respond to the document's questions in the order presented in the document.

GENERAL COMMENTS

Disappointingly, this document leaves out any discussion or consideration of air quality metrics. One of the drawbacks of the RESOLVE methodology in the 2016 IRP was its failure to calculate emissions from cycling and steady-state operations within the model. By failing to include the relevant emissions factors and information, the prior RESOLVE results did not allow users to capture the emission changes from both cycling and steady-state operation at the outset. Instead, the Energy Division conducted an analysis after the fact to attempt to account for the impact of operations on air emissions.[1]

[1] *See* D.18-02-018, p. 60 (describing Staff's analysis). This analysis, however, did not include consideration of cycling emissions.

To attempt to remedy this, CEJA and Sierra Club request that the RESOLVE model this upcoming round of Integrated Resource Planning ("IRP") explicitly include and model emissions factors for cycling, partial load, and steady-state operations. Potential emission factors for cycling, partial load, and steady-state operations can be developed from real data that is collected by EPA's Air Market Division[2] or by use of permit conditions for plants throughout California. Another potential starting place for development of emission factors is the SB 350 study conducted for CAISO.[3]

In addition, if possible, the length of time facilities operate at partial load should be estimated within the model. Units that are spinning and operating at partial load generally emit more pollutants per megawatt hour ("MWh") than units operating at full capacity. For example, a National Renewable Energy Laboratory ("NREL") analysis estimated that "Gas CCs emit 29% more NOx per megawatt-hour at 50% load compared with full-load."[4]

The inclusion of air quality metrics should not be optional. SB 350 requires consideration of how to minimize air emissions,[5] and the Commission's recent decision in this proceeding requires consideration of both cycling and steady-state emissions.[6] Inclusion of air quality metrics will help ensure that this analysis happens at each step during the IRP process.

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[2] *See* U.S. EPA, Air Markets Division, http://www.epa.gov/airmarkets. Hourly NOx data is collected for some, but not all, of the natural gas power plants within CAISO's balancing area.
[3] CAISO SB 350 Studies, Volume 9, p. 100, https://www.caiso.com/Documents/SB350Study-Volume9EnvironmentalStudy.pdf (showing that one start can emit the equivalent of up to 38 hours of operation). This study's usefulness, however, is limited because the assumptions do not include shutdown emissions, which are also higher than steady-state operation.
[4] National Renewable Energy Laboratory, Impact of Wind and Solar on Fossil Fuel Generators, p. 6 (2012), https://www.nrel.gov/docs/fy12osti/53504.pdf,
[5] Cal. Public Util. Code § 454.52(a)(1)(H).
[6] D.18-02-018, p.p. 68-69.

In addition to lacking key air quality metrics, this document does not include consideration of demand-side resources. CEJA and Sierra Club hope to see a set of assumptions developed for consideration in a stakeholder process related to demand-side resources in the near future. The Draft IRP Supply Resources document states that "[d]emand-side resource assumptions and load will largely be based on the 2018 IEPR…We will discuss demand-side updates at a later time in 2018."[7] More thought should be put into the development of demand-side resources than mere inclusion of the IEPR.

Another significant drawback of using RESOLVE in the 2016 IRP was its inability to optimize demand-side resources. As the Commission noted, the RESOLVE model previously has not optimized "energy efficiency, BTM PV, and some forms of demand response."[8] Although the optimization of DERs is included in the budget for planned technical support for the next IRP cycle,[9] it is not clear whether this optimization will be prioritized to the extent necessary.

Demand-side resources are first in the loading order,[10] and they must be a critical component of any plan for meeting our greenhouse gas and air quality requirements. Indeed, SB 350 requires that LSEs' IRPs "[e]nhance distribution systems and demand-side energy management."[11] Demand reduction products are also a necessary part of a diversified procurement portfolio.[12] To ensure an optimization that best reflects the capabilities of demand-side resources, more work will need to be done than just integrating the IEPR assumptions.

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[7] Draft IRP Supply Resources, p. 1.
[8] D.18-02-018, p. 34.
[9] *See* D.18-02-018, p. 148.
[10] *See, e.g.,* Cal. Public Util. Code § 454.5(b)(9).
[11] Cal. Public Util. Code § 454.52(a)(1)(G).
[12] *See, e.g.*, Cal. Public Util. Code § 454.52(b)(3)(B) (including "demand reduction products" are part of a diversified portfolio).

CEJA and Sierra Club request that demand-side resource assumptions and plans to optimize demand-side resources be a priority moving forward.

RESPONSES TO QUESTIONS

CEJA and Sierra Club respond to the questions in the order presented. CEJA and Sierra Club have chosen not to respond to all the questions presented.[13]

Question 1: Gas Retrofits Data: Although the list of assumptions related to Gas Retrofits includes both fixed and variable O&M costs, it is not clear if there is any consideration of the age of the facility or of how the facility will be operated when considering O&M costs. O&M costs change dramatically for older plants when certain parts of a unit may begin to reach their end of life and if the plant is used to cycle more often than intended. As a report by the National Renewable Energy Laboratory found:

> Cycling of thermal plants can create thermal and pressure stresses in power plant components. This leads to increased O&M costs, more frequent repairs, reduced component life, and more frequent forced outages. Power plants that were designed for baseloaded operation suffer much more wear-and-tear damage from cycling.[14]

These types of considerations should be included when examining potential retrofits and costs associated with the operation of gas plants. One source of gas retrofit data is regulatory filings such as air permits and applications filed with this Commission. The NREL report cited above also includes some estimates of how O&M costs are impacted by increased cycling.

Questions 2-3: Solar PV Data: As related to the proposed breakdown of types of solar (fixed vs. tracking), the Commission should ensure that the percentage best reflects the current

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[13] Sierra Club has also submitted informal comments with Defenders of Wildlife and other conservation parties. Those comments address issues not discussed in these comments.
[14] *See* D. Lew et al., Nat'l Renewable Energy Lab., The Western Wind and Solar Integration Study Phase 2: Executive Summary 5 (2013), http://www.nrel.gov/docs/fy13osti/58798.pdf.

trends. A Lawrence Berkeley National Laboratory report recently found that 79% of new U.S. utility-scale solar capacity included tracking systems.[15] Given this trend, it does not appear that the 25% tracking and 75% fixed breakdown is consistent with the current market.

As related to cost data, one report that should be considered is the Natural Renewable Energy Laboratory report entitled *U.S. Solar Photovoltaic System Cost Benchmark: Q1 2017*.[16] This report details recent costs of solar PV and should be included and considered in the IRP's development of cost assumptions.

Questions 4-7: Battery Storage: As related to types of batteries, to the extent possible, the model should assume that the most cost effective battery that can perform the needed services is chosen. As Lazard's Levelized Cost of Storage Analysis indicates, the costs of batteries can vary significantly.[17] To develop these costs, the most recent literature should be used as the cost of storage is expected to continue to decrease. Multiple use applications for storage should be modeled to the extent possible because the value of storage comes in part from its ability to perform multiple types of different applications. This should necessarily include modeling the combination of storage and solar facilities to see the impact that this has on the operation of these facilities. In particular, pairing storage with resources in particular areas is likely to reduce cycling air pollution from power plants. This possibility should be explored, and the value of storage to reduce these emissions should be considered.

Question 10: New Resource Types: As discussed above, CEJA and Sierra Club hope that this process develops ways to consider demand-side resources such as energy efficiency and distributed generation as candidate resources. In addition to those resources, one related resource

[15] The report is available here: https://emp.lbl.gov/utility-scale-solar/.
[16] The report is available here: https://www.nrel.gov/docs/fy17osti/68925.pdf.
[17] *See* https://www.lazard.com/media/450350/lcos3executive-summary.pdf.

type that is not being considered is the potential for more microgrids. The University of California San Diego currently operates a 42-MW microgrid,[18] and the California Energy Commission recently released a draft report discussing the importance of developing microgrids in California.[19]

In addition, in the Demand Response Proceeding, the Commission is currently considering pilot projects to reduce pollution and provide economic development to disadvantaged communities.[20] The results of these pilot projects should be integrated into the demand response assumptions to better inform targeted placement of demand response.

Question 11: Other Data Sources: In addition to considering the potential cost of GHG allowances, there should also be consideration of the costs of emission reduction credits. Natural gas power plants that emit NOx and PM in certain areas of the state are required to purchase emission reduction credits. These costs can be significant. For example, the South Coast Air Quality Management District estimated that the cost of NOx emission reduction credits for 2014 was an average of $63,014 per ton per year, and the cost of coarse particulate matter ("PM_{10}") emission reduction credits in 2014 per ton per year was $521,868 per ton per year.[21] The best estimates of these potential costs is from the local air districts. These costs need to be included to best reflect the cost of operating a natural gas facility.

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[18] *See* https://energycenter.org/self-generation-incentive-program/business/technologies/microgrid.

[19] CEC, *Roadmap for Commercializing Microgrids in California* (2017), http://docketpublic.energy.ca.gov/PublicDocuments/16-EPIC-01/TN221347_20170929T154043_Roadmap_for_Commercializing_Microgrids_in_California.pdf.

[20] *See, e.g.*, A.17-01-012, Assigned Commissioner's Office Draft Straw Proposal for Pilots Targeting Demand Response to Benefit Disadvantaged Communities (Feb. 7, 2018).

[21] *See* South Coast Air Quality Management District, Report of Emission Reduction Credits, http://www.aqmd.gov/docs/default-source/permitting/ercs/2014/h-s-code-40709-5-cy-2014-report.pdf?sfvrsn=4.

Question 12: PV Costs: As related to cost data, one report that is not listed that should be considered is the Natural Renewable Energy Laboratory report entitled *U.S. Solar Photovoltaic System Cost Benchmark: Q1 2017*.[22] This report details recent costs of solar PV and should be included and considered in the IRP's development of cost assumptions.

CONCLUSION

CEJA and Sierra Club appreciate the opportunity to submit these comments.

Dated: April 23, 2018

Respectfully Submitted,

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[22] The report is available here: https://www.nrel.gov/docs/fy17osti/68925.pdf.

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VIA ELECTRONIC MAIL

April 23, 2017

Mr. Paul Douglas
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Re: Informal Comments on Sources for 2019-2018 Supply-Side Resource Modeling

Dear Mr. Douglas:

The purpose of this letter is to provide the Energy Division with limited comments on the Draft Sources for the 2019-2020 IRP Supply-Side Resources. TransWest Express LLC (TransWest) propose the high priority inclusion of the Wyoming Chokecherry and Sierra Madre Wind Energy Project (CCSM Project) as a new candidate resource due to the commercial availability to procure prior to the expiration of the federal Production Tax Credit (PTC) and the significant positive impacts this resource can provide. While our comments are limited to the CCSM Project, any other wind energy project or resource area that could demonstrate commercial availability prior to the expiration of the PTC should also be considered as new candidate resources.

The comments below focus on questions 10 and question 14 from the list provided in the draft document.

Resource Potential

Question 10: Are there any new resource types (not described in your responses to Questions 1 – 9) that Energy Division should prioritize including as a candidate resource in the 2019 IRP?

Yes, the Energy Division should prioritize the inclusion of the Wyoming wind resources that require transmission expansion and can provide the benefits to ratepayers associated with diverse resources and the federal PTC. These resources were modeled within RESOLVE for the 2017 IRP. However, they were “not made available for selection in the core cases or sensitivities” due to concerns about feasibility and costs of the transmission. Aa outlined below these resources should be a high priority resource for inclusion as new candidate resources that can be analyzed and selected if warranted in the 2019 IRP.

Describe how the new resource type satisfies the new candidate resource criteria listed below.

- Resource must have plausible trajectory to commercial availability within planning time horizon.
- Magnitude of potential impact on future portfolio costs and composition must be sufficient to justify changes to model functionality and run-time.

The Energy Division did perform some analysis on out-of-state resources including the transmission upgrades and found the potential for out-of-state wind to represent a significant cost savings if procured prior to the expiration of the federal PTC. This finding is also supported by various publically available studies.[1]

The 3,000 MW Chokecherry and Sierra Madre Wind Energy Project located in south central Wyoming is a fully permitted wind energy project that has started a program of continuous construction in 2016 after eight years of permitting. These resources are commercially available to be procured as Portfolio Content Category 1 (PCC 1) in time prior to the expiration of the federal PTC. The recently completed CAISO Special Study on the 50% RPS Out-of-State portfolio found there was a severe lack of Available Transmission Capacity (ATC) to facilitate the procurement and delivery of large scale out-of-state resources as PCC 1 resources. The 3,000 MW TransWest Express Transmission Project (TWE Project) was found to be the only proposed transmission project that could provide the required ATC to connect the CAISO system to these resources without relying on other transmission assets or systems. The TWE Project can be placed in-service in time to provide 3,000 MW of PCC1 wind resources with the PTC into the mid 2020's.

The magnitude of the potential impact of up to 3,000 MW of PCC1 wind resources net of the increased cost in the transmission expansion is very significant and far exceeds the limited amount of changes required to the model functionality and run time. Given the unique nature of this new candidate resource it may be more efficient and effective to analyze aspects of this

[1] Regional Transmission Expansion Assessment, PA Consulting, October 2016; Wind Diversity Enhancement of Wyoming/California Wind Energy Projects; Wind Energy Research Center, July 2015; California-Wyoming Grid Integration Study, National Renewable Energy Laboratory, March 2014; Investigating a Higher Renewables Portfolio Standard in California: Energy + Environmental Economics, January 2014; WECC 10-Year Regional Transmission Plan, Western Electricity Coordinating Council, September 2011.

potential candidate resource outside of the model. The required changes in the model apply to altering the timing of the availability of the PTCs for this specific resource and the in-service dates for the transmission solution. All other changes to the model could be handled on the generic basis for the technology with respect to costs and output profiles.

List the data sources available for quantifying the cost and potential of the proposed resource type and describe how the data sources satisfy the data source criteria listed below.

- Publicly available
- Technically credible
- Cost data reflects future costs
- Cost data can be used to develop all-in technology costs
- Resource potential data is geographically specific at level of transmission zones used in RESOLVE

TransWest has provided formal comments throughout the IRP proceeding on the CCSM Project and the TWE Projects and their commercial viability. These comments include citations to various data sources that meet all of these data source criteria.

Resource Costs
Question 14: Should any of the cost and financing assumptions in RESOLVE's LCOE calculations be modified, for example assumptions related to state and federal tax incentives, the cost of capital, and financing lifetime? Explain and support any recommended changes using publicly available information, to the greatest extent possible.

The assumptions used for the application of the federal tax incentive for large scale wind energy projects should be extended beyond 2020 through 2025 for the CCSM Project and 2022 in-service date for the TWE Project should be included within the model. TransWest notes that the draft document refers to work being performed this year to inform the cost for capacity expansion solutions will come from the CAISO TPP. The cost for the capacity expansion related to the TWE Project or any other proposed project to access out-of-state resources, or any other analysis by the CAISO on these projects are not included within their 2018-2019 TPP Study Plan. The Energy Division will need to rely on other sources than the CAISO for this vital transmission information.

TransWest appreciates the opportunity to provide these comments.

Sincerely,

/s/

David F/ Smith
Director – Engineering and Operations

BEFORE THE PUBLIC UTILITIES COMMISSION

OF THE STATE OF CALIFORNIA

Order Instituting Rulemaking to Develop an Electricity Integrated Resource Planning Framework and to Coordinate and Refine Long-Term Procurement Planning Requirements.	Rulemaking 16-02-007 (Filed Feb. 11, 2016)

INFORMAL COMMENTS OF TRIDENT WINDS, LLC ON THE DRAFT SOURCES FOR 2019-2020 IRP SUPPLY-SIDE RESOURCES

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April 23, 2018

BEFORE THE PUBLIC UTILITIES COMMISSION

OF THE STATE OF CALIFORNIA

Order Instituting Rulemaking to Develop an Electricity Integrated Resource Planning Framework and to Coordinate and Refine Long-Term Procurement Planning Requirements.	Rulemaking 16-02-007 (Filed Feb. 11, 2016)

COMMENTS OF TRIDENT WINDS, LLC
ON THE DRAFT SOURCES FOR
2019-2020 IRP SUPPLY-SIDE RESOURCES

I. PROPOSED RESOURCE DATA

On March 27, 2018, California Public Utilities Commission Energy Division staff released a draft document providing a list of supply-side resources to be used for capacity expansion modeling for the 2019-2020 cycle of the Integrated Resources Planning (IRP) proceeding (Draft Sources Document).[1] The Draft Sources Document requests that the IRP parties comment on twelve questions related to supply-side resource potential and cost. Trident Winds, LLC (Trident) submits the following comments in response to Questions 10 and 11, which ask whether there are any new resource types that Energy Division should prioritize as a candidate resource and what data sources should be used to quantify resource costs and potential.

[1] Energy Division, *Draft Sources for 2019-2020 IRP Supply-Side Resources* (Mar. 27, 2018).

Trident proposes preliminary evaluation of floating offshore wind as a new supply-side resource during the 2019-2020 IRP cycle and anticipates formal consideration of offshore wind as a candidate resource in the 2021-2022 IRP.

A. Background

Offshore wind is an abundant, renewable, zero-emission resource characterized by steady wind speeds and a generation profile that complements solar and onshore wind generation.[2] These uncommon attributes make offshore wind ideally suited to increase resource diversity, decrease curtailment and integration costs, improve reliability and resilience, sustain higher levels of solar penetration, and support cross-sectoral decarbonization.

B. NREL Offshore Wind Data

California's abundant but untapped offshore wind resources were detailed by a 2016 study prepared by the National Renewable Energy Laboratory (NREL).[3] The 2016 NREL study modeled the site-specific levelized cost of energy (LCOE) for various offshore wind locations in California for the period 2015-2030. This study is the most comprehensive, publicly-available dataset on offshore wind in California. Trident submits the NREL data for Energy Division's consideration.

The Draft Sources Document sets out five criteria for data on supply-side resources. The data must be publicly available, technically credible, useful for developing all-in technology costs, specified at the level of RESOLVE transmission zones, and reflective of future costs. For new candidate resources, the data must show a "plausible trajectory to commercial availability" within the IRP planning time horizon that justifies changes to model functionality or model run

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[2] Walter Musial et al., NREL, *Potential Offshore Wind Energy Areas in California: An Assessment of Locations, Technology, and Costs*, 3 (2016) (NREL 2016).
[3] Walter Musial et al., NREL, *Energy from Offshore Wind*, 2 (2006).

time. The NREL study data generally satisfy these criteria. The data are accessible online, were developed using detailed methodology that draws upon a large body of research, and show that offshore wind LCOEs will be competitive by the time of deployment in the 2025-2030 timeframe.[4]

Nonetheless, the 2016 NREL data should not be relied upon for future cost projections in the 2019-2020 IRP planning process. The 2016 NREL data were prepared using a conservative methodology that extrapolated future costs based on the performance of single units of offshore wind prototypes and is already arguably outdated. These costs date to 2008-2013 and do not reflect the current state of offshore wind operational knowledge or floating offshore wind technology.[5] For example, the NREL data show a 2030 LCOE as low as $97/MWh.[6] However, strike prices for European offshore wind auctions are already lower than those discussed in the 2016 NREL data.[7] Winning bids have decreased from $200/MWh for projects with a 2017-2019 commercial operation date to $65/MWh for a 2024-2025 commercial operation date.[8] Prices have already reached grid parity in some places,[9] and by 2020, European offshore wind prices may decline by another 70%.[10] Although these prices are not directly translatable to California LCOE, they strongly indicate that the 2016 NREL study significantly overstates the cost of California offshore wind.

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[4] *See* NREL 2016 at vi ("The eventual commercialization of floating offshore wind is supported by market indicators such as accelerating deployment, improving cost, and increasing global research and development spending").
[5] See *id.* at 35 (discussing methodology and data from prior studies).
[6] *Id.* at xii, 56.
[7] Walter Musial et al., NREL, *2016 Offshore Wind Technologies Market Report*, v (2017) (NREL 2017).
[8] *Id.*
[9] *Id.* at 54.
[10] *See* Arnout de Pee et al., McKinsey & Co., *Winds of Change? Why offshore wind might be the next big thing* (May 2017).

Rapid cost declines also reflect technological requirements for offshore wind. There are two broad categories of foundations used to support offshore wind turbines: fixed-bottom and floating. Fixed-bottom foundations are fixed to the seabed. The vast majority of California's wind resources, however, are located over water too deep for fixed foundations; wind turbine support structures must float instead.[11] Floating platforms are a recently-commercialized technology early in its innovation curve. Rapid cost decreases are occurring and should be expected to continue. This is supported by the fact that fixed-bottom technology—despite having been commercialized for decades—continues to experience cost decreases faster than forecasted. In Europe, for example, fixed-bottom costs have declined by as much as 60% over the past 10 years.[12]

Faster-than-anticipated cost declines make it appropriate to adjust the NREL data to reflect costs more accurately. Trident proposes to work with Energy Division staff over the course of the current and upcoming IRP cycles to provide reliable cost data on offshore wind. Both proprietary and publicly-available information should be used for adjustment. Although proprietary information is confidential because of its competitive sensitivity, Trident and other members of the offshore wind industry have access to the most recent cost data and financial projections. Trident hopes to provide Energy Division with the best possible information for the 2021-2022 IRP, which would include both publicly-available and proprietary data,.

Given the decreases in offshore wind auction prices and the expected cost-savings from innovations in floating platforms, formal consideration of floating offshore wind as a candidate resource during the 2019-2020 IRP would be premature. At this time, the NREL data should be used with the RESOLVE model for preliminary study and to illustrate the unique benefits and

[11] *See generally* NREL 2016.
[12] *Id.* at 49.

attributes of offshore wind. This initial investigatory work is appropriate in anticipation of full consideration of offshore wind during a subsequent IRP cycle.

C. Resource Data

The NREL offshore wind data are presented in tabular form in Appendix A. The data consist of value ranges for sites identified by the 2016 NREL study that are most likely to reflect recent cost declines and interconnection feasibility.

II. ATTRIBUTES OF OFFSHORE WIND

Although offshore and onshore wind may seem interchangeable, offshore wind has a significantly different resource profile. Offshore wind has significantly higher wind speeds but a relatively flat 24-hour production profile with a modest peak in the late afternoon and evening for most months. These attributes increase generation potential.[13]

Offshore wind is also characterized by a high capacity factor. Existing projects have demonstrated capacity factors over 60%, which is approximately twice the capacity factor of onshore wind.[14] Furthermore, NREL forecasts that California offshore wind turbines could have gross capacity factors as high as 73% by 2027.[15] These values exceed the capacity factor for most forms of renewable energy and compare favorably with dispatchable and "baseload" resources such as natural gas, as shown in the following table:

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[13] *Energy from Offshore Wind* at 2 ("The wind blows faster and more uniformly at sea than on land. A faster, steadier wind means less wear on the turbine components and more electricity generated per turbine. The winds increase rapidly with distance from the coast, so excellent wind sites exist within reasonable distances from major urban load centers reducing the onshore concern of long distance power transmission.").

[14] Matthew Klippenstein, Greentech Media, "World's First Floating Offshore Wind Farm Achieves 65% Capacity Factor After 3 Months" (Mar. 10, 2018) available at https://www.greentechmedia.com/articles/read/worlds-first-floating-offshore-wind-farm-65-capacity-factor#gs.7iESm3s (last accessed Apr. 23, 2018).

[15] NREL Study at 32.

Comparison of Capacity Factors by Resource Type[16]	
Resource Type	Net Capacity Factor (%)
Nuclear	92.2
Geothermal	76.4
Landfill Gas and Municipal Solid Waste	70.9
Offshore Wind	50.0 - 65.0[*]
Natural Gas - Combined Cycle	54.8
Coal	53.5
Other Biomass	50.7
Onshore Wind	36.7
Solar Photovoltaic	27.0
Solar Thermal	21.8
Natural Gas - Steam Turbine	11.3
Natural Gas - Combustion Turbine	9.4

III. VALUE OF OFFSHORE WIND

A. Resource Diversity, Decarbonization, and Other Benefits

RESOLVE selected approximately 9,000 MW of utility-scale solar for procurement by 2030, which represents 73% of the incremental capacity in the IRP Reference System Portfolio (RSP).[17] Aside from 1,100 MW of in-state wind (9% RSP), almost no new resources are added until 2030, at which point 200 MW of geothermal and 2,000 MW of battery storage is added (18% RSP). This composition is consistent with the results of the RESOLVE sensitivity cases, which show that beyond a certain amount of solar, integration solutions will be necessary as curtailment costs increase and grid reliability is affected. Such solutions include resource diversity, long-duration storage, or increased regional trading. On its current trajectory, California will reach this threshold amount of solar between 2026 and 2030.

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[16] U.S. Energy Information Administration, *Electric Power Monthly*, Tables 6.7.A, 6.7.B (Mar. 23, 2018).
[*] *See* NREL Study at 32–33; McKinsey & Co., *supra*, note 10.
[17] *Decision Setting Requirements for Load Serving Entities Filing Integrated Resource Plans*, D.18-02-018, R.16-02-007, 79 (Feb. 8, 2018).

Offshore wind can provide unique diversity, reliability, resilience, and decarbonization benefits for California. Its generation profile is largely flat and, as a result, "the market value of offshore wind is roughly similar to that of a similarly located flat block of power . . . over a 24-hour period."[18] At the same time, offshore wind displays a modest afternoon-evening peak that follows California's demand profile and is complementary to solar. This profile allows offshore wind to provide dependable, zero-GHG power that can displace both thermal "baseload" and peaker generation that would otherwise be required during solar down-ramp and off-peak periods. Adding offshore wind to California's resource portfolio could also reduce GHG-emissions associated with 100% renewable energy tariffs offered by utilities and community choice aggregators. Such tariffs primarily rely on solar and renewable energy credits to reach 100% renewable generation, which increases GHG emissions from thermal plants during solar off-peak periods and also drives curtailment and integration costs. In contrast, the steady generation offered by offshore wind could allow greater penetration of renewables while maintaining reliability and reducing GHG emissions.

Achieving California's aggressive climate change goals, including an 80% reduction of GHG emissions by 2050, will require cross-sectoral solutions such as the extensive electrification of buildings and transportation. These policies, if successful, will increase load and the need for flexibility. RESOLVE sensitivity cases indicate that higher loads significantly increase the value of diversity, especially if energy efficiency deployment is low or flexibility is constrained.[19] These conditions should increase the value of offshore wind, which can provide

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[18] Andrews D. Mills et al., Lawrence Berkeley Nat'l Lab., *Estimating the Value of Offshore Wind Along the United States' Eastern Coast*, 8 (Apr. 2018) (LBNL Study).
[19] *See* Energy Division, Proposed Reference System Plan, 75 (Sept. 18, 2017).

nighttime renewable generation to meet increased load from buildings and electric vehicle charging as well as reduce evening ramping needs.

Given its generation profile, the diversity value of offshore wind in the California market is likely to be high. Recent research from Lawrence Berkeley National Laboratory (LBNL) modeled the site-specific marginal value of offshore wind for states on the Atlantic Coast and found that its value ranged as high as $110/MWh for the period 2007-2016.[20] The energy and capacity value of offshore wind exceeded the value of onshore wind by $6/MWh-$20/MWh due to offshore wind sites being located closer to major population centers and also having a time-varying profile of electricity production that is better correlated with electricity demand.[21] Under more demanding conditions in California—including high solar penetration, transmission constraints, a 50% Renewable Portfolio Standard, and a GHG emissions reduction target of 40% below 1990 levels—the value of offshore wind should be even higher.

The Lawrence Berkeley National Laboratory study also suggests that offshore wind's benefits may not be fully captured by the RESOLVE model. For example, avoided emissions are a measurable health and climate benefit of offshore wind. For Atlantic states, these health and climate benefits varied between $26/MWh and $120/MWh.[22] Similar analyses could be performed for California to determine how offshore wind could facilitate decarbonization and reduce air pollution in disadvantaged communities identified by the IRP proceeding. The high capacity factor and flat generation profile of offshore wind could also permit the early retirement of thermal plants in disadvantaged communities without significantly increasing reliability costs or reducing resilience.

[20] LBNL Study at 6, 11.
[21] *Id.* at 9.
[22] *Id.* at 11.

Offshore wind can also mitigate costs associated with curtailment and the duck curve. Currently, the RESOLVE model prefers solar for capacity expansion and favors curtailment for low-cost grid integration. Integrating solar and land-based wind is becoming more expensive, and day-ahead spot prices during the evening ramp can reach $609/MWh.[23] Related daytime over-generation creates negative pricing that forces utilities (and ratepayers) to pay wholesale customers for demand response. Eventually, curtailment costs could limit the availability of project financing. By complementing the daytime peak and evening drop in solar generation, however, offshore wind "could potentially enable higher penetrations of renewable energy to be deployed."[24] In addition to reducing curtailment, offshore wind can limit the impact of California's evening ramp. Energy Division has predicted that California will experience an extreme evening ramp by 2020 that will require the addition of 13 GW to the grid over a three-hour period.[25] Offshore wind's late-afternoon and evening peak largely overlaps with the evening ramp.

Finally, offshore wind helps solve California's scalability problems. California must add several gigawatts of capacity each year to meet its 2050 GHG-reduction goal. NREL estimates that the amount of California offshore wind energy that is commercially viable with available technology and current permitting requirements is as much as 15 GW.[26]

B. Avoided Transmission Costs and Locational Value

California has few options to easily increase out-of-state imports due to transmission constraints. Offshore wind can solve many transmission challenges by repurposing California's existing transmission and distribution infrastructure, capacity on which is becoming available as

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[23] California Independent System Operator, *Q2 2017 Report on Market Issues and Performance*, 13 (2017).
[24] NREL 2016 at 3.
[25] CPUC, *Beyond 33% Renewables: Grid Integration Policy for a Low-Carbon Future*, vii (2015).
[26] NREL 2016 at 5.

coastal conventional and nuclear generation is being retired. Favorable sites for offshore wind development are distributed along California's northern and central coasts. This dispersion allows the deployment of zero-carbon, renewable generation near population centers without the need for overland transmission because multiple coastal generation sites have been or will be retired soon. These facilities are generally located near load centers such as Los Angeles and San Francisco, which eliminates the need to construct new long-distance transmission lines or to establish new rights-of-way. The reuse of existing infrastructure also improves grid resilience because power flows will more closely resemble flows for which transmission and distribution assets were originally designed. Furthermore, ratepayers will not be required to pay for new or stranded transmission assets.

Despite these advantages, transmission costs savings associated with offshore wind have not been quantified for California. Offshore wind values for the East Coast, however, indicate that the savings would be significant. As noted above, Lawrence Berkeley National Laboratory found that the energy and capacity value of offshore wind for Atlantic states exceeded the value of land-based wind by $6/MWh-$20/MWh. This value largely results from the ability to avoid long-distance transmission costs by siting offshore wind within miles of major population centers.[27] European data also reveals the avoided cost of transmission. Recent auctions for offshore wind installations for the 2020-2025 timeframe have had strike prices less than $70/MWh, including transmission expenses.[28]

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[27] LBNL Study at 1.
[28] NREL 2017 at 58; LBNL Study at 14.

IV. NEXT STEPS

Trident thanks Energy Division and the Modeling Advisory Group for the opportunity to provide feedback on inputs for the RESOLVE model. Although the NREL data and other available evidence do not support inclusion of offshore wind as a candidate resource during the 2019-2020 IRP, such evidence does warrant initial investigation. Trident looks forward to working with Energy Division staff to develop reliable cost data on offshore wind that can be used for planning in the 2021-2022 IRP.

Respectfully submitted April 23, 2018, at San Francisco, California.

/s/ Christopher G. Parker

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APPENDIX A

2025 FID (2027 COD) Project

LIFETIME COSTS

Project Size	600
Turbine Size	10
Number of Units	60

Level	Category Name	Fixed Value or Factor (if applicable)	CAPEX ($2015) Low	CAPEX ($2015) High	CAPEX ($2015/kW) Low	CAPEX ($2015/kW) High
1	Turbine Capital Cost (TCC)	971,630,632	971,630,632	971,630,632	1,619	1,619
1	Balance of System Capital Cost (BOS)	sum	1,376,335,532	1,566,227,022	2,294	2,610
2	Development	2%	43,563,340	47,163,178	73	79
2	Project Management	4%	76,235,844	82,535,562	127	138
2	Port & Staging, Logistics, Transport	50,000,000	50,000,000	50,000,000	83	83
2	Support Structure		0	0	0	0
3	Floating Substructure	480,550,580	480,550,580	480,550,580	801	801
3	Mooring System (Lines & Anchors)	Site Specific	219,673,629	308,478,460	366	514
2	Assembly and Installation	Site Specific	82,473,172	89,613,897	137	149
2	Electrical Infrastructure	Site Specific	0	0	0	0
3	Array Cable System	Site Specific	118,505,434	150,919,507	198	252
3	Export Cable System	Site Specific	218,192,808	332,195,650	364	554
3	Grid Connection	Site Specific	80,000,000	83,200,000	133	139
1	Soft Costs	sum	312,202,355	383,807,595	520	640
2	Insurance During Construction	1%	23,479,662	25,378,577	39	42
2	Project Completions/ Commissioning	1%	23,479,662	25,378,577	39	42
2	Surety Bond (Decommissioning)	15%	12,370,976	13,442,085	21	22
2	Sponsor Contingency	sum	91,220,251	146,395,059	152	244
3	Procurement Contingency	5%	64,336,082	121,310,523	107	202
3	Installation Contingency	30%	24,741,952	26,884,169	41	45
2	Construction Financing Cost	Formula	160,580,696	174,673,757	268	291
	TOTAL CAPEX		2,660,168,518	2,893,633,167	4,434	4,823

	($2015/yr.) Low	($2015/yr.) High	($2015/kW/yr.) Low	($2015/kW/yr.) High
TOTAL OPEX	59,848,284	63,039,507	100	111

ENERGY PRODUCTION SUMMARY

Level	Category Name	Fixed Value or Factor (if applicable)	Low LCOE Percentage	High LCOE Percentage
1	Environmental Losses		1.59%	1.59%
2	Icing/Blade Soiling Loss	1.00%	1.00%	1.00%
2	Low/High Temp Shutdown	0.50%	0.50%	0.50%
2	Lightning Loss	0.10%	0.10%	0.10%
1	Technical Losses		0.60%	0.60%
2	Hysteresis	0.50%	0.50%	0.50%
2	Onboard Equipment (parasitic load)	0.05%	0.05%	0.05%
2	Rotor Misalignment	0.05%	0.05%	0.05%
1	Site Specific Losses		13.65%	12.99%
2	Wake Loss	Site Specific	4.91%	3.52%
2	Total Electrical Loss	Site Specific	3.41%	3.80%
2	Availability Loss	Site Specific	5.98%	6.26%
	TOTAL LOSSES		15.53%	14.89%

	Low (MWh)	High (MWh)
Gross AEP	3,568,030	3,712,875
Gross Capacity Factor	67.9%	70.6%
Net AEP	3,013,895	3,159,887
Net Capacity Factor	57.3%	60.1%

	Low ($/MWh)	High ($/MWh)
LEVELIZED COST OF ENERGY	108.09	111.00
Perecent Change versus 2015 LCOE	-40.3%	-38.9%

BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF CALIFORNIA

Order Instituting Rulemaking to Develop an Electricity Integrated Resource Planning Framework and to Coordinate and Refine Long-Term Procurement Planning Requirements.	Rulemaking 16-02-007 (Filed February 19, 2016)

INFORMAL COMMENTS OF THE UTILITY CONSUMERS' ACTION NETWORK (UCAN) ON THE DRAFT SOURCES FOR 2019-20 IRP SUPPLY-SIDE RESOURCES

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April 23, 2018

INFORMAL COMMENTS OF THE UTILITY CONSUMERS' ACTION NETWORK (UCAN) ON THE DRAFT SOURCES FOR 2019-20 IRP SUPPLY-SIDE RESOURCES

The Utility Consumers' Action Network submits these informal comments regarding the "Draft Sources for 2019-20 IRP Supply-side Resources" document emailed March 27, 2018, by the Energy Division. Throughout the Integrated Resource Plan (IRP) proceeding (R.16-02-007), UCAN made the case for flexibility for Load Serving Entities (LSEs), including the Investor-Owned Utilities (IOUs) when developing individual IRP's and when adopting greenhouse gas (GHG) reducing generation. UCAN believes this to be the best path to achieve the state's GHG reduction mandates while resulting in the lowest costs to utility ratepayers. UCAN continues this flexibility concept while answering questions 3, 3.2.3, 3.3, 7, 8, 12, 14 below, and adding a final comment.

Question 3. Solar PV: How should high- and low-cost trajectories for future PV costs be developed?

UCAN: No comment on expected solar PV technology development. However, the fact that these various renewable technologies are changing to improve efficiency and lower costs suggests that flexibility should be not only accepted but encouraged so that the LSEs adopt these technologies at the right time and avoid potential obsolescence because of ongoing technology developments. As these technologies improve in efficiency and/or lower costs, a reasonable strategy can be to wait rather than adopt. Combined with the ideal time to adopt in terms of when the resource is needed for the individual LSE, and consistent with meeting mandated GHG reduction and Renewables Portfolio Standard (RPS) objectives, the LSEs should have the flexibility to delay procurement when justified by need for power or expected costs.

Section 3.2.3 Wind: NREL WIND Toolkit is the most current source for wind profiles, but its assumptions on power curves and hub height result in capacity factors that don't accurately capture performance of older existing wind plants.

UCAN: No comment on differences between older and newer wind technology development. However, the fact that these various renewable technologies are changing to improve efficiency and lower costs suggests that flexibility should be not only accepted but encouraged so that the

LSEs can adopt these technologies at the right time and avoid potential obsolescence because of technology developments and improvements. As these technologies improve in efficiency and/or lower in cost, a reasonable strategy can be to wait rather than adopt. Combined with the ideal time to adopt in terms of when the resource is needed for the individual LSE, and consistent with meeting mandated GHG reduction and RPS objectives, the LSEs should have the flexibility to delay procurement when justified by need for power or expected costs.

Section 3.3 Available Transmission Capacity

UCAN: This section is very brief but warrants careful consideration. Comparing the cost of alternative resources located at varying distances from the load center requires both the cost of the generation resource and the cost of delivering that resource to the load. This is especially true where the renewable resource such as solar PV or wind are remotely located and large acreage is needed to accommodate the number of solar panels or windmills comprising a utility generation resource. These transmission costs can include incremental transmission capacity necessary to access the resource, the corresponding operational and maintenance expenses per mile times the number of miles to the load center, and transmission losses per mile times the number of miles to the load center. Including these transmission costs is the only way to ensure that all resources are fairly compared. Ignoring transmission costs can ultimately and unfairly favor remote resources where the land may be less scarce and therefore less expensive but the cost to deliver the power to the load represents a critical compensating cost factor.

Question 7. Battery: How should high- and low-cost trajectories for future battery costs be developed?

UCAN: See response to Question 3. The same need for flexibility applies here.

Question 8. Pumped Storage: How should pumped storage costs be represented given that they are highly site-specific and difficult to estimate on a generic basis?

UCAN: The site-specific aspect of pumped storage offers another rationale for granting individual LSEs sufficient flexibility to procure resources at the best time for their unique need and other circumstances.

Question 12. Resource Costs: Are there any additional sources of capital cost, operating cost, and performance projections (not described in your responses to Questions 1 – 9) that should be considered for solar PV or wind? Please describe and provide a link for any suggested sources. Explain how the data source meets the data source criteria listed above.

UCAN: No comment except to say that uncertainty about future costs suggests the need to grant LSEs sufficient flexibility compared to the Reference System Plan (RSP) to ensure that the right technologies will be adopted at the right time when they can be procured at least cost while contributing to mandated RPS and GHG objectives.

Question 14. Resource Costs: Should any of the cost and financing assumptions in RESOLVE's LCOE calculations be modified, for example assumptions related to state and federal tax incentives, the cost of capital, and financing lifetime? Explain and support any recommended changes using publicly available information, to the greatest extent possible.

UCAN: Given the time horizon of the overall IRP, there is too much uncertainty beyond the current year and perhaps the very near future (1-3 years) to predict changes to state and federal tax incentives. We should expect rational tax incentives to take into account expected costs to the LSEs since tax incentives should decline as the cost of these resources decline and is more comparable to conventional resources.

UCAN Final Comments:

UCAN suggests that the characteristics of all the plant types should include a range of characteristics that indicate how the resource will operate. These include the construction lead times necessary to get a new plant online, features related to dispatchability, e.g., where the resource, if dispatchable, is placed in the generation stack (base load, cycling or peaking), heat rate (an indicator of plant efficiency), location of the resource (distance from the load centers or existing transmission grid), transmission costs (incremental transmission capacity necessary to access the new resource, operational and maintenance expenses per mile, and transmission losses per mile), operating costs at minimum and maximum plant capacity factor, fuel type, fuel costs and expected fuel costs.

Furthermore, each LSE will have different load curves that suggest different operating parameters at different load levels and times of the day and the resulting capacity utilization when placed in the stack which can affect the cost effectiveness of the resource depending on the unique load profile of the LSE. Specifically, plant operating characteristics as stand-alone plants are very different than the operating characteristics when placed in the generation stack. The economics that is most useful is in the context of the generation portfolio. Stand-alone operating characteristics are much less meaningful. This is another reason why the LSEs need flexibility in terms of what to add and when to minimize costs, consistent with meeting mandated GHG reduction and RPS objectives.

April 23, 2018

Respectfully submitted,

/s/ Jane Krikorian
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BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF CALIFORNIA

Order Instituting Rulemaking to Develop an Electricity Integrated Resource Planning Framework and to Coordinate and Refine Long-Term Procurement Planning Requirements	R.16-02-007 (February 11, 2016)

CERTIFICATE OF SERVICE

I, Jane Krikorian, certify under penalty of perjury under the laws of the State of California that the following is true and correct:

On April 23, 2018, I served a copy of:

INFORMAL COMMENTS OF THE UTILITY CONSUMERS' ACTION NETWORK (UCAN) ON THE DRAFT SOURCES FOR 2019-20 IRP SUPPLY-SIDE RESOURCES

on all eligible parties on the attached list R.16-02-007 by sending said document by electronic mail to each of the parties via electronic mail, as reflected on the attached Service List.

Executed this Monday, April 23, 2018.

______/S/______
Jane Krikorian
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CALIFORNIA PUBLIC UTILITIES COMMISSION
Service Lists

Proceeding: R1602007 - CPUC - OIR TO DEVELO
Filer: CPUC
List Name: LIST
Last changed: April 23, 2018

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BEFORE THE PUBLIC UTILITIES COMMISSION OF THE STATE OF CALIFORNIA

Order Instituting Rulemaking to Develop an Electricity Integrated Resource Planning Framework and to Coordinate and Refine Long-Term Procurement Planning Requirements.	Rulemaking 16-02-007 (Filed February 11, 2016)

INFORMAL COMMENTS OF WELLHEAD POWER SOLUTIONS, LLC ON QUESTIONS RAISED IN CONNECTION WITH MODELING 2019-20 IRP SUPPLY-SIDE RESOURCES.

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April 23, 2018

BEFORE THE PUBLIC UTILITIES COMMISSION OF THE STATE OF CALIFORNIA

Order Instituting Rulemaking to Develop an Electricity Integrated Resource Planning Framework and to Coordinate and Refine Long-Term Procurement Planning Requirements.	Rulemaking 16-02-007 (Filed February 11, 2016)

INFORMAL COMMENTS OF WELLHEAD POWER SOLUTIONS, LLC ON QUESTIONS RAISED IN CONNECTION WITH MODELING 2019-20 IRP SUPPLY-SIDE RESOURCES.

Wellhead Power Solutions, LLC is pleased to submit the following in response to the Energy Division's Modeling Advisory Group's request for comments on questions raised in connection with modeling 2019-20 IRP Supply-Side Resources.

More specifically, our comments respond to question 10 by proposing that the IRP model Energy Storage Hybrid Gas Turbine (aka "Hybrid EGT") technology as a separate resource category. Then we will cover question one by responding to the requests for costs and performance information for the retrofit of existing LM6000 gas turbines with this new technology.

A. <u>Response to Question 10</u>

Question 10: Are there any new resource types (not described in your responses to Questions 1 – 9) that Energy Division should prioritize including as a candidate resource in the 2019 IRP? Describe how the new resource type satisfies the new candidate resource criteria listed above. List the data sources available for quantifying the cost and potential of the proposed resource type and describe how the data sources satisfy the data source criteria listed above.

1. Response: Wellhead proposes that the retrofit of gas resources in California with Energy Storage Hybrid EGT technology be included as a candidate resource category in the 2019 IRP.

2. Background and justification: In 2017, for the first time, a battery (10MW/4.3MWh) was electronically integrated with a simple cycle combustion turbine to give it 100% flexibility, reduce GHG emissions, and spinning reserves qualification in the CAISO market. The Hybrid EGT technology from General Electric[1] was commissioned by Southern California Edison Company as a retrofit of its LM6000 Peaker plants at Center and Grapeland.

SCE recently reported[2] to the CPUC that, pre-construction, the Hybrid EGT was expected to significantly reduce overall plant emissions by providing grid services such as Spinning Reserve without burning fuel -

- Fewer Gas Turbine Starts and Run Hours
- Higher capacity utilization

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[1] GE refers to the technology as the "Electric Gas Turbine" or "EGT."

[2] *Notice of Southern California Edison Company (U 338-E) of Ex Parte Communication with the Office of Commission President Michael Picker,* Application [No 18-03-002] of Southern California Edison (U 338-E) for Approval of its 2018 Energy Storage Procurement and Investment Plan, Dated April 13, 2018.

- Higher value grid services such as Spinning Reserve

The Hybrid EGT's actual performance results compared with SCE's non-hybrid peakers demonstrated over the same period -

- Higher capacity utilization
- Lower fuel gas usage
- Lower emissions
- Higher market revenues

Further, SCE reported that the performance of the initial two Hybrid EGTs have exceeded expectations thus far -

- Spinning reserve utilization higher than expected
- Primary frequency response performance much higher than expected
- The Hybrid EGT has at times responded to over 500 frequency droops in a day, helping to maintain a stable electric system frequency

Finally, SCE reportedly is actively analyzing the customer value of additional Hybrid EGT upgrades at its three remaining GE LM6000 peakers -

- Mira Loma Peaker (Ontario, CA)
- Barre Peaker (Stanton, CA)
- McGrath Peaker (Oxnard, CA)

3. <u>Data Sources:</u>

a) <u>SCE report to CPUC</u>[3]

[3] Id.

SCE's Hybrid EGT plants have been in operation for over one year and SCE recently reported to the CPUC the following attributes and benefits of the technology:

Greenhouse Gas Free Attributes

- Instant Response/Always Ready Technology
- 50 MWs of Operating Reserve
- Primary Frequency Response
- -8 to +5 MVAR Voltage Support
- 134 MW-Secs Inertia
- Black Start Technology

With Fuel Consumption Attributes

- 50 MWs Peaking Energy for Local Contingency
- 25 MWs of High Speed Frequency Regulation
- Demand Charge Management
- Self-Managed Battery System State Of Charge ("SOC")

In other public documents,[4] SCE has forecasted that the Hybrid EGT retrofit will reduce GHG and criteria pollutants by over 60% and water usage by over 45% (about one million gallons per year) compared to pre-Hybrid EGT peaker performance. This would significantly benefit disadvantaged communities.

b) <u>Wellhead Modeling Results</u>

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[4] Brochure: *Southern California Edison's Hybrid Enhanced Gas Turbine, Unlocking the Value*, Published April 2017.

1. **Hybrid LM6000s**. Wellhead Power Solutions has commissioned independent system modeling of retrofitting LM6000 peakers with the following results:

- Installing two Hybrid EGTs providing spinning reserves in a certain IOU's service territory in CAISO would:

    - reduce GHG by approximately 14,000 MT/year per EGT and
    - create over $4 million of annual load payment savings per EGT from reducing the marginal heat rate of the dispatch stack by allowing CCGTs, previously backed down to provide spinning reserves, to run at their most efficient load point.

- Retrofitting a single LM6000 as a Hybrid EGT in a certain WECC balancing area would result in system production cost savings over the 13-year study period of between $31 million and $44 million ($20-$30MM of present value at the BA's WACC), as well as a reduction in renewable energy curtailment.

2. Hybrid CCGT's. Wellhead Power Solutions has commenced modeling efforts for evaluating the integration of a battery with a CCGT to eliminate the steam-turbine lag in startup thereby dramatically increasing the ramp rate of the facility. This technology is expected to have important benefits in reducing system curtailment and GHG emissions. Performance metrics should be available later this year so that this technology may be modeled as a separate candidate resource in the 2019-20 IRP.

3. Expected Future Modeling Results. Wellhead's recent Hybrid EGT modeling in the CAISO assumed the current RPS with only 12 months of operation. Future modeling is expected to show that the additional flexibility gained by hybridizing existing gas-fired resources will result in the California not only reaching its GHG goals faster but also with significantly lower renewable overbuild. As renewables increase, the level of needed reserves increases. We expect the modeling to show the EGT as one of the lowest GHG options to meet increasing flexibility and reserve requirements.

B. Responses to Other Questions

Question 1: Do parties have recommendations on public data sources that capture the costs and operational characteristics of retrofitted power plants?

1. **Response:**

The Hybrid EGT technology is newly installed in the fleet. As a consequence, there is limited public cost data available. The following data is provided by Wellhead Power Solutions based on the performance characteristics provided by General Electric. SCE is expected to be filing additional performance reports to the CPUC.

Because the Hybrid EGT is both a gas turbine and a battery, our responses will deal with both technologies separately in two sections – first as a gas retrofit and secondly as a battery.

2. **Gas Retrofits**

Description: Cost and performance assumptions for retrofits of existing gas generators.

Data needs:

o **Cost inputs**: - Not publicly available at this time.

- Capital cost, $/kW - Not publicly available at this time.
- Fixed O&M, $/kW-yr - Not publicly available at this time.
- Variable O&M, $/MWh - Not publicly available at this time.
- Financing assumptions (cost of capital, capital structure, contract duration etc.) - - Not publicly available at this time.
- Tax assumptions - Not publicly available at this time.

o **Performance assumptions *in Hybrid Mode*:**

- Pmax, MW – 47 to 49.9 MW
- Pmin, MW – zero
- Ramp rates, MW/min – 10
- Start cost, $/start – zero commitment cost
- Heat rate (Btu/kWh)
  @ Pmin – zero
  @ Pmax – 9,900
- Minimum up time – zero
- Minimum down time – zero

3. Battery

Description: Options for new battery technologies.

Data needs:

o **Assumed operational parameters for each technology option:**

- Storage duration (hrs) – 0.43 hrs

- Round-trip losses (%) – 85%
- Ability to contribute to reserve requirements (spin/frequency response/regulation/load following) - Yes
- Point of interconnection – Inverter AC output connects to gas turbine output breaker
- Ramping limitations, if applicable (MW/min) -20MW/sec
- Online date -
- Capacity (MW) – 10MW AC
- Other operational limits such as minimum time to switch from charge to discharge – 1sec Dmax to Cmax or Cmax to Dmax

o **Current cost, performance, and financing assumptions (used to develop forward-looking projections of levelized capacity cost, $/kW-yr):**

- Capital cost, $/kW (power block) and $/kWh (reservoir) – Not publicly available at this time.
- Fixed O&M, $/kW-yr – Not publicly available at this time.
- Financing inputs (cost of capital, capital structure, contract duration etc.) – Not publicly available at this time.
- Tax credits (PTC, ITC) – Does not currently qualify for PTC or ITC

o **Assumed future cost reductions for battery technology (multiple levels of cost reduction will be examined) – Substantial cost reductions are forecasted.**

<u>**Conclusion**</u>

The Hybrid EGT technology is a commercially proven technology that has demonstrated material benefits to the system by reducing GHG, production costs, and load payment costs. Wellhead Power Solutions, as patent holder and co-developer with General Electric of the Hybrid EGT technology is committed to working with the Energy Division to develop public cost and performance data so that this new technology, for both peaker and CCGT retrofits, can be accurately modeled in the 2019-20 IRP as candidate resources.

Respectfully submitted,

__________/s/____________________

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Order Instituting Rulemaking to Develop an Electricity Integrated Resource Planning Framework and to Coordinate and Refine Long-Term Procurement Planning Requirements.	Rulemaking 16-02-007 (Filed February 11, 2016)

CERTIFICATE OF SERVICE

I hereby certify that I have this day served a copy of "INFORMAL COMMENTS OF WELLHEAD POWER SOLUTIONS, LLC ON QUESTIONS RAISED IN CONNECTION WITH MODELING 2019-20 IRP SUPPLY-SIDE RESOURCES" on all known parties listed on the Service List for this Proceeding R.16-02-007. All parties have been served by email, in accordance with Commission Rules.

Executed April 23, 2018 in Sacramento, California

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CPUC Home

CALIFORNIA PUBLIC UTILITIES COMMISSION
Service Lists

PROCEEDING: R1602007 - CPUC - OIR TO DEVELO
FILER: CPUC
LIST NAME: LIST
LAST CHANGED: APRIL 23, 2018

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