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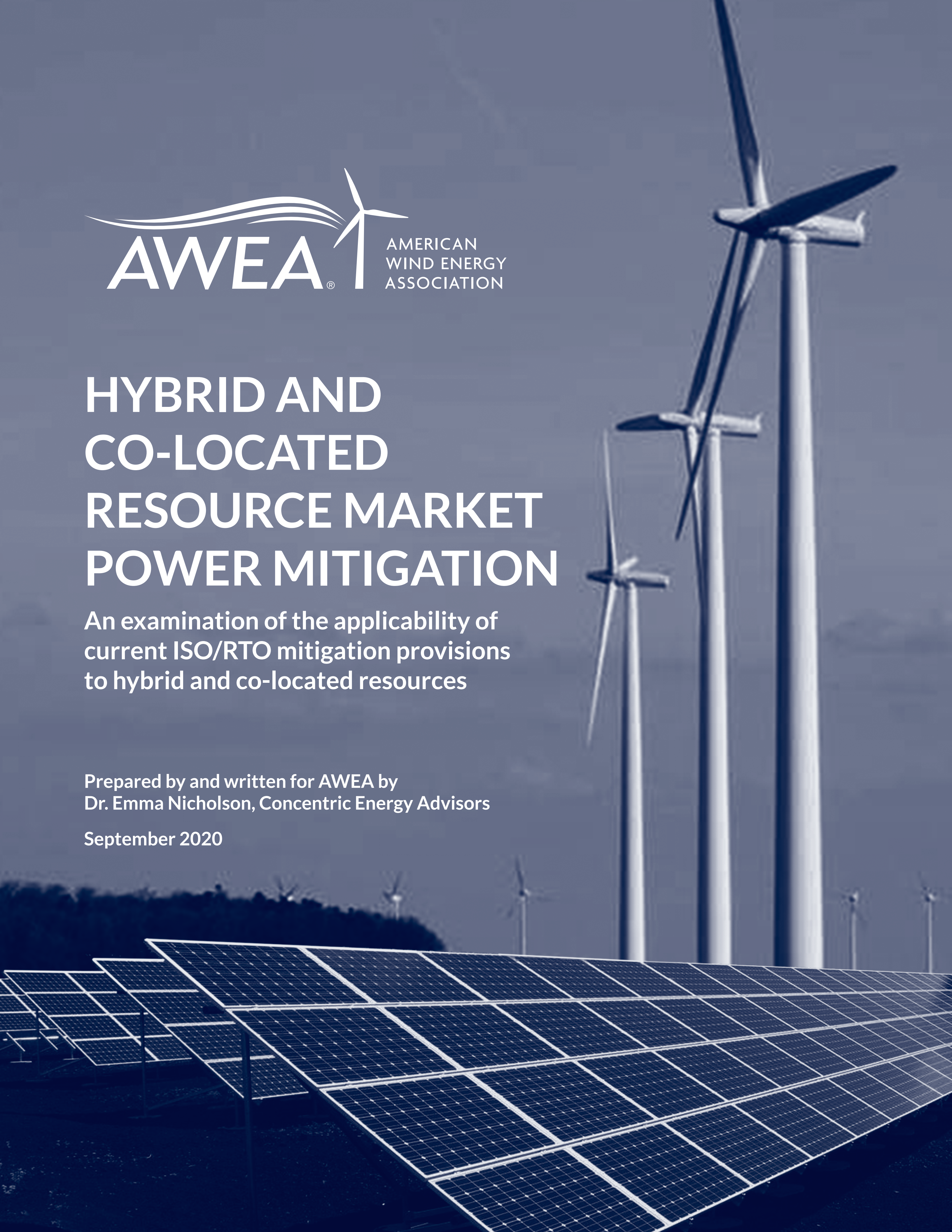

HYBRID AND CO-LOCATED RESOURCE MARKET POWER MITIGATION

An examination of the applicability of current ISO/RTO mitigation provisions to hybrid and co-located resources

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ABSTRACT

This paper discusses issues hybrid and co-located resources are likely to face in wholesale electricity markets in the United States related to market power mitigation. Specifically, the paper considers whether changes are needed to market power mitigation provisions to ensure that hybrid and co-located resources are treated in a non-discriminatory manner and not inefficiently over-mitigated. Section 2 of the paper provides an overview of market power mitigation in wholesale electricity markets, which are operated by independent system operators and regional transmission organizations (ISOs). Section 3 discusses the economic incentives that hybrid and co-located resources are likely to have in ISO markets given the revenue streams such resources are eligible to earn outside of ISO markets, principally through long-term power purchase agreements or through the sale of renewable energy credits (RECs). Section 4 explains that the methods ISOs currently use to develop competitive offers for hybrid and co-located resources may not be appropriate for hybrid and co-located resources because they are designed for other resource types. Section 4 also explains that existing rules regarding physical withholding may need to be revised when applied to hybrid and co-located resources given their unique operating characteristics. Finally, section 5 of the paper presents possible solutions to revise ISO market power mitigation rules to better reflect the economic incentives and optimal operation of hybrid and co-located resources. Developing such solutions will involve the ISO working with hybrid and co-located resource owners to adapt market power mitigation rules related to reference levels, physical withholding, and other provisions in a manner that mitigates market power and also appropriately reflects the incentives, short-run marginal costs, and optimal operation of such resources.

1. INTRODUCTION

This paper is a follow on to an August 2020 paper ("Hybrid Issues Paper") prepared for the American Wind Energy Association that identified issues in four key areas that hybrid and co-located resources are likely to face in wholesale electricity markets in the United States.[1] These four key areas are: market participation; capacity value; interconnection; and market power mitigation. This paper provides more detail about the market power mitigation issues for hybrid and co-located resources and considers whether changes to ISO market power mitigation are needed to ensure that hybrid and co-located resources are treated in a non-discriminatory manner. Failing to adapt market power mitigation provisions to account for the unique incentives and operating characteristics of hybrid and co-located resources could result in these resources being inefficiently over-mitigated and could thus prevent such resources from offering their full value to ISO markets and their customers.

As noted in the Hybrid Issues paper, integrating hybrid and co-located resources into wholesale electricity markets, which are operated by independent system operators and regional transmission organizations (referred to herein is ISOs), is important because these resources offer benefits to the system, such as reducing the intermittency of variable energy resources and increasing the system's operational flexibility.[2] For clarity, like the Hybrid Issues paper, this paper adopts the hybrid resource definition from *Ahlstrom et al*., which defines a hybrid resource as "a combination of multiple technologies that are physically and electronically controlled by an owner/operator behind the point of interconnection (POI) and offered to the market or system operator as a single resource at that POI."[3] Unlike a hybrid resource, a "co-located resource" is a resource that physically shares a POI with another co-located resource(s) of a different type(s) but interacts with the ISO markets independently from the other co-located resource(s). This paper modifies the Ahlstrom et al. hybrid resource definition and defines co-located resources as "a combination of multiple technologies that are physically and electronically located behind a common POI and offered to the market or system operator as separate resources at that POI."

ISOs have largely established market participation and market power mitigation rules and procedures for the individual components of hybrid resources, but given their relative nascency, ISOs have not yet developed comparable rules and procedures for hybrid and co-located resources. However, as noted in the Hybrid Issues report, every ISO has either initiated or is in the late stages of completing stakeholder processes to develop new market rules or revise existing rules to enable more effective hybrid and co-located resource participation.[4] For example, ISOs have developed and refined rules to integrate variable energy resources (VERS)[5] and refined those rules over time. Additionally, the six ISOs subject to Federal Energy Regulatory Commission (FERC) jurisdiction are currently in the process of complying with FERC's December 2018 Storage Participation rule that sought to remove barriers to entry for electric storage resources (ESRs) and revise ISO market rules to better account for the unique physical operating characteristics of ESRs.[6]

Integrating hybrid and co-located resources in an efficient manner, such as the participation model contemplated by Ahlstrom et al., will require revisions to existing ISO market rules and operating procedures. As noted in the Hybrid Issues paper, determining which ISO rules and operating procedures should be revised and how, will require ISOs, stakeholders, and regulators to gain a better understanding and appreciation for the optimal use of hybrid and co-located resources so that revisions can be crafted that enable these resources to provide the highest value to ISO energy, ancillary services, and capacity markets. Such revisions will also require an understanding of the costs hybrid and co-located resources incur, which are heavily based on opportunity costs, and the revenues they are eligible to earn outside of ISO markets in order to understand their economic incentives. Understanding a hybrid or co-located resource's optimal operation, associated costs, and economic incentives will help identify appropriate methods to mitigate the market power of such resources, to the extent market power exists.

This is an important issue to address today because significant additions are expected in the near future - almost 500 GW hybrid and co-located capacity representing over ten percent of the ISO interconnection queues was planned as of April 2020.[7] Additionally, a December 2019 US Department of Energy's Berkeley Lab report about utility-scale solar explains that adding storage increases the value of a solar facility, and notes a "proliferation" of 38 completed or announced utility-scale hybrid power purchase agreements (PPAs) executed in recent years, totaling 4.3 GW of PV capacity and 2.6 GW ESR capacity.[8] The 38 hybrid projects are largely concentrated in Arizona, California, Hawaii, and Nevada, but hybrid resource additions are planned in states across the US as evidenced by the seven ISO interconnection queues.[9] The majority of hybrid and co-located resources will be PV paired with energy storage resources (ESRs).[10] Additionally, a July 2020 report by the Lawrence Berkeley Lab found that as of the end of 2019, 28% of new solar capacity is proposed as a hybrid (102 GW) and 5% of new wind capacity is proposed as a hybrid (11 GW).[11]

Existing VERs are also expected to add storage to existing installations. The Berkeley Lab notes the trend of battery retrofits at VER facilities has become more common since the Internal Revenue Service provided guidance that the cost of battery investments that charge at least 75% of their energy from a solar resource also qualify for the Investment Tax Credit (ITC), subject to certain conditions discussed further below.[12]

The market power mitigation provisions ISOs apply to hybrid and co-located resources will become more important as the penetration of these resources increases. A proactive approach to facilitate the integration hybrid and co-located resources, which will require developing appropriate market power mitigation procedures, will reduce potential barriers to entry for such resources, avoid potential disputes, and enable ISO markets to make the best use of hybrid and co-located resources.

The review of current ISO market power mitigation procedures described herein finds that current market power mitigation provisions in ISOs may need to be revised to better reflect the optimal use and costs, mostly borne as opportunity costs, of hybrid and co-located resources. Specially, the market power mitigation procedures used to account for hybrid and co-located resource opportunity costs and the methods used to identify physical withholding could result in the inefficient over-mitigation and subsequent sub-optimal use of hybrid and co-located resources in a manner that prevents these resources from realizing the full value they offer to ISO markets. Unless they are revised, certain ISO market power mitigation provisions could discourage hybrid and co-located resource entry and full participation in ISO markets.

2. ISO MARKET POWER MITIGATION

ISOs strive to establish clearing prices that reflect the system's cost to supply the required levels of energy, ancillary services, and (where applicable) capacity. Achieving this outcome requires that the resource offers used to determine ISO market clearing prices do not reflect the exercise of market power. Market power is generally defined as a supplier's ability to profitably raise the market clearing price above the competitive level. ISOs employ market power mitigation measures to help ensure that market outcomes, principally market clearing prices, resource schedules, and dispatch instructions, are consistent with competitive outcomes and thus free from the exercise of market power. In support of this objective, FERC requires jurisdictional ISOs to address market power concerns with market power mitigation provisions and assign independent market monitors to assess and report on the efficacy of those provisions. The Public Utility Commission of Texas (PUCT) also requires ERCOT to address market power and ERCOT also has an independent market monitor.

Accordingly, resource offers to provide energy, ancillary services, and capacity in ISO markets are potentially subject to market power mitigation. If, according to the market power mitigation provisions specified in the ISO tariff, a resource's offer potentially constitutes an exercise of market power, that resource's offer may be mitigated and replaced with a lower offer the ISO deems to better reflect the resource's actual costs (i.e., a competitive offer).

2.1 Market power mitigation overview

All ISOs in the US employ market power mitigation as an interim step in the market clearing process that performs automated market power screens and, if necessary, mitigates resource offers to estimates of short-run marginal costs prior to determining day-ahead and real-time market clearing prices and awards or dispatch instructions.[13]

In the day-ahead and real-time energy and ancillary services markets, ISOs seek to identify and mitigate the impacts of physical and economic withholding, which is anti-competitive behavior that generally raises market clearing prices above the competitive level. Competitive clearing prices in energy and ancillary services markets generally equal the short-run cost of the marginal resource providing the energy or ancillary service.[14] Although defined and identified differently across ISOs, physical withholding occurs when a resource fails to offer all of its available supply to the market (e.g., by falsely declaring an outage or understating a maximum operating limit). Economic withholding can have the same impact on clearing prices but differs from physical withholding because the resource owner makes the resource physically available to the market though a supply offer, but at offer prices that significantly exceed the resource's short-run marginal cost.

If a resource lacks market power, it generally has no incentive to physically or economically withhold capacity from ISO markets because it is not profitable to do so. However, if a resource owner possesses market power (either individually or as the owner of several resources) and chooses to exercise it by either physically or economically withholding its capacity to generate energy or provide an ancillary service, then it can do so profitably. Market power mitigation provisions are designed to identify and mitigate the extent to which such anti-competitive behavior results in market outcomes that are inconsistent with what would be observed in a competitive market.[15]

ISO market power mitigation generally consists of two steps. Since a resource must possess market power in order to exercise it, the first step is a market power screen to determine whether a given market participant, which owns either a single resource or a portfolio of resources, possess market power. A resource is more likely to possess market power at the local level than at the system level. If the market power screen determines that a resource likely possess market power, a second step determines if the resource is attempting to exercise market power by submitting an offer that exceeds its short-run marginal cost.[16] This second step compares a resource's supply offer to an estimate of that resource's short-run marginal cost, which is referred to herein as a "reference level". If a resource is found to both possess market power and potentially be exercising it, that resource's offer is mitigated to its reference level, or in CAISO, to the higher of its reference level and a competitive proxy price.

CAISO and PJM employ a "structural approach" to market power mitigation that automatically subjects resource offers to mitigation if a market power screen determines that the resource possesses market power. Although it is employed slightly differently, both CAISO and PJM employ the three pivotal suppler test that examines the market local structure to determine if the three largest suppliers available to supply demand in that local market are jointly required or "pivotal" to meet local demand.[17] The offers of resources found to be pivotal suppliers are automatically mitigated to reference level offers in PJM and to the higher of the resource's reference level and a competitive proxy price in CAISO.

The Midcontinent ISO (MISO), ISO New England (ISO-NE), New York ISO (NYISO) ,and Southwest Power Pool (SPP) employ "conduct and impact" mitigation, which unlike the structural approach to market power mitigation, involves two steps.[18] The first step in the conduct and impact approach involves performing a conduct test, a behavioral screen that initially determines whether a resource's offer exceeds its reference level by a pre-determined threshold. The second step, which occurs if the resource's offer fails the conduct test, determines whether the impact that the resource's offer has on market clearing prices exceeds a pre-determined threshold. Under the conduct and impact mitigation approach, a resource's offer is only mitigated if it fails both the conduct and impact tests. Finally, In what is commonly referred to as "big fish" mitigation, ERCOT only applies market power mitigation to market participants that own 5% of more of the installed capacity in ERCOT.[19] A market participant that is a big fish can submit a Voluntary Mitigation Plan with the PUCT.[20]

Finally, many ISOs also have mitigation measures to prevent the gaming of uplift payments. Such gaming opportunities typically arise if a resource is committed outside of the market clearing process to maintain reliability (e.g., local voltage support, posturing to acquire reserves, etc.). Resources can earn undue uplift payments by submitting relatively inflexible offer parameters, such as long minimum run time, high economic minimum, or a slow ramp rate. Both ISO-NE and MISO have mitigation measures designed to prevent resources from earning undue uplift payments to address such uplift gaming behavior.[21] Given the operating capabilities afforded by their storage capability, hybrid resources are expected to have relatively flexible operating parameters (e.g., short start-up time, fast ramping capability, short minimum run time, and low minimum operating levels).[22] This operational flexibility, along with existing ISO market power and monitoring provisions designed to prevent uplift gaming, should reduce concerns about hybrid resources submitting inflexible operating parameters solely to earn undue uplift payments. As stand-alone resources, co-located VER resources are unlikely to be committed and or dispatched out-of-market to address reliability needs and in the event an ESR is called upon, it also has flexible offer parameters.

2.2 Opportunity cost-based reference levels

As noted above, resource offers that are deemed to constitute an exercise of market are mitigated to a lower level (i.e., a reference level) that the ISO deems is more consistent with that resource's competitive offer. In the case of day-ahead and real-time energy markets, estimating a resource's short-run marginal cost is fairly straightforward if the resource faces relatively few fuel supply or operating limitations. For example, the short-run marginal cost of a thermal resource with access to sufficient quantities of fuel and relatively few operational constraints can be reasonably estimated by that resource's fuel costs and variable operations and maintenance expenses.

However, estimating a resource's short-run marginal cost is more difficult when the resource is "energy limited" due to limitations on its fuel supply or physical operation. A resource's operation may be limited or otherwise constrained by regulatory requirements (e.g., air permit that limits a resource's annual or seasonal operating hours), or other physical limits due to its operational characteristics (e.g., limited hydro reservoir or ESRs with limited durations). For certain energy limited resources, selling energy to the ISO market in the current interval limits that resource's ability to sell energy in future periods, which is referred to in economics as an "opportunity cost". In the context of ISO markets, opportunity costs are the costs associated with a resource foregoing its next most profitable alternative. Short-run marginal costs of energy limited resources in day-ahead and real-time energy markets, are largely borne as opportunity costs, and therefore their reference levels must accurately reflect those opportunity costs.

As described further below, every ISO but ERCOT permits a resource to include opportunity costs in its reference level, but methods vary across markets. Opportunity costs have typically been most relevant for energy limited hydroelectric (hydro) resources that face physical and regulatory operating restrictions (e.g., reservoir level restrictions, spill restrictions, etc.). Given the need to develop appropriate reference levels for all system resources, ISOs with significant quantities of hydro resources have established and refined procedures to calculate reference levels based on the opportunity costs of such resources.[23] A similar process will likely be necessary for hybrid and co-located resources as more of these resources enter ISOs markets.

The remainder of this section summarizes how ISO tariffs and other procedures permit resources to include opportunity costs in their reference levels. Many FERC-jurisdictional ISOs recently revised their guidelines and/or procedures to account for such opportunity costs to comply with FERC's Storage Participation rule, and these revisions are discussed below. Although a stand-alone ESR is different to a hybrid resource, examining the ISOs approach to calculating reference levels for such resources is instructive because it gives some indication of how ISOs might approach the calculation of opportunity cost-based reference level of hybrid resources because ISOs are likely, at least initially, to apply existing market rules and procedures to new resource types. The discussion below also provides an indication of the complexities inherent in producing third party estimates of a resource's opportunity cost. Furthermore, the standalone ESR components of co-located resources will be subject to market power mitigation provisions applied to ESRs, which in some ISOs involve reference levels that are likely to understate the ESR's true opportunity cost.

2.2.1 CAISO

CAISO refers to reference levels as Default Energy Bids (DEBs). There are currently three ways to calculate DEBs in CAISO: 1) Locational Marginal Price (LMP)-based DEBs calculated from the weighted average of the lowest 25% of LMPs at the resource's location in periods the resource was dispatched in the prior 90 days; 2) Cost-based DEBs calculated according to CAISO's Variable Cost option, a formulaic calculation based on a resource's heat rate, fuel prices, and variable O&M;[24] and 3) Consultation-based DEBs developed through the "Negotiated Rate" option available in the tariff, which may include opportunity costs.[25] CAISO did not propose any tariff revisions to comply with FERC's Storage Participation rule related to accounting for the opportunity costs of ESRs within DEBs. However, CAISO proposed - and FERC accepted - recent tariff changes to better reflect opportunity costs within DEBs.

In 2018, FERC accepted CAISO's proposal to permit use-limited resources to include opportunity cost adders in their DEBs.[26] CAISO proposed revisions because the commitment decisions made in the market clearing process do not explicitly recognize a resource energy use limitations that spanned more than the 24-hour operating day over which DEBs are typically calculated.[27] Although nominally available to all resource types, these particular revisions were focused on natural gas resources. As a result of the 2018 revisions, certain use-limited resource were permitted to include opportunity costs in their Cost-based[28] or Consultation-based DEBs to account for opportunity costs incurred over a longer period, such as a limitation on a resource's annual start-ups.[29]

The methods to include opportunity costs in resource DEBs were revised again when FERC accepted a CAISO proposal to the DEBs of hydro resources.[30] As discussed further below, CAISO proposed the revisions because the DEB procedures at the time did not adequately account for the opportunity costs of hydro resources in the Energy Imbalance Market (EIM), which were complex and differed significantly from other resource types in CAISO. Based on input from hydro resource owners, CAISO developed a "Hydro DEB" based on the higher of: 1) the hydro resource's long-term or geographic opportunity costs based on the resource's foregone opportunity to sell generation in the longer-term future, including bilateral sales to different geographic markets; 2) the hydro resource's short-term opportunity costs associated with short-term water use limitations; and 3) a "fail safe" option based on the cost of purchasing replacement energy from a natural gas resource in the EIM market should the hydro resource exceed its short-term limitations.[31]

2.2.2 ERCOT

Like the FERC-jurisdictional ISOs, ERCOT also mitigates resource offers that "significantly" exceed marginal cost to an estimate of that resource's short-run marginal cost made pursuant to the resource owner's Voluntary Mitigation Plans. ERCOT uses the Verifiable Cost Manual for market power mitigation. However, the Verifiable Cost Manual does not appear to permit resources to include opportunity costs in their reference levels or include any procedures for calculating a resource's opportunity costs. For example, the only mention to opportunity costs is referenced in the context of verifiable maintenance costs and notes that "Prospective opportunity costs, such as the loss of generating capacity during maintenance, are not verifiable and, therefore, will not be approved by ERCOT."[32] Instead, the Verifiable Cost Manual establishes mitigated offer caps for ESRs based on previous prices at the ESRs location adjusted by a multiplier and other adders.[33] According to ERCOT staff and the ERCOT market monitor, ESR opportunity costs vary over time and across resources, but such opportunity costs are "not a value that ERCOT currently can accurately measure."[34] Given these complexities, in 2019 ERCOT established an interim practice to set the offer cap for ESRs at the system wide offer cap, which can change within a given year but can currently be as high as $9,000/MWh.[35] ERCOT and its stakeholders will continue to study the issue and provide a report on the topic by December 31, 2023.

2.2.3 ISO-NE

Reference levels in ISO-NE can be established based on one of the following three methods: 1) offer-based reference level calculated as the lower of the mean or the median of a resource's accepted offers in competitive periods during the prior 90 days, adjusted for fuel prices;[36] 2) LMP-based reference level equal to the mean of the LMP at the resource's location during the lowest-priced 25% of the hours that the resource was dispatched during the previous 90 days in similar hours, adjusted for fuel prices;[37] 3) cost-based reference level developed in consultation with the market monitor and consistent with the methods prescribed in the tariff.[38] Opportunity costs may be included within the cost-based reference level based on factors including, but not limited to, the costs associated with complying with emissions limits, water storage limits, and other operating permits that limit energy generation.[39] ISO-NE did not propose any tariff revisions to comply with FERC's Storage Participation rule related to accounting for the opportunity costs in ESR reference levels. However, ISO-NE initiated a two-phase review of its opportunity costs for energy-limited resources in 2018. The first phase was focused on refinements to better reflect the opportunity costs of dual-fuel units with short-term fuel supply limitations.[40] The second phase will be focused on a more generalized approach to address energy-limited resource limitations of any type and over the horizon relevant to the specific limitations due to factors including annual (unpriced) emissions regulations, permit restrictions, seasonal river flows, storage capacity, or other factors, with horizons ranging from days to a full year.[41]

2.2.4 MISO

MISO reference levels can be established based on one of the following two methods: 1) offer-based reference level calculated as the lower of the mean or the median of the resource's accepted offers during competitive periods in similar hours or load levels during the prior 90 days, adjusted for fuel prices;[42] and 2) consultation-based reference level, which may include opportunity costs, legitimate risks, and justifiable technical characteristics, which is subject to the review and approval of the independent market monitor.[43] Regarding opportunity costs, the independent market monitor may request data or information relating to regulatory, environmental, technical, or other restrictions that limit the run-time or other operating characteristics of a generation resource.[44] MISO did not propose any tariff revisions to comply with FERC's Storage Participation rule related to accounting for opportunity costs in ESR reference levels.

2.2.5 NYISO

NYISO reference levels can be established based on one of the following three methods: 1) offer-based reference level calculated as the lower of the mean or median prior accepted offers in peak periods deemed to be competitive during the prior 90 days;[45] 2) price-based reference level calculated as the mean of the Location Based Marginal Prices (LBMPs)[46] at the resource's location during the lowest-priced 50% of the hours the resource was dispatched during the prior 90 days;[47] and 3) consultation-based level based on prior consultation with NYISO and calculated in accordance with NYISO specifications.[48]

NYISO revised the method resources can use to include opportunity costs as part of its compliance with FERC's Storage Participation rule. Specifically, NYISO permits resources to submit an "Opportunity Cost Adjustment" to their day-ahead and real-time energy offers. The Opportunity Cost Adjustment would increase the resource's reference level, which NYISO said would "prevent over-mitigation" of ESRs and "enhance price formation."[49] NYISO resources may now submit Opportunity Cost Adjustment and a justification for the request, which is subject to NYISO review.[50]

During the Storage Participation rule proceeding, NYISO clarified to FERC that it would calculate the opportunity costs of an ESR, which would be used to establish that ESR's reference level, based on NYISO's forecast of LBMPs in future intervals. NYISO provided an example of calculating and ESR's opportunity cost-based reference level in the day-ahead market, which was based on NYISO's estimation of the ESR's "optimal schedule". NYISO would determine the ESR's optimal schedule by "comparing the expected peak (high) and trough (low) LMBPs for the market-day."[51] Specifically, NYISO stated that "If an expected peak LBMP is greater than the trough LMBP divided by the resource's roundtrip efficiency, then this would indicate that a new profit can be achieved by scheduling injections and withdrawals."[52] NYISO explained that it would calculate an ESR's opportunity cost for a given hour as "the revenue foregone by an incremental deviation from the optimal schedule."[53] Under this approach, which FERC approved in 2019[54] NYISO resources can submit alternative opportunity cost calculations to NYISO, which would be approved or denied at NYISO's discretion.[55]

NYISO explained in stakeholder presentations, that the algorithm it will use to estimate an ESR's optimal schedule could involve the ESR charging and discharging multiple times per day, with the optimal number of cycles depending on expected LBMPs and the ESR's roundtrip efficiency.[56] NYISO would estimate as the day-ahead LBMPs based on the average LBMP for that hour during the prior 90 days adjusted for fuel price changes. Real-time LBMP forecasts would be based on the day-ahead LBMP for the corresponding hours.[57]

2.2.6 PJM

Resources in PJM calculate and submit their own reference levels, which are referred to as cost-based offers in PJM. The methods resources must use to calculate cost-based offers are contained in the Cost Development Guidelines (PJM Manual 15).[58] The fuel cost components included in incremental energy reference levels in PJM must be calculated according to a resource-specific fuel cost policy that a resource submits to both PJM and the independent market monitor, with PJM having the final authority to approve the fuel cost policy. According to PJM's Cost Development Guidelines, energy limited resources, such as ESRs, are permitted to include "Non-Regulatory Opportunity Costs" in their cost-based offers.[59] As specified in the PJM Operating Agreement, opportunity costs are calculated based on PJM Western Hub forward prices, taking into account historical basis differentials between the Western Hub and the resource's location during the prior three years.[60] PJM Manual 15 outlines the specific formulas resources must use to calculate non-regulatory opportunity costs, which can employ short-term method (calculated from daily forward prices within the next 30 days) or a long-term method (calculated from monthly Western Hub forward prices).[61] PJM resources may seek alternative methods to calculate opportunity costs which are subject to PJM approval as well as independent market monitor review.[62]

2.2.7 SPP

Similar to PJM, SPP resources calculate and submit their own reference levels, which are referred to as mitigated energy offers, pursuant to SPP's Mitigated Offer Guidelines.[63] SPP's Mitigated Offer Guidelines define methods to include opportunity costs in mitigated energy offers. In December 2019, as part of SPP's compliance with the Storage Participation rule, FERC accepted SPP's proposal to calculate an ESR's opportunity cost based on the sum of the charging cost, which accounts for roundtrip efficiency, and the resource's opportunity cost, calculated as the average expected LMP in next hour.[64] Specifically, SPP defines an ESR's opportunity cost as "the average profit in the next hour forgone by charging or discharging in the current hour."[65] SPP will calculate the expected LMP for the next hour based on the unweighted average of the LMPs in that same hour during the prior 45 days.

SPP's approach assumes that the ESR will make charge and discharge decisions on an hourly basis. A technical report by SPP's Market Monitoring Unit explained that an ESR's optimal charging pattern depends on the changes in expected price during the operating day. "Over a longer optimization period (e.g., an operating day or multiple operating days), there may be multiple peaks and troughs in prices. These multiple troughs and peaks can be evaluated to establish the optimization subperiods associated with the expected maximum profit."[66] The Market Monitoring Unit explained that under its methodology, the optimal path for a storage resource may involve charging and discharging multiple times per day:

> First, for an ESR positioned to discharge, the resource may have the potential to discharge and charge again before reaching the peak price hour associated with minimum expected profit. In other words, if a recharging opportunity exists, an 'early' discharge before reaching the expected maximum profit peak price operating hour(s) does not preclude the ESR from also producing in that peak price hour and realizing the associated profits. It only implies that some charging energy would have to be replaced at a potentially higher price than that paid for the initial charging energy, and thus the profit from discharge in the next peak price hour would be reduced, but not entirely eliminated.[67]

Similar to NYISO, the SPP approach calculates opportunity costs for ESRs based on deviations from the ISO's assumed optimal schedule for that ESR, and that optimal schedule assumes an energy arbitrage model where the ESR will charge and discharge continuously based on an expected price forecast developed by the ISO. The number of ESR cycles is based solely on expected prices and the roundtrip efficiency of the battery.

In response to protests of this method raised in SPP's Storage Participation rule compliance proceeding, the SPP Market Monitoring Unit argued that using the SPP's forecast of price in the next hour was appropriate because "The ESR has an opportunity to either charge or to discharge in each hour" and an ESR's "opportunity cost must be based on the next available opportunity to charge or discharge."[68] The Market Monitoring Unit concluded that "Recognizing this opportunity [to charge or discharge] in the next hour will maximize profit in nearly all cases. Conversely, failing to recognize the opportunity to recharge before the next peak will not maximize the profit for the ESR and will not serve load at a minimal production cost."[69] A resource can request an exemption from the requirement to calculate its opportunity costs in this manner by submitting a request to use an alternate proposal to the SPP Market Monitoring Unit, which has the authority to approve or deny the request.[70] SPP resources are also permitted to make intra-day changes to their mitigated energy offers.[71]

3. HYBRID AND CO-LOCATED RESOURCE INCENTIVES

To design appropriate market power mitigation for a resource, it is essential to understand that resource's optimal use, which can typically be achieved in a competitive market where that resource (and all other resources) submit competitive offers that accurately reflect its short-run costs. Failing to properly account for a resource's actual short-run costs, which may be borne primarily as opportunity costs, could result in over- or under-mitigating a given resource's offer and dispatching that resource at the incorrect level (an inefficiently high level if the reference level is too low and an inefficiently low level if the reference level is too high).

Dispatching a resource sub-optimally distorts market clearing prices away from efficient and competitive levels and reduces the revenues of that resource. Focusing specifically on over-mitigation, mitigating a resource's offer to a reference level *below* its short-run costs can also result in inefficient overuse of that resource and sends inaccurate price signals to market participants about the cost to serve the next increment of load on the system.[72] Under-mitigating a resource by setting its reference level above its sort-run costs can also result in inefficient outcomes, typically inefficiently low dispatch and/or inefficiently high prices if that resource possesses market power and chooses to exercise it. As a result, appropriate market power mitigation involves balancing the risks of under- and over-mitigating a resource and developing a system of market power screens and reference levels that permit the market to achieve a competitive and efficient outcome.

3.1 Hybrid and co-located resource configuration and optimal use

Apart from maximizing market surplus, in a competitive market with no market power a resource's optimal dispatch is also the most profitable outcome for the resource itself. Therefore, it is critical that a resource's reference level does not prevent or otherwise reduce the likelihood that the resource can submit offers in ISO markets that reflect their actual costs and thus result in optimal dispatch.

The configuration of a given hybrid or co-located resource governs its optimal use. As such, market power mitigation provisions for hybrid and co-located resources must recognize their optimal use. A hybrid or co-located resource's optimal and most profitable use depends on several factors, including the configuration of the resource, characteristics of the VER, and the non-ISO market revenues available to that resource. Hybrid and co-located resources can also earn revenues from ISO markets as well other markets, such as bilateral and Renewable Energy Credit (REC) markets, and from federal policies that promote the investment in and production of renewable energy.

The physical capabilities of a hybrid or co-located resource can vary along many dimensions, including the ratio of VER capacity and storage capacity (the "storage generation ratio"), and the ratio of the combined DC generation capacity (e.g., PV capacity plus the ESR's maximum injection capacity) to the AC inverter (the inverter loading ratio), and the ratio of installed capacity relative to the maximum injection limit at the POI. For example, the Berkeley Lab reports that of the 36 PV+ESR hybrid resources for which storage duration information is available, ESR storage duration ranged between 2 and 5 hours, with an average of 3.8 hours, and clear majority (26 of the 36 projects)of these hybrids had 4.0 hours of storage capability.[73] The composition and physical capabilities of a hybrid or co-located resource govern the revenues it can earn within and outside of ISO markets and thus determine its optimal use.

A PV+ESR hybrid or co-located resource, particularly a DC-coupled system, may be designed for the primary purpose of storing PV energy that would otherwise be curtailed or "clipped" by the ISO (or system operator in non-ISO regions) due system balancing requirements.[74] To qualify for the "battery ITC", at least 75% of the energy due to charge the battery must be derived from the PV array. The battery ITC is also prorated depending upon the amount of energy charged from the PV array. Once the 75% eligibility threshold is met, the ITC rises proportionately with percentage of energy the ESR charges from the PV array (e.g., a battery charged by the PV array 80% of the time is eligible for 80%, of the 30% ITC, or a 24% tax credit). A PV+ESR hybrid or co-located resource can only capture the full value of the ITC if the battery charges 100% from the associated PV array. The "battery ITC" clearly gives the ESR component of a PV+ESR hybrid or an ESR co-located with a PV different incentives than a stand-alone ESR.

As such, the optimal use of PV+ESR hybrids and co-located resources may not involve charging from the grid at all. Researchers expect hybrid and co-located ESR components to participate in the ITC and charge from the co-located PV array at least 75% of the time.[75]

Research has shown that the battery ITC incents residential PV+ESR systems to charge 100% of their energy in order to capture the full value of the ITC because, according to simulation results, revenue from the tax credit exceeds possible revenue from the standard arbitrage that might be expected of a stand-alone storage resource.[76] This fact was evident from stakeholder comments in CAISO's recent hybrid resource stakeholder process. Commenters suggested that the battery ITC would be instrumental in driving hybrid resource incentives (and thus optimal operation) in CAISO.[77] For example, 8minute stated that in an effort to guarantee eligibility for the battery ITC, "8minute expects project investors to insist that the onsite [electric storage system] plant controller monitor the onsite PV generation and prevent grid charging as a backup to the ISO commands."[78] 8minute added that the use of the battery component of the hybrid may change after the value of the ITC has been realized.[79]

Furthermore, a CAISO study found that warranty and battery degradation concerns associated with the excessive cycling that is likely to result from the intraday energy arbitrage envisioned by SPP and NYISO tends to make ESRs prefer modes of operation that provide ancillary services, such as regulation, as opposed to modes of operation driven purely by arbitrage. CAISO found that:

> [E]nergy storage resources are incentivized to reduce cycling through regulation services and only provide energy in the day-ahead or real-time market when prices are high. Several factors lead to this behavior. Storage resources on the system today degrade as they charge and discharge (cycle) energy. Second, storage resources receive a capacity payment from resource adequacy to reflect fixed costs. The majority of the fixed cost represent warranty contracts that specify an amount of cycling the resource can achieve over a pre-defined time horizon. A typical warranty for a four-hour storage device may allow for one cycle, a full discharge and charge, per day over ten years of operation. If the resource exceeds the limit, it could void its warranty, or reduce the "guaranteed" calendar life of the battery.[80]

Given ESR concerns about battery warranties and general wear and tear, CAISO found that "a majority of the 150 MWs sell very little energy into the system" with most batteries providing regulation.[81] Based on the operational experience of standalone ESRs in CAISO, operating an ESR in pure arbitrage mode as contemplated by SPP and NYISO is less likely than other ESR operating modes because, “it is unclear if actual price spreads in the electricity market are sufficient to clear any hurdle that would make it economic for these resources to shift large quantities of energy.”[82] As such, the energy arbitrage model ISOs such as SPP and NYISO propose to use as a default reference level for ESR (which can be adjusted per the resource’s request) is not appropriate for a hybrid resource or co-located PV + storage resource that also intends to claim the battery ITC.

PV+ESR hybrid and co-located resources are also expected to shift energy generated from the PV array to higher priced periods. For example, the Berkeley Lab found that most recent PV+ESR hybrids with PPAs “focus predominantly on the ability to shift energy for later use.”[83] Hybrid and co-located resources that perform this function maximize the value of the energy generated from the PV arrays by shifting energy from market periods when energy generally is available in surplus (and thus has a low marginal value) to higher priced periods when it has a higher value.

A hybrid or co-located resource could also be configured to provide maximum operating flexibility and the ability to charge the ESR from both onsite generation components and the grid. Such a hybrid or co-located resource would typically require AC coupling of the component resources. AC coupled hybrid and co-located resources are relatively more likely to include wind or both wind and solar as components than solar alone because wind facilities typically opt for the Production Tax Credit rather than the ITC. Such hybrid resources could be designed to provide additional operational flexibility to the ISO that would be provided through dispatchable energy offers, ramp capability, and ancillary services.

Depending on how ISO capacity market rules are designed and how hybrid and co-located resource capacity is accounted for in ISO capacity markets which is currently unclear in many ISOs[84], adding storage capability to an existing VERs or a planned VER could increase the capacity resources the resulting hybrid resource earns. Depending on the ISO’s capacity valuation rules and potential capacity revenues versus other potential revenue streams, some hybrid resources may also be configured to increase the capacity value of a hybrid resource and thus its capacity revenues. This is less of an issue for co-located resources, which will participate in the capacity market as separate resources and have capacity values based on their specific type as limited by any deliverability constraints at the POI.[85] Finally, VER hybrid and co-located resources could be designed to reduce the uncertainty associated with the intermittency of the VER component, which can lower the ISO’s production costs and enhance reliability by reducing the system’s need for balancing energy and ramp capability.

3.2 Hybrid resource economic incentives in ISO markets

As noted above, the physical configuration of a hybrid or co-located resource governs its optimal use. The revenue streams available to a hybrid or co-located resource, from both ISO and non-ISO markets, also govern the resource’s optimal use and can impact the economic incentives of such resources. As discussed further below, revenues earned outside of ISO markets are expected to give hybrid and co-located resources with VER components the incentive to generate as much energy as possible and generally make such resources less likely to physically or economically withhold generation as compared to resources that do not receive such revenues.

VER hybrids and the VER components of co-located resources can sell RECs, a revenue stream earned outside of ISO markets, which gives VER resources an additional incentive, over and above the energy price in ISO markets, to generate electricity. The incremental REC revenues VER resources earn from generating electricity make it relatively less likely that a VER resource has an incentive to withhold supply from the market. State REC eligibility requirements also impact a VER hybrid and with co-located VER incentives. For example, if energy charged from a qualifying VER and subsequently discharged to the grid during a future interval qualifies for RECs, the VER hybrid or co-located VER resource will have an additional incentive to use the ESR component to store VER generation relative to using the ESR component to arbitrage price differences between market intervals.

The PTC and comparable state policies (if applicable) also constitutes a revenue stream available to hybrid and co-located resources that change their incentives in a manner that makes them generally less likely to withhold capacity from ISO markets than resources that do not receive such revenues. Wind facilities typically opt for the PTC, which gives hybrid and co-located resources with wind components even more incentive to generate electricity relative to resources that to not receive the PTC. It is well documented that the combination of REC and PTC revenues can dramatically change the economic incentives of wind resources, and as discussed further below, wind resources have submitted negative offer prices in ISO markets, indicating that certain wind units are willing to pay up to the opportunity cost of not generating wind electricity, which is foregone REC and PTC revenue for some units.

Finally, the VER components of hybrid and co-located resources are likely to have sold some or all of the energy output of their resources through PPAs, which contractually establish the amount the VER component is paid (in $/MWh) for the VER component's output. As DOE reports note, a significant quantity wind and solar capacity in the US is financed through PPAs.[86] These PPAs could be with utilities with mandatory state RPS compliance requirements or with the growing voluntary market for RECs. Economic literature shows that selling power on a forward basis (such as through a bilateral arrangement) generally makes a seller less sensitive to market clearing prices in the spot market (day-ahead or real-time market in the context of ISOs) and generally gives the seller the incentive to offer its capacity more competitively in the spot market (i.e., reduces the resource's incentive to exercise market power).[87]

Although compensation schemes vary across PPAs, a standalone VER or a VER component of a hybrid or co-located resource is relatively less exposed to the ISO market price as compared to resources that have not sold their output forward in the bilateral market. As such, provided they don't have a larger portfolio that includes non-VER resources, hybrid and co-located resources with VER components that have PPAs, are relatively less likely to have an incentive to physically or economically withhold capacity in an effort to raise the ISO market clearing price because their compensation relies more heavily on the terms agreed to in the PPA as opposed to the ISO market clearing price.

3.3 VER offer behavior

Given the limited operational experience and deployment of hybrid and co-located resources in ISOs, there is no publicly available empirical evidence about their offer behavior as a class of resources. However, there is information about the typical offer behavior of standalone VER resources, a likely component of most hybrid and co-located resources. Unfortunately, with their fairly limited deployment, there is limited information about stand-alone non-hydro ESR offer behavior in ISOs. Hybrid and co-located resources will generally have different incentives, and thus different offer and operational behavior, to stand-alone VER or stand-alone ESR components,[88] so the offer behavior of stand-alone VERs is not a perfect proxy for the expected offer behavior of a hybrid or co-located VER resource.

Nonetheless, as noted above, depending on the configuration of the hybrid or co-located resource, the VER components of the resource will affect the resource's optimal use. Furthermore, the REC revenues, the PTC, and PPAs generally increase a hybrid or co-located VER's incentive to generate electricity and thus reduces the incentive to physically or economically withhold capacity from the ISO market relative to non-VERs that do not earn such revenues.

A review of the empirical evidence of offer behavior in ISOs corroborates this assertion and shows that stand-alone VERs – which face similar (although not identical) incentives to VER hybrids and co-located VERS given the REC and PTC revenues do not typically engage in physical or economic withholding. To the contrary, wind units in particular offer in a manner consistent with the incentive discussion above, and as a class, stand-alone wind and solar resources submit zero or negative energy offers. Contrary to any evidence of withholding, such offer behavior maximizes their chance of supplying energy to the ISO.

There is no empirical evidence of significant or pervasive market power abuse by wind units. For example, the PJM independent market monitor calculated that the average real-time markup component of LMP was $1.58/MWh in 2019, the average wind markup was negative, at -0.01/MWh.[89] While 2019 in PJM, 93.1% of the wind units on the margin in real-time had negative offer prices, 6.1% had zero offer prices, and only 0.8% had positive offer prices.[90]

Furthermore, wind units were only on the margin and thus set the market clearing price 3.81% of the time in 2019 and solar resources were on the margin 0.7% of the time in 2019.[91] The fact that wind and solar units are infrequently the marginal unit also suggest that they are often inframarginal when they are supplying electricity to the grid, however this low percentage in PJM is also due the fact that financial transactions (i.e., virtual bids and offers and up-to-congestion bids) set the market clearing price the majority of the time.

4. POTENTIAL MARKET POWER MITIGATION ISSUES FOR HYBRID AND CO-LOCATED RESOURCES

ISOs, market monitors, and regulators must develop market power mitigation provisions that differentiate between competitive offers that reflect a resource's actual costs and physical operating characteristics and offers that constitute an exercise of market power. As discussed above, it is critical that ISO market power mitigation provisions enable ISO markets to make the most efficient use of all resources while also ensuring competitive outcomes. Accomplishing these objectives for hybrid and co-located resources which will require, among other things, calculating reference levels as accurately as possible and ensuring that market power mitigation screens are aligned with the optimal use of hybrid and co-located resources.

Based on the review of the tariff provisions described in section 2, existing ISO market power mitigation procedures used to account for opportunity costs in hybrid resource reference levels and standalone ESRs, and the screens used to identify physical withholding could result in the inefficient over-mitigation of hybrid and co-located resources. These issues are discussed in turn below.

4.1 Including opportunity costs in reference levels

The current ISO provisions for opportunity costs in resource reference levels are inappropriate for hybrid resources and the standalone ESR components of ESR resources, which is likely to misestimate the actual opportunity costs of such resources. The "default" methods to include opportunity costs in reference levels discussed in section 2.2 above are largely based on the opportunity to arbitrage energy prices in different intervals, which is inconsistent with the optimal use of most hybrid and co-located resources and the actual opportunity costs of hybrid resources. As noted above, hybrid and co-located PV+ESR resources are not expected to use their ESR components purely for energy price arbitrage, and many PV+Battery Hybrids may not charge from the gird at all. Additionally, applying the default methods NYISO and SPP will use to calculate ESR opportunity costs to hybrid resources and the stand-alone ESR components could result in excessive cycling because these methods do not account for either the optimal use of these resources (e.g., shift solar energy from the time it is generated to higher priced intervals) or the impact that excessive cycling has on battery storage warranties. Finally, although resources in FERC-jurisdictional ISOs currently allow individual resources to propose alternative methods to include opportunity costs in their reference levels, this approach lacks transparency, limits the hybrid resource protection under the tariff, and imposes uncertainties and administrative burdens on Hybrid resources.

4.1.1 Hybrid resource reference levels

The current methods that exist to calculate resource short run costs, which are captured in reference levels, are not suitable for hybrid resources. As Ahlstrom, et al. observes, a hybrid resource is similar in many respects to a hydroelectric facility with storage capability, but with operating decisions based on the availability of wind and solar conditions as opposed to water. As such, a hybrid resource's storage injection and withdrawal decisions will occur on a much faster timescale (e.g., within an operating day) as compared to a hydroelectric facility's, which could occur over several months.[92] Stand-alone ESRs and VERs also share certain characteristics with hybrid resources, but are fundamentally different to hybrid resources.

Developing reference levels for hybrid resources will require an understanding of their costs, which will be borne primarily as opportunity costs. Similar to hydro resources, hybrid resources do not face fuel procurement costs, and face fairly low non-fuel variable O&M costs. However, hybrid resources with VER components do face use limitations given the intermittency of the VER, and duration capability of the ESR. A hybrid resource's low variable costs combined with the use limitations and non-ISO market REC, PTC, and ITC revenues result in short-run costs that will be primarily incurred as opportunity costs. Establishing reference levels for hybrid resources that closely align with their opportunity costs will ensure that ISO market power mitigation provisions do not prevent the resource from achieving its optimal profit-maximizing dispatch, which will also maximize the value it provides to the market.

The optimal use of hybrid and co-located resources will be based on a complex combination of factors, ranging from resource configuration, the ratio of storage capacity to generation, the operating characteristics of any component VER resources, the relative compensation for energy, ancillary services and capacity within ISO markets, eligibility for REC payments, the PTC, or ITC, and operation costs, including warranty costs. As noted above, hybrid resources and the ESR component of a co-located resource are unlikely to operate the ESR component under a pure arbitrage model, and if combined with a PV resource, nay not charge from the grid at all. Instead, the hybrid will likely be operated in a manner that maximizes the joint revenue available to the collection of component resources, some of which are derived from non-ISO markets.

Depending on the combination of factors described above, a hybrid resource, particularly a PV+ESR hybrid or an ESR co-located with a PV may elect to use the storage component purely as a means to prevent the curtailment of the PV arrays.[93] If the ESR is charged onsite from the PV array, the ESR resource generally has an incentive to inject the stored solar generation into the ISO energy market when it is most valuable to the system. However, the ESR component of a hybrid or co-located resource may elect to discharge the energy in the storage component during low priced hours if a discharge is necessary to create the capability to store solar generation in subsequent periods, comply with an ISO capacity supply obligation, or create the capability to provide ancillary series.

First Solar noted these tradeoffs, which all hybrid resources will have to make, during the CAISO Hybrid resources stakeholder process and explained that the ISO should not simply assume that hybrid resource storage components will be use to smooth out the variability (relative to forecasts) of VERs because "such a strategy would harm that resource's ability to meet its forecast in subsequent hours of the day and, in particular, during system net load peak conditions."[94]

Given the importance of opportunity costs, the optimal use of a hybrid or co-located resource will ultimately depend on the resource's estimate, which is complex, of the opportunity costs it faces. The resource itself has the best information to make such assessments (which could be verified by the market monitor). A hybrid or co-located resource's estimation of its own opportunity cost will depend on complex modeling assumptions that take into account the output of the VER resource, expectations of future energy prices, and the relative compensation, including non-ISO revenues, it will receive from providing different services to the ISO. These forecasts will likely differ from the default ISO opportunity cost calculations described above, most of which were based in part on ISO energy price forecasts.

For example, certain hybrid and co-located resources will produce high quality proprietary forecast of their VER, which can differ from the ISO's forecast for that VER. 8minute commented to CAISO that it employed sophisticated VER forecast techniques that were superior to CAISO's own forecasts for VER resources. Specifically, 8minute indicated that it "8minute found that [the VER] forecast quality of the next hour improved by ~200% when using onsite thermal imaging and advanced machine learning to provide feedback to the forecast provider based on what actually occurs onsite. 8minute includes ensemble satellite based forecasts with onsite thermal cloud imaging and advanced machine learning feedback of the of PV generation to improve the forecast."[95] Given this level of sophistication, certain hybrid and co-located resource assessments of their own opportunity costs will almost certainly differ from the ISO calculations for the resource.

4.1.2. Excessive cycling

As discussed above, SPP and NYISO opportunity cost calculations assume that an ESR will completely charge and discharge multiple times per day, based on the ISO's calculation of expected energy prices (which are based on historical rather than current market conditions) with the number of cycles only limited by the ESR's roundtrip efficiency. This assumed operation may be inconsistent with the optimal use of a both a stand-alone ESR and an ESR component of a hybrid or co-located resource because it could result in excessive cycling or degradation of the ESR.

For example, several stakeholders noted in the CAISO hybrid and co-located resource stakeholder process that batteries must limit the number of cycles per year to maintain their warranty.[96] First Solar also explained that such resources would also consider longer-term costs associated with the battery, noting that excessive cycling "may harm [the battery's] long-term life and associated value proposition as an [resource adequacy] resource."[97]

In response to the battery warranty issue, CAISO noted in the revised straw proposal that "The CAISO does not believe that number of cycles or their impact on battery warranties should be an input to the CAISO's market processes or systems. Any associated management of the storage component use should be performed by resource owner/operators and managed through their use of bids/offers and the self-provided forecast for hybrid resources"[98] CAISO added that hybrid and co-located resource participation is "heavily reliant on the management of the resource components and the onsite optimization of resource components will need to be performed by the resource owner, *not the CAISO*".[99]

4.1.3 Consultation-based reference levels

Resources that face short-run costs that differ propose alternative methods to include opportunity costs in their reference levels, and often elect to do so when the reference level calculations included in the tariffs and/or manuals are not suitable. For example, in the Hydro DEB proceeding, CAISO noted that hydro resources, which face short-run costs in the form of opportunity costs, "generally elect negotiated default energy bids" that are "negotiated separately and non-publicly."[100] CAISO explained that the hydroelectric resources chose to engage in these negotiations because CAISO's existing reference levels at the time do not accurately reflect their opportunity costs.

Relying on non-public negotiations with the ISO to determine appropriate reference levels also imposes uncertainties and increases a resource's cost of doing business. For example, CAISO noted that the non-public reference level negotiations "[do] not provide certainty for all hydroelectric resources because it is not transparent and does not provide a clear indication of how the resource's marginal costs will be valued".[101] Hydro resources in the EIM commented in the CAISO's Hybrid DEB proceeding that "The negotiated DEB option requires a lengthy negotiation process that may be a barrier to entry for smaller market participants, and has been unworkable in practice for new entrants with energy-limited hydroelectric storage resources whose opportunity costs cannot be fixed with precision."[102]

Consultation-based approaches to calculate resource reference levels also create ambiguity and uncertainty for the resource because the ISO and/or the market monitor determines the method that is ultimately used to calculate the resource's reference level. The lack of tariff specificity about how to calculate opportunity costs for a class of resources puts a resources in that class at a disadvantage when seeking recourse before regulators, because the resource has no tariff provisions to rely on in the event a dispute arises between the ISO and/or market monitor and the resource. Without more guidelines and specificity in ISO tariffs and public engagement with stakeholders, hybrid and co-located resources will face uncertainty similar to that faced by EIM hydro resources.

4.2 Physical withholding

Another issue with market power mitigation is differentiating between instances of genuine anti-competitive physical withholding and a hybrid resource optimizing the joint operation of its component resources. A hybrid resource that chooses instead to charge its storage resource exclusively from a PV component of the hybrid rather than take advantage of arbitrage opportunities through charges /discharges from/into the grid should not be regarded as physically withholding capacity.

Physical withholding is often associated with the must offer requirements attendant with a capacity supply obligation. Of course, hybrid resource with a capacity supply obligation should be expected to meet that supply obligation, which may differ for certain resources depending on the ISO. Ahlstrom posits a hybrid resource participation model where the hybrid resource faces the same obligations and non-performance penalties (if applicable) for non-performance. CAISO recently proposed to treat hybrid resources with VER components similar to stand-alone VER resources and allow them to have a must offer obligation based on a short-term forecast of the hybrid resource's output.[103] Regardless of the arrangement, the must offer requirements of hybrid resources must be clearly defined and any associated market power mitigations should reflect the physical capabilities of the resource.

Certain ISOs have expressed concerns about the probability that hybrid resources will exercise market power given their unique characteristics.[104] For example, in the CAISO hybrid and co-located resource stakeholder process, CAISO initially noted a market power concern, "The CAISO understands that this proposal for a [must offer obligation] for hybrid resources to be variable based upon the self-provided forecast may raise some concerns related to the potential for these hybrid resources to manipulate their forecasts to allow them to withhold capacity or allow a possibility for the exercise of market power." [105] However, CAISO ultimately determined that it would monitor hybrid resource VER forecasts for strategic behavior and, on an initial basis, will not apply market power mitigation provisions to hybrid resources but will likely do so in the future.[106]

Consistent with the hybrid resource incentives discussion above, CAISO noted that "The CAISO also anticipates that these VER-storage combo hybrids will be developed with an intended use case of maximizing renewable production … and therefore have an incentive to maximize their energy production. *Therefore, the CAISO also believes that any concerns related to the potential for physical withholding or market power are minimal*."[107] CAISO subsequently clarified that such a market power "exercise" could result from a hybrid resource submitting forecasts to capitalize on systematic differences between prices in CAISO's Fifteen Minute Market and real-time market, which would actually constitute behavior to game forecasts rather than exercise market power.[108]

With respect to the stand-alone ESR components of co-located resources, SPP's Market Monitor posits "Resources with local market power in generation can potentially exercise this market power by charging at uneconomically high prices. An ESR with local market power in generation that continues to charge when uneconomic has the same market impact as a generator with local market power withholding incremental generation."[109] This behavior is possible and could be monitored for and local market power mitigation already account for instances when a market participant owns multiple resources.

5. POSSIBLE SOLUTIONS

This section proposes possible solutions and paths forward to resolve the opportunity cost issues identified above and better align market power mitigation provisions with the unique characteristics of hybrid and co-located resources. An inherent tension exists between developing reference levels that are rigorous enough to prevent the exercise of market power while also avoiding overly prescriptive reference level calculation methodologies that substitute the ISO's or market monitor's estimates for the hybrid or co-located resource's more accurate assessment of its opportunity costs.[110] While difficult, it is possible to strike a reasonable balance between these two objectives. For example, in the recent past, ISOs have held stakeholder processes to refine opportunity cost calculations for certain classes of resources. Three such processes – two in CAISO and one in ISO-NE – were discussed above. A similar model could be employed to account for hybrid resources.

As FERC has observed in prior orders, calculating resource opportunity costs is complex and often case specific.[111] However, relying on non-public negotiations between a hybrid or co-located resource to develop consultation-based reference levels create uncertainties for the market participant. Furthermore, when FERC approved CAISO's Hydro DEB proposal, it expressed an interest in transparent calculations of resource opportunity costs "CAISO's proposal represents a transparent alternative to the existing negotiated DEB option that will allow hydroelectric resources with storage to reflect their opportunity costs in their DEBs, and in turn will ensure that hydroelectric resources will be dispatched when they are most needed."[112]

Additionally, CAISO noted that standardized and transparent opportunity cost options also have the benefit of treating different resource classes in a more comparable manner, "The CAISO believes a standard hydro DEB option is important to treat hydroelectric resources comparable with gas-fired resources, which have a standard transparent cost-based option."[113]

ISOs could use a similar approach that CAISO and its EIM stakeholders used in the Hydro DEB process to develop a generic and flexible method to calculate opportunity costs for hybrid resources. Similar to the Hydro DEB approach, the methodology should be flexible enough to account for the different opportunity costs that hybrid resources bear, which could vary across hybrid resource configurations as well as over the operating day and across seasons. Consistent with the options currently available to market participants, an individual hybrid resource could still propose an alternative methodology to determine its reference level if the generic opportunity cost methodologies do not reflect its actual costs.

CAISO observed in its Hydro DEB proceeding that CAISO's hydro DEB approach does not attempt to "precisely model each resource's operation…but is rather based on the typical operation of a hydroelectric resource."[114] ISOs should apply a similar approach based on CAISO's experience, because CAISO conceded that "A high degree of precision for each resource would result in the CAISO 'second-guessing' market participant's water management considerations"[115] which CASIO indicated it was not interested in doing.[116] In approving CAISO's Hydro DEB proposal, FERC also stressed the need to verify resource opportunity costs, "CAISO's proposal includes sufficient safeguards to verify that access and, thereby, ensure that the values used by the formula represent verifiable opportunity costs"[117] The methodologies employed to develop more accurate hybrid and co-located resource opportunity costs could also be verified by the market monitor.

To account for the impacts of battery cycling noted above, the generic opportunity cost methodology could be expanded to include opportunity cost adders that account for opportunity costs incurred over a longer time period than 24 hours. Incorporating the costs of battery degradation and maintaining warranties, which occur over a longer timeframe than a single operating day and can be viewed as a quasi-fixed cost over certain time periods, is managed in some ISOs as a major maintenance adder.[118] For example, as noted above, CAISO permits resources to include major maintenance adders to reflect opportunity costs related to major maintenance that is incurred as a function of a generators' run hours or starts. A similar approach could be adopted to account for the battery degradation costs experienced by hybrid resources, co-located ESRs, and stand-alone ESRs.

It is important to stress that none of the solutions proposed herein are intended to afford special treatment or otherwise confer advantages to hybrid or co-located resources relative to other resource types. Instead, adopting the solutions proposed above or alternative solutions that further refine opportunity cost calculations for hybrid and co-located resources would revise market power mitigation rules to better align with the economic incentives, optimal use, and operational characteristics of hybrid and co-located resources. Such revisions would revise existing ISO tariff provisions that could inefficiently disadvantage hybrid and co-located resources from fully participating in ISO markets. In the Storage Participation proceedings, FERC declined to provide additional clarity for hybrid resource participation in ISO markets, which was understandable at the time given low hybrid and co-located resource penetration levels that existed at the time.[119] This position may become untenable over time as a significant number of hybrid and co-located resources plan to enter ISO markets in the near future. FERC appears to recognize the importance of hybrid and co-located resource participation in ISO markets and held a technical conference on the subject in July 2020, suggesting that it is appropriate to consider whether ISO reforms are necessary.

ENDNOTES

[1] American Wind Energy Association, Facilitating Hybrid and Co-located Resource Participation in Wholesale Electricity Markets, prepared by Emma Nicholson of Concentric Energy Advisors, August 2020.

[2] Id. at 1. *See also* Mark Ahlstrom, Andrew Gelston, Jeffrey Plew and Lorenzo Kristov, *Hybrid Power Plants – Flexible Resources to Simplify Markets and Support Grid Operations*, 2019 working paper, (Ahlstrom et al.) https://www.esig.energy/wp-content/uploads/2019/10/Hybrid-Power-Plants.pdf.

[3] Ahlstrom et al., at 1.

[4] Appendix A, of the Hybrid Issues report "ISO Stakeholder Processes for Hybrid and Co-located Resources" summarized the status of these stakeholder processes as of July 2020.

[5] See e.g., Integration of Variable Energy Resources (Order No. 764), 139 FERC ¶ 61,246, June 22, 2012.

[6] Electric Storage Participation in Markets Operated by Regional Transmission Organizations and Independent System Operators, 162 FERC ¶ 61,127 (March 6, 2018) (Storage Participation rule).

[7] Hybrid Issues paper, Table 1 "Hybrid and Co-located Resources in ISO Interconnection Queues as of April 2020".

[8] Lawrence Berkeley National Laboratory, Mark Bolinger, Joachim Seel, and Dana Robson, *Utility-Scale Solar, Empirical Trends in Project Technology, Cost, Performance, and PPA Pricing in the United States-2019 Edition*, December 2019, at iv, 17, 39-40.

[9] Id. at Table 3, "Metadata for Online and Announced PV Hybrid Projects".

[10] Hybrid Issues paper, Table 1 "Hybrid and Co-located Resources in ISO Interconnection Queues as of April 2020".

[11] Ryan Wiser, Mark Bolinger, Will Gorman, Joe Rand, Seongeun Jeong, Joachim Seel, Cody Warner, and Ben Paulos, *Hybrid Power Plants: Status of Installed and Proposed Projects*, July 2020, at 15, *available at* https://eta-publications.lbl.gov/sites/default/files/hybrid_plant_development_2020.pdf

[12] Id. at 41. *See also* Internal Revenue Service, Private Letter Ruling 201809003, released March 2, 2018, https://www.irs.gov/pub/irs-wd/201809003.pdf. The ITC is scheduled to be phased out.

[13] In NYISO, prospective mitigation only occurs in Constrained Areas, currently defined as New York City. See NYISO, Market Administration and Control Area Services Tariff, Attachment H, Section 23.3.1.2.

[14] The marginal cost of providing ancillary services is typically borne as the opportunity cost of forgone energy revenues.

[15] Market power mitigation provisions also address other undesirable behavior such as uneconomic production and behavior designed to earn undue uplift payments. However, these provisions are less relevant for hybrid resources and thus not the focus of this paper.

[16] A market participant may possess market power without attempting to exercise it.

[17] FERC, Staff Analysis of Energy Offer Mitigation in RTO and ISO Markets, October 2014, at 4-5. https://www.ferc.gov/legal/staff-reports/2014/AD14-14-mitigation-rto-iso-markets.pdf.

[18] FERC, Staff Analysis of Energy Offer Mitigation in RTO and ISO Markets, October 2014, at 5-6. https://www.ferc.gov/legal/staff-reports/2014/AD14-14-mitigation-rto-iso-markets.pdf. For details on SPP, see Attachment AF of the SPP Protocols.

[19] PUCT Rules Section 25.504(c). This subsection notes that "Controlling 5% or more of the installed generation capacity in ERCOT does not, of itself, mean that a generating entity has market power."

[20] Id. at §25.504(e).

[21] See, e.g., Midcontinent Independent System Operator, Inc., 145 FERC ¶ 61,259 (2013); ISO New England Inc., 145 FERC ¶ 61,129 (2013).

[22] See e.g., Ahlstrom et al. at 7.

[23] See e.g., the discussion below about CAISO's 2019 revisions to opportunity cost calculations for hybrid resources in the Energy Imbalance Market.

[24] CAISO Tariff, Section 39.7.1.3.

[25] CAISO Business Practice Manual for Market Instruments, Section D.6.1.

[26] California Independent System Operator Corporation, 163 FERC ¶ 61,211, June 21, 2018), at P 32. In this Order, FERC directed CAISO to describe how CAISO will develop the forecasted prices used in the opportunity cost calculator in the CAISO tariff as opposed to the CAISO manuals.

[27] CAISO Transmittal, Docket No. ER18-1169-000, March 23, 2018, at 9.

[28] Specifically, the opportunity cost could be included in the proxy cost methodology of the cost-based DEB option.

[29] See e.g., California Independent System Operator Corporation, 163 FERC ¶ 61,211, June 21, 2018) at PP 12-13.

[30] *California Independent System Operator Corporation*, 168 FERC ¶ 61,213, Order on Tariff Revisions, September 30, 2019, at P 36.

[31] CAISO Transmittal, Docket No. ER19-2347-000, July 2, 2019, at 32-33 (CAISO Hydro DEB Proposal).

[32] ERCOT Verifiable Cost Manual, Section 9.1.2 (3), September 1, 2020, available at http://www.ercot.com/mktrules/guides/vcm/library.

[33] ERCOT Verifiable Cost Manual, Appendix 10, September 1, 2020.

[34] ERCOT, ESR Mitigation, Dan Jones, ERCOT and Steve Reedy, Independent Market Monitor, October 18, 2019,, at 2 http://www.ercot.com/content/wcm/key_documents_lists/194777/Key_Topic-3_ESR_Mitigation_10_18_2019.pptx.

[35] ERCOT, Consensus Key Topic Concept 3: Dispatch Pricing Mitigation BESTF Consensus, December 10, 2019, http://www.ercot.com/content/wcm/key_documents_lists/194777/BESTF_KTC_03_Dispatch_Pricing_Mitigation_Charging_During_Emergencies_120619.docx.

[36] ISO-NE Tariff, Market Rule 1, Appendix A, Section III.A.7.3.

[37] Id., Section III.A.7.4.

[38] Id., Section III.A.7.5.

[39] Id., Section III.A.7.5.

[40] ISO-NE, Energy Market Opportunity Cost Project, https://www.iso-ne.com/participate/support/customer-readiness-outlook/emoc-project

[41] ISO-NE Letter to NEPOOL, Opportunity Costs for Resources with Inter-temporal Production Limitation, July 27, 2018, at 1.

[42] MISO Tariff, Module D, §64.1.4.a.i.

[43] MISO Tariff, Module D, §64.1.4.a.ii. If insufficient information exists to calculate the offer-based reference level and the consultation-based option is not available, MISO may use an alternate calculation, such as The mean of the LMP or applicable MCP at the unit's location during the lowest 25% of the hours that the unit was dispatched during the previous 90 days for similar hours or load levels, adjusted for changes in fuel prices. *See* MISO Tariff, Module D, §64.1.4.b.ii

[44] MISO Tariff, Module D, Section 61.1.b.

[45] New York Independent System Operator, Inc. - NYISO Tariffs - Market Administration and Control Area Services Tariff, Section 23.3.1.4.1.

[46] NYISO has Location-Based Marginal Prices rather than LMPs but the two pricing calculations can be viewed as identical for purposes of this report.

[47] New York Independent System Operator, Inc. - NYISO Tariffs - Market Administration and Control Area Services Tariff, Section 23.3.1.4.2.

[48] New York Independent System Operator, Inc. - NYISO Tariffs - Market Administration and Control Area Services Tariff, Section 23.3.1.4.3.

[49] NYISO, Response to April 1, 2019 Letter and Notification of Implementation Issues that Necessitate Additional Limited Compliance Tariff Revisions in Docket No. ER19-467-000, May 1, 2019, at 9-10.

[50] Id. at 10.

[51] Id. at 11.

[52] Id. at 11.

[53] NYISO, Response to April 1, 2019 Letter and Notification of Implementation Issues that Necessitate Additional Limited Compliance Tariff Revisions in Docket No. ER19-467-000, May 1, 2019, at 11.

[54] *New York Independent System Operator, Inc*, 169 FERC ¶ 61,225 (December 20, 2019) at

P 75. Note that FERC rejected portions of NYISO's proposed compliance with the Storage Participation Rule that were unrelated to opportunity costs and directed NYISO to make further compliance filings.

[55] NYISO, Response to April 1, 2019 Letter and Notification of Implementation Issues that Necessitate Additional Limited Compliance Tariff Revisions in Docket No. ER19-467-000, May 1, 2019, at 11. See also NYISO Market Services Tariff, Section 23.1.4.1.3.

[56] NYISO, *Opportunity Costs for Energy Storage Resources*, presented to the Market Issues Working Group, June 11, 2019, at 17-18.

[57] Id. at 12.

[58] PJM Manual 15: Cost Development Guidelines.

[59] PJM Operating Agreement, Sch 2, Section 1.1(b)

[60] Id.

[61] PJM Manual 15: Cost Development Guidelines, Section 12.

[62] Id., Section 12.3.

[63] SPP Protocols, Appendix G.

[64] *Southwest Power Pool, Inc.*, 169 FERC ¶ 61,048, October 17, 2019, at PP 34-37. See also SPP Protocols, Attachment AF, section 3.2(I).

[65] SPP Protocols, Attachment AF, section 3.2(I).

[66] SPP Market Monitoring Unit, Dynamic Opportunity Cost Mitigated Energy Offer Framework for Electric Storage Resources, August 24, 2018, at 3. https://www.spp.org/documents/58525/dynamic%20opp%20cost%20esr%20mitigated%20offer%20framework_20180824.pdf.

[67] Id.

[68] SPP Market Monitoring Unit Comments, Docket No. ER19-460-000, February 15, 2019, at 2-3.

[69] Id. at 3.

[70] SPP Protocols, Appendix G, Section G.1.5.

[71] SPP 841 Compliance Filing, Docket No. ER19-460, at 11; SPP, OATT, Sixth Revised Volume No. 1, Attachment AF, section 3.2(J).

[72] See e.g., Kevin Wellenius and Susan L. Pope, *Challenges of Estimating Opportunity Costs of Energy-Limited Resources and Implications for Efficient Local Market Power Mitigation*, May 9, 2018, at 3, https://www.caiso.com/Documents/FTIConsultingWhitePaper-Challenges-EstimatingOpportunityCosts-Energy-LimitedResources-etc.pdf.

[73] Id. at 41.

[74] Lawrence Berkeley National Laboratory, Mark Bolinger, Joachim Seel, and Dana Robson, Utility-Scale Solar, Empirical Trends in Project Technology, Cost, Performance, and PPA Pricing in the United States-2019 Edition, December 2019, at 40-41. The report notes that NextEra's Citrus project in FL, which a inverter loading ratio of 1.65, was primarily configured to clip mid-

day solar energy.

[75] Will Gorman, Andrew Mills, Mark Bolinger, Ryan Wiser, Nikita Singhal, Erik Ela, Eric O'Shaughnessy, *Motivations and options for deploying hybrid generator-plus-battery projects within the bulk power system*, The Electricity Journal, Vo. 33 (2020) (Gorman et al.).

[76] See e.g., Denholm, P., Eichman, J., Margolis, R., August 2017. *Evaluating the Technical and Economic Performance of PV Plus Storage Power Plants*. Tech. Rep. NREL/TP-6A20-68737, National Renewable Energy Laboratory, Golden, CO. See also S. Varghese and R. Sioshansi, *The Price is Right? How Pricing and Incentive Mechanisms in California Incentivize Building Distributed Hybrid Solar and Energy Storage Systems*, working paper, https://cpb-us-w2.wpmucdn.com/u.osu.edu/dist/a/53641/files/2019/12/pv_storage.pdf for a discussion of the impacts of the battery ITC on distribution-connected systems.

[77] See e.g., Avangrid, First Solar, PG&E, and 8minute comments in the CAISO Hybrid Resource stakeholder process, http://www.caiso.com/StakeholderProcesses/Hybrid-Resources.

[78] 8Mintue Solar Energy, Stakeholder Comments on CAISO Hybrid Resource stakeholder process, August 12, 2019, at 2, http://www.caiso.com/InitiativeDocuments/EDPRComments-HybridResourcesIssuePaper-Aug162019.pdf.

[79] Cite.

[80] CAISO, Energy Storage and Distributed Energy Resources Phase 4, Final Proposal, August 21, 2020, at 19. http://www.caiso.com/InitiativeDocuments/RevisedStrawProposal-EnergyStorage-DistributedEnergyResourcesPhase4.pdf

[81] CAISO, Energy Storage and Distributed Energy Resources Phase 4, Final Proposal, August 21, 2020 at 18.

[82] CAISO, Energy Storage and Distributed Energy Resources Phase 4, Final Proposal, August 21, 2020 at 19.

[83] Hybrid Issues report at 17.

[84] Hybrid Issues report at 13-15.

[85] *Id*. at Appendix A.

[86] Lawrence Berkeley National Laboratory, Mark Bolinger, Joachim Seel, and Dana Robson, Utility-Scale Solar, Empirical Trends in Project Technology, Cost, Performance, and PPA Pricing in the United States-2019 Edition, December 2019, and Office of Energy Efficiency and Renewable Energy, 2018 Wind Technologies Market Report, at 21-22.

[87] Allaz, B. and J-L Vila, 1993, "Cournot competition, forward markets and efficiency", Journal of Economic Theory, vol. 59.

[88] Ahlstrom et. al at 8.

[89] Monitoring Analytics, 2019 State of the Market Report for PJM, March 2020, Table 3--109 Markup component of real-time, load-weighted, average LMP by primary fuel type and technology type: 2019 and 2019.

[90] Monitoring Analytics, 2019 State of the Market Report for PJM, Section 3, at167.

[91] Monitoring Analytics, 2019 State of the Market Report for PJM, Table 3-52 "Type of fuel used and technology (by real-time marginal units): 2015-2019.".

[92] Ahlstrom et. al at 5.

[93] See e.g., Ahlstrom at 10. Note that the majority of PV+battery PPAs signed to date appear to follow this mode of operation.

[94] First Solar Hybrid Resource Initiative Comments [cite].

[95] 8Minute Hybrid Resource Initiative Comments, August 12, 2019, at 3, http://www.caiso.com/InitiativeDocuments/8MinuteSolarEnergy-HybridResourcesIssuePaper-Aug132019.pdf

[96] 8Minute Hybrid Resource Initiative Comments, October 21, 2019, at 2. http://www.caiso.com/InitiativeDocuments/8minuteSolarComments-HybridResourcesStrawProposal.pdf

[97] First Solar Inc., Hybrid Resource Initiative Comments, October 21, 2019, at 2, http://www.caiso.com/InitiativeDocuments/FirstSolarComments-HybridResourcesStrawProposal.pdf

[98] CAISO, Hybrid Resources Revised Straw Proposal, December 10, 2019, at 57.

[99] CAISO, Hybrid Resources Revised Straw Proposal, December 10, 2019 at 64. Emphasis added.

[100] CAISO Hydro DEB Proposal Transmittal, Docket No. ER19-2347-000, July 2, 2019, at 33.

[101] Id at 30.

[102] Joint Commenters, Docket No. ER19-2347-000, filed July 23, 2019, at 5.

[103] CAISO, Hybrid Resources Revised Straw Proposal, at 45.

[104] Ahlstrom et. al, at 10-11.

[105] CAISO, Hybrid Resources, Straw Proposal, September 30, 2019, at 32-33. http://www.caiso.com/InitiativeDocuments/StrawProposal-HybridResources.pdf

[106] CAISO, Hybrid Resources – Revised Straw Proposal, April 29, 2020, at 16. http://www.caiso.com/InitiativeDocuments/SecondRevisedStrawProposal-HybridResources.pdf

[107] CAISO, Hybrid Resources, Straw Proposal, September 30, 2019, at 32-33, emphasis added. http://www.caiso.com/InitiativeDocuments/StrawProposal-HybridResources.pdf

[108] CAISO, Hybrid Resources, Revised Straw Proposal, December 10, 2019, at 45-46.

[109] SPPP, Mitigated Offer Framework, 2018 at https://www.spp.org/documents/58525/dynamic%20opp%20cost%20esr%20mitigated%20offer%20framework_20180824.pdf at 3.

[110] The Hybrid resource itself is clearly in the best position fully understand and assess the nature of its costs, including opportunity costs, which can subsequently be reviewed by the market monitor.

[111] *Southwest Power Pool, Inc.*, 169 FERC ¶ 61,048, Order on Compliance Filing and Instituting Section 206 Proceeding (October 17, 2019), at P 36.

[112] *California Independent System Operator Corporation*, 168 FERC ¶ 61,213, Order on Tariff Revisions, September 30, 2019, at P 36.

[113] CAISO Hydro DEB Proposal Transmittal, Docket No. ER19-2347-000, July 2, 2019, at 33.

[114] CAISO Hydro DEB Transmittal at 40-41.

[115] CAISO Hydro DEB Transmittal at 40-41.

[116] CAISO Hydro DEB Transmittal at 40-41.

[117] *California Independent System Operator Corporation*, 168 FERC ¶ 61,213, Order on Tariff Revisions, September 30, 2019, at P 36.

[118] Market monitors also disagree about whether major generator maintenance costs are appropriately considered short-run marginal costs. For example, at the 2014 FERC Technical Conference on Market Power Mitigation, David Patton and Joe Bowring disagreed about whether major maintenance adders are appropriately considered short-run marginal costs.

[119] *Southwest Power Pool, Inc.*, 169 FERC ¶ 61,048, October 17, 2019, at P 38.

Hybrid and Co-located Resource Market Power Mitigation

An examination of the applicability of current ISO/RTO mitigation provisions to hybrid and co-located resources.

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