Pacific Northwest
NATIONAL LABORATORY

PNNL-34472

FERC Order No. 2222 and Considerations for Distributed Wind

July 2023

Rebecca M Tapio
Alice Orrell

U.S. DEPARTMENT OF ENERGY

Prepared for the U.S. Department of Energy
under Contract DE-AC05-76RL01830

DISCLAIMER

PACIFIC NORTHWEST NATIONAL LABORATORY
operated by
BATTELLE
for the
UNITED STATES DEPARTMENT OF ENERGY
under Contract DE-AC05-76RL01830

Printed in the United States of America

Available to DOE and DOE contractors from the
Office of Scientific and Technical Information,
P.O. Box 62, Oak Ridge, TN 37831-0062;
ph: (865) 576-8401
fax: (865) 576-5728
email: reports@adonis.osti.gov

Available to the public from the National Technical Information Service
5301 Shawnee Rd., Alexandria, VA 22312
ph: (800) 553-NTIS (6847)
email: orders@ntis.gov <https://www.ntis.gov/about>
Online ordering: http://www.ntis.gov

PNNL-34472

FERC Order No. 2222 and Considerations for Distributed Wind

July 2023

Rebecca M Tapio
Alice Orrell

Prepared for
the U.S. Department of Energy
under Contract DE-AC05-76RL01830

Pacific Northwest National Laboratory
Richland, Washington 99354

Executive Summary

The Federal Energy Regulatory Commission (FERC) issued Order No. 2222 in October 2020. The rule directs Regional Transmission Organizations and Independent System Operators (ISOs) to amend their tariffs and participation models to accommodate heterogeneous distributed energy resource (DER) aggregations in the wholesale energy markets that they operate, including capacity, energy, and ancillary service markets. The Commission issued the rule to better capture the benefits provided by DERs deployed in the United States, whose use has been expanding rapidly.

The Commission defines DERs as “any resource located on the distribution system, any subsystem thereof or behind a customer meter,” including but not limited to “electric storage resources, distributed generation, demand response, energy efficiency, thermal storage, and electric vehicles and their supply equipment.”

The rule aims to increase DER participation in wholesale markets by allowing the creation of DER aggregations, in which multiple DERs that are too small to meet minimum capacity requirements for wholesale markets individually would be able to participate in markets as a single unit.

As of June 20, 2023, all ISOs have filed initial compliance plans and a number have begun implementation. Compliance dates range from 2024 to 2029, with Midcontinent ISO having the latest date of compliance proposed for 2029. Southwest Power Pool still has an outstanding date, having no final order yet from FERC, but a target date of the third quarter of calendar year 2025.

The rule, which is technology agnostic and requires ISOs to create participation plans that accommodate different DERs, provides an opportunity for distributed wind market expansion. In addition, distributed wind can bring benefits to heterogenous DER aggregations. These benefits include resource diversity (i.e., a complementary generation profile to other types of distributed generation), its small footprint and ability to be co-located with load, and its potential to provide frequency response, voltage support, and black start services, among other ancillary services.

This report provides a status update on FERC Order No. 2222, the current state of ISO compliance, and information relevant to the distributed wind industry as DER aggregators and other stakeholders expand their participation to wholesale energy markets.

Acknowledgments

The authors would like to thank Sarah Barrows and Kamila Kazimierczuk for their guidance in developing this report and Catie Himes for editing the report.

Acronyms and Abbreviations

DER	distributed energy resource
ERCOT	Electric Reliability Council of Texas
FERC	Federal Energy Regulatory Commission
ISO	Independent System Operator
MISO	Midcontinent Independent System Operator
NYISO	New York Independent System Operator
PV	photovoltaic
RERRA	Relevant Electric Retail Regulatory Authorities
RTO	Regional Transmission Organization
SPP	Southwest Power Pool

Contents

Figures

Tables

1.0 Introduction

In October 2020, the Federal Energy Regulatory Commission (FERC) issued Order No. 2222, directing the Regional Transmission Organizations (RTOs) and Independent System Operators (ISOs) under its jurisdiction to amend their tariffs and participation models to accommodate heterogeneous distributed energy resource aggregations in the wholesale energy markets that they operate (FERC 2020b). These include capacity, energy, and ancillary service markets that meet electricity demand in real time and account for future reliability. Among the North American ISOs, the Electric Reliability Council of Texas (ERCOT) is unique in that it operates entirely within the Texas Interconnection, and thus does not fall under FERC's regulatory authority for Order No. 2222 due to limitations enacted as part of the Federal Power Act (U.S.C. 1920; Walton 2022). Due to the similar purposes of RTOs and ISOs, this report will refer to both of these entities as ISOs.

This report provides a status update on FERC Order No. 2222, the current state of ISO compliance, and information relevant to the distributed wind industry as distributed energy resource aggregators and other stakeholders expand their participation to wholesale energy markets.

Anticipating that new types of distributed energy resources (DERs) will emerge in the future, FERC wrote the rule to apply across broad categories of technology. The order may have considerable impact on distributed generation sources, including distributed wind, which previously could not participate in wholesale markets due to the former minimum sizes for deployable resource capacity. For the purpose of the rule, FERC defines DERs as "any resource located on the distribution system, any subsystem thereof or behind a customer meter," including but not limited to "electric storage resources, distributed generation, demand response, energy efficiency, thermal storage, and electric vehicles and their supply equipment" (FERC 2020b).

Previously, behind-the-meter DERs would only provide benefits to individual users. These benefits include avoided energy costs from demand management, power support during outages and increased resilience, improved reliability and power quality, revenue from grid operators or providers for producing more energy than is consumed by the customer, and other financial incentives based on local policies (GL 2014; IEA 2022).

DERs provide a number of benefits, including load shifting, increased power system capacity and flexibility, ancillary service values, non-wired alternatives, and voltage support for higher levels of renewable energy on the grid (Zhou, Hurlbut, and Kaifeng 2021). They can also improve power system reliability and avoid transmission and distribution losses from energy transportation when they are co-located with load (Cory 2020).

The rule aims to increase DER participation in wholesale markets by allowing the creation of DER aggregations, in which multiple DERs that are too small to meet minimum capacity requirements for wholesale markets individually would be able to participate in markets as a single unit. FERC defines a DER aggregator as "an entity that aggregates one or more distributed energy resources for purposes of participation in the capacity, energy and ancillary service markets of the regional transmission operators and independent system operators" (FERC 2020b).

Order No. 2222 requires coordination between the ISOs, the DER aggregator, Relevant Electric Retail Regulatory Authorities (RERRAs), and distribution utilities in both day-ahead and real-

time functions. This presents new challenges because ISOs have historically had no visibility on the distribution system, and their interactions with distribution utilities are limited or run through intermediaries, such as Local Control Centers (George 2022).

The rule comes as DER deployment in the United States has been increasing across the board due to a number of factors, including tax incentives; lower turbine, solar panel, and material construction costs; and new renewable energy targets that have enabled growing levels of deployment (Fasching 2023; Jamison 2022). Current DER technologies typically include one or more of the following: generation, storage, energy efficiency, and demand-response services. Distributed generation includes solar photovoltaics (PV) and distributed wind.

Small-scale solar PV generation capacity in the U.S. has increased from 6,221 megawatts (MW) in 2014 to 42,917 MW in 2022 (EIA 2023, 2015). Distributed wind cumulative capacity has also grown from 808 MW in 2014 to 1,104 MW in 2022 (Orrell, Kazimierczuk, and Sheridan 2022).

This rapid uptake of DERs is occurring as the aging U.S. electric grid continues to use technology and equipment that was predominately built and designed during the twentieth century with load and generation sources in mind that are very different than the projected resource mix of the future (Aniti 2018). FERC Order No. 2222 was intended to enable the full use of DER potential in wholesale markets to ensure the lowest possible cost for power and to update the work of ISOs to current technological conditions.

As of June 2023, all six ISOs under the jurisdiction of Order No. 2222 have submitted their initial compliance plans detailing how they will adjust their tariffs and processes to integrate DER aggregators into the wholesale energy markets they operate. Some have already gone through several rounds of compliance filings after incorporating FERC's feedback, and a number are waiting on final orders from the Commission to begin implementing their plans. Having met the regulatory deadlines accorded to them by the rule, the ISOs are now either waiting for approval, preparing to supply more information to the Commission or stakeholders who have submitted comments, or are implementing their approved compliance plans.

For the distributed wind industry, this phase of the process will include further observation of FERC's decisions and the stakeholder engagement done by their local ISO, in addition to any consultation prospective DER aggregators are beginning in light of compliance filings. The implementation of this order may provide opportunities for members of the industry to enter wholesale markets as part of a heterogeneous DER aggregation. This will depend on the competitive nature of wholesale prices as they compare to the retail market that distributed wind currently serves. Additionally, the treatment of multi-nodal aggregations, which may serve rural and remote areas that are also valuable locations of distributed wind generation, will be a vital factor for the economics of wholesale market entry. The Commission does not require that ISOs allow DER aggregations across multiple nodes, but several ISOs are still in consultation with FERC on whether they will allow multi-nodal aggregations in their compliance plans due to technological and system constraints.

2.0 Background

In the late 1990s, FERC issued Order No. 888, which required all public utilities to provide wholesale market users nondiscriminatory access to transmission services under similar terms that vertically integrated utilities would provide to themselves (FERC 1996). In states that

restructured their energy markets accordingly, electric utilities were required to separate generation from other aspects of their businesses.

Many retained their transmission and distribution assets to continue providing these necessary services, but the generation of power became competitive. This process created retail customer choice and wholesale energy markets, which are now managed in some states by voluntarily created RTOs and ISOs (Cleary and Palmer 2020). Although terms defining ISOs were first created in Order No. 888 and those for RTOs were established in FERC Order No. 2000, the two are typically used interchangeably.

States that did not choose to restructure their energy systems remained traditionally regulated bilateral markets that are run by vertically integrated utilities who control the generation, transmission, and distribution of electricity to customers (Gallo 2022; EPA 2023). These utilities are regulated by state public utility commissions or public service commissions. The traditionally regulated areas of the country are the white spaces in the United States map in Figure 1.

Two-thirds of the electricity load in the United States is served in ISO regions (FERC 2023a). ISOs manage the transmission system for regional reliability and competitive neutrality in wholesale electricity markets. A primary focus is equal access for different types of power suppliers to the electricity grid. They also purchase balancing services for the system and manage markets for energy and grid services, including maintaining system reliability (FERC 2023a). The balancing authority areas of the North American RTOs/ISOs can be seen in Figure 1 below.

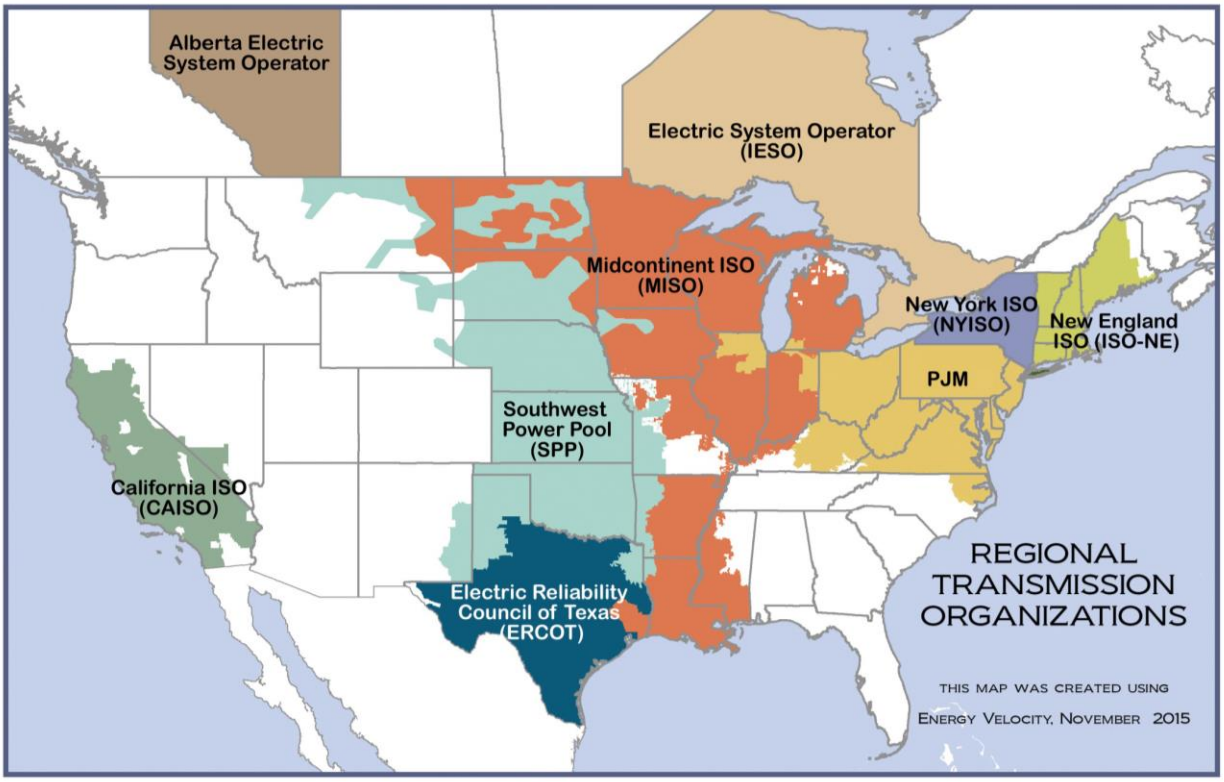

Figure 1. Map of Regional Transmission Organizations/Independent System Operators (FERC 2015)

ISO markets were designed with synchronous baseload generators in mind, which have different physical and technological considerations than DERs, which are inverter-based. These generators can typically be planned to distribute energy to the grid a day ahead and are not intermittent or variable the way that some forms of distributed generation are, including available solar and wind resources.

There are multiple types of markets helmed by ISOs due to their status as voluntarily established regional organizations, many of which cover part or all of several states. Each state may have a partially or fully deregulated energy market, which affects what types of market an ISO may manage (NGA 2023). The primary classes of electricity markets are described in the rest of this section and detailed by ISO in Table 1.

All ISOs operate on a two-settlement system, which includes day-ahead and real-time markets that price and schedule the production of energy. The day-ahead market is based on forecasted load for the next day and represents roughly 95% of market transactions, sales, and purchases of electricity (NGA 2023). The units that are available for dispatch are ordered by least operating cost to meet demand for the lowest possible price (Cleary and Palmer 2020).

Real-time markets represent the remaining transactions as demand changes throughout the day, accounting for the difference between the day-ahead schedule and actual variations in supply and demand. Prices vary by the minute, and these markets coordinate the dispatch of additional generation to meet changing needs across a large geographical area at regular intervals and to ensure balance at all times (typically once an hour and once every five minutes) (Cleary and Palmer 2020).

All ISOs also operate ancillary services markets, which acquire services used to maintain transmission system frequency and operation and support reliability. These services include but are not limited to frequency control, spinning reserves, standby and reactive power, and voltage control and support (NGA 2023). Several ISOs operate capacity markets, which ensure that reliability standards set by the North American Electric Reliability Corporation (NERC) are met for adequate generating capacity to serve peak electricity demand in the future (Cleary and Palmer 2020).

Table 1. Markets Operated by Independent Service Operators (NGA 2023)

ISO	Day-ahead	Real-time	Capacity	Ancillary services	Congestion revenue rights	Operating reserve
California ISO (CAISO)	X	X		X	X	
ERCOT	X	X		X	X	
ISO New England (ISO-NE)	X	X	X	X		
Midcontinent ISO (MISO)	X	X	X	X		
New York ISO (NYISO)	X	X	X	X		
PJM Interconnection (PJM)	X	X	X	X		
Southwest Power Pool (SPP)	X	X		X		X

3.0 Regulatory Motivation and Implementation

FERC is a federal government agency that regulates the bulk power system. The agency regulates the interstate transmission of electricity, natural gas, and oil, is involved in siting decisions for oil and natural gas pipelines, and reviews certain corporate transactions by electricity companies, including mergers and acquisitions. FERC is responsible for regulating electric grid reliability and has jurisdiction specifically over the “users, owners, and operators” of the bulk power system (FERC 2022). Some of these entities, including federal power agencies, municipal utilities, and rural electric cooperatives, were historically excluded from economic regulation by the Commission, but they were brought under this regulatory umbrella by Congress in the Energy Policy Act of 2005 (FERC 2020a).

This regulatory umbrella is limited to interconnection, market manipulation, and reliability standards set by NERC for one ISO, ERCOT. The Federal Power Act, which grants FERC the authority to regulate energy sales in interstate commerce, limits that authority when sales remain within a single state. ERCOT operates entirely within the Texas Interconnection, one of the alternating current (AC) power grids in North America. Therefore, Order No. 2222 does not apply to ERCOT, though the ISO has reportedly authorized a pilot project evaluating DER aggregations in its wholesale electricity market (Walton 2022; U.S.C. 1920).

The Commission has previously engaged in actions intended to remove market barriers for clean technologies (Americas 2021). On March 15, 2011, FERC issued Order No. 745, which requires that demand-response providers who reduce load in wholesale markets be compensated at the same rate as if they met the need by generating electricity (FERC 2011). On February 15, 2018, they issued Order No. 841, later affirmed in Order No. 841-A, which directed ISOs to remove barriers to the participation of electric storage resources in the markets operated by ISOs (FERC 2019). The Notice of Proposed Rulemaking stage of this order included provisions to cover aggregated DERs, but upon receiving public comment from stakeholders including the ISOs, NextEra Energy, the Electric Power Research Institute, FERC agreed to continue evaluating requirements for integrating DER aggregations in wholesale markets in a future order. (FERC 2019)

These provisions and the public commentary that followed led to the issuance of Order No. 2222 on September 17, 2020. The order requires that ISOs amend their tariffs to allow heterogeneous distributed energy resource aggregations to participate and compete in wholesale electricity markets. The goal of this rule is to remove market barriers for DER participation and ensure just and reasonable rates by improving competition in wholesale power markets.

The rule requires that ISOs establish DER aggregations as a type of market participant and allow them to directly participate in markets, allow aggregators to register aggregations under one or more participation models that accommodate their physical and operational characteristics, and establish a minimum size requirement for aggregations that do not exceed 100 kW.

ISOs must also address the following for DER aggregations: locational requirements, distribution factors and bidding parameters, information and data requirements, metering and telemetry requirements, coordination between the RTO/ISO, the aggregator, the distribution utility, and relevant electric retail authorities, modifications to the list of resources in a DER aggregation, and market participation agreements for DER aggregators (FERC 2020b). As

noted in the order, rules governing participation in markets are “designed for traditional resources and in effect limit the services that emerging technologies can provide.”

Before Order No. 2222, the role of DERs in wholesale markets was limited to demand-response services, in which customers reduce their electricity consumption due to increased energy prices or are provided incentive payments to induce load reduction. FERC issued two additional orders in 2021 clarifying Order No. 2222’s interaction with two previously issued rules, Order No. 719 and 719-A, in March and June of 2021, respectively. No. 2222-A was an initial clarification of the interaction between the rules, followed by No. 2222-B that was a retraction of that previous clarification.

In the order, FERC cited a number of benefits of integrating DERs into planning and operations as part of the motivation for its issuance. Doing so will help account for their impacts on installed capacity requirements and day-ahead energy demand, as well as reducing uncertainty in load forecasts and the risk of over-procurement of resources, which increases costs (FERC 2020b). The Commission also noted that DER aggregation participation will help identify where new capacity is most needed using price signals, which can help alleviate congestion and its costs during peak load conditions and reduce the costs of transmitting energy to persistently high-priced load pockets.

FERC states that aggregation of DERs can help address commercial and transactional barriers to DER participation by enabling cost-sharing of necessary metering, telemetry, and communication equipment. The benefits of DERs in aggregate can be increased if they are co-located with load due to their reduced lead time and ability to improve reliability and reduce system costs due to their shortened development time and capability to respond to short-term system needs (FERC 2020b).

The final order[1] required ISOs to submit compliance filings detailing their tariff changes within 270 days of publishing in the Federal Register, setting a deadline of July 19, 2021. The full list of directives included in Order No. 2222 can be found in Appendix A. As of June 20, 2023, all ISOs covered by FERC’s authority have filed initial compliance plans and a number have begun implementing these plans. Compliance dates range from 2024 to 2029, with MISO having the latest date of compliance proposed for 2029. SPP still has an outstanding date, having no final order yet from the Commission, but a target date of Q3 of 2025. Table 2 below provides greater detail on the status of ISO implementation. In response to feedback from FERC on their compliance plans, ISOs have had to submit revisions that align shared terms and the size of

[1] Federal agencies in the United States must be authorized by law to issue legislative rules, which have the force of law and regulate a variety of conduct, including standards and market function. During the regulatory process, the agency examines an issue that can be addressed through regulation, proposes a draft standard, collects public feedback, and then issues a final rule or standard that includes responses to that feedback.

Agencies issue notices in the Federal Register that include relevant information and documents justifying the rule, which is then followed by a public comment period during which feedback on the rule can be submitted to the agency. Once the Final Rule has been integrated into the Code of Federal Regulations, parties subject to the rule (in the case of Order No. 2222, ISOs) go through the iterative process of submitting compliance plans to FERC. Once initial plans have been filed, the Commission can respond in multiple ways to accept the plans fully or partially, requiring changes or answers to specific questions (Register 2011).

permittable aggregators, as well as double counting provisions and other technical compliance directives (ISO-NE 2022).

Table 2. Current Status of ISO Implementation of FERC Order No. 2222 as of June 20, 2023 (FERC 2023b)

ISO	Compliance Date	Docket Number	Current Status
CAISO	November 1, 2024	ER21-2455	Second Compliance Filing was accepted by FERC on 5/18/23 after the original proposal and First Compliance Filing partially complied with order requirements. (Accession Number: 20230518-3044)
MISO	Proposed: October 1, 2029	ER22-1640	After submitting their initial compliance filing to FERC on 4/14/22, MISO submitted responses to an 8/12/22 request for additional information on 10/11/22. They also submitted several answers in response to public comments in July and December 2022. FERC has not yet responded to MISO's October 2022 filing. (Accession Number: 20220414-5193)
ISO-NE	November 1, 2026	ER22-983	On 5/9/23, ISO-NE submitted a tariff filing revision with changes in line with FERC's feedback and requested an extension of the compliance deadline to 11/1/26. They requested additional time to address a FERC directive that the DER aggregator be the entity solely responsible for submitting metering data to the ISO, pending their rehearing request because it conflicted with New England participating transmission owners' responsibility for that function and existing associated processes. FERC issued a Notice of Denial of Rehearing on May 1, 2023, which allows FERC to reassess the filing at a later date. FERC has not yet responded to the submission of this Further Compliance Revision. (Accession Number: 20230509-5085)
NYISO	December 31, 2026	ER21-2460	On 4/20/23, FERC accepted NYISO's compliance filing, subject to further filings. NYISO was directed to file another document detailing changes in line with FERC's feedback within 30 days and also by no later than 12/31/24 to address compliance around ancillary services; they must submit informational filings by 10/20/23 and every 6 months thereafter to provide updates on progress around stakeholder process and compliance. NYISO submitted their compliance filing on May 22, 2023, which FERC has yet to respond to. (Accession Number: 20230522-5156)
PJM	February 2, 2026	ER22-962	FERC accepted PJM's Second Compliance Filing on 5/30/23, subject to a further compliance filing, which PJM submitted with the expected revisions on 6/14/23. (Accession Number: 20230614-5084)
SPP	Proposed: Target of Q3 of 2025 subject to the Commission issuing a final order	ER22-1697	After submitting their compliance filing on 4/28/22, numerous parties submitted public comments. FERC requested extensive additional information on 8/12/22 to process the filing, which SPP responded to on 10/12/22. FERC has yet to respond to this additional information. (Accession Number: 20221012-5036)

4.0 Distributed Wind and Order No. 2222

Distributed wind energy systems are defined by their proximity to the end user and point of interconnection into the electrical grid. They are installed close to the point of end-use to meet on-site demand, interconnected directly to the distribution grid to support local loads, or deployed in remote applications off the grid (NREL 2022).

Distributed wind systems are primarily deployed behind the meter at the customer's retail access point, meaning these systems are not connected to the bulk or wholesale electric power system (GL 2014). Although the vast majority of distributed wind systems providing energy to meet on-site demand are connected behind-the-meter, they supply less than half of the distributed wind capacity in the United States. Though 90% of all documented distributed wind projects were interconnected for on-site use between 2012 and 2021, just 45% of the total installed project capacity was used on site in this period while 55% of the capacity served local loads on the distribution grid (Orrell, Kazimierczuk, and Sheridan 2022). Turbines interconnected directly to the distribution system to serve local loads are referred to as front-of-the-meter projects (Orrell and Homer 2022).

FERC Order No. 2222 directs ISOs to accommodate DER aggregations in their tariffs and participation models, focusing on their locations on the distribution grid. Accordingly, ISO compliance plans have kept their references to DERs similarly broad.

Although the participation models are intended to be inclusive of all DERs that FERC recognizes, there could be some impacts specific to distributed wind. For example, the primary form of distributed generation that ISOs are seeing deployed is distributed solar PV, which can be installed on customer rooftops and in more urban areas (George 2022). Consequently, at least one ISO is focusing on solar PV expansion as a result of the existing market within their service territory; ISO New England is looking exclusively at the future of distributed PV solar deployment within their service territory, connected to the distribution system and not involved in wholesale markets, because it represents the vast majority of anticipated distributed generation and is not visible to the ISO directly (ISO-NE 2023).

On the other hand, FERC Order No. 2222 provides an opportunity for distributed wind market expansion, and distributed wind can supply benefits to heterogenous DER aggregations. The smaller minimum capacity requirement associated with Order No. 2222 allows both front-of-the-meter and behind-the-meter distributed wind installations, which previously were too small to participate in wholesale markets, to benefit from these markets as part of heterogeneous DER aggregations. In order to participate in wholesale markets under the authority of Order No. 2222, behind-the-meter DERs must be part of an aggregation.

A front-of-the-meter distributed wind project could be part of an aggregation or, if it meets the new size minimum, could participate as a standalone DER. Large-scale distributed wind turbines may have to participate as standalone DERs because of maximum capacity constraints.

The *Distributed Wind Energy Futures Study* found that there was extensive economic potential for front-of-the-meter and behind-the-meter distributed wind (McCabe et al. 2022). FERC Order No. 2222 could now help drive this potential. The study found that economic potential for behind-the-meter distributed wind was particularly strong in Texas, Minnesota, Montana, Colorado, Oklahoma, and Indiana. Approximately 500 GW of economically viable behind-the-meter distributed wind is possible in these states alone due to their windy land and higher retail

electricity rates (McCabe et al. 2022). The study found similar potential for front-of-the-meter distributed wind, with an estimated 300 GW of potential in Oklahoma, Nebraska, Illinois, Kansas, Iowa, and South Dakota. They found that 97% of the economic potential for front-of-the-meter wind was located in agricultural lands, creating additional opportunities for agricultural decarbonization and revenue diversification. Additionally, distributed wind has a smaller land footprint than other sources of local generation, making it well suited to areas that engage in multiple uses, such as farms (Bukowski et al. 2021).

Many of these states with the greatest economic potential for distributed wind deployment, with the exception of Texas, are crossed by one or more ISOs. In these states, distributed wind could be deployed either as behind-the-meter or as part of heterogeneous DER aggregations, depending on which application provides developers with the greatest value (i.e., the retail or wholesale market).

Distributed wind can be a valuable part of a heterogeneous DER aggregation. Resource diversity in aggregations will provide complementary renewable energy generation that may be a vital part of reaping the full benefits of wholesale market participation. Distributed wind's generation profile is well-suited to provide resource diversity as wind energy produced at night and during the winter months complements solar PV energy, which generates power mostly during the day and summer months (Orrell and Homer 2022). Hybridizing these generation assets with storage can greatly increase their value and smooth demand peaks (Kazimierczuk, Mongird, and Barrows 2022).

Distributed wind's typical co-location with load can help avoid power congestion and losses in the distribution and transmission systems, which will be stressed in coming years by extensive deployment of renewable energy. Supplying load locally lessens the need for generation and transmission of power across long distances, reducing energy lost during transfer and extending the useful life of transmission and distribution assets (Orrell and Homer 2022). With smart inverters and advanced controls, current distributed wind technology can also engage in a number of grid services, including frequency response, voltage support, real-time regulation, and potentially even black start services (Bhatti et al. 2023; Orrell and Homer 2022).

5.0 Challenges of Implementing Order No. 2222

The implementation of Order No. 2222 presents a number of challenges. It calls for new levels of coordination between DER aggregators, distribution utilities, and ISOs, who all may use different technology and mechanisms of market communication. Additionally, the requirement for allowing DER aggregators that have resources spread across multiple nodes presents a technological challenge for distribution utilities and ISOs that must balance infrastructure constraints and utility boundaries.

The directives in Order No. 2222 call for the creation of market rules for coordination between DER aggregators, distribution utilities, ISOs, and RERRAs. States and local regulators have jurisdiction over the physical interconnection of DERs, which will then be managed by DER aggregators, making the aggregator the point of contact with the ISO. However, ISOs must coordinate with state authorities to make sure that state and ISO policy are aligned, as well as with distribution utilities that manage resource interconnections and maintain system reliability.

The ISOs have submitted a wide range of implementation dates in their compliance filings, which may create significant uncertainty for DER aggregators and other stakeholders or

developers who are seeking to enter the wholesale market. ISOs, as inherently regional entities, cross multiple states and market jurisdictions, with some states covered by multiple different system operator service territories.

Additionally, there are technological barriers for coordinating communication between ISOs, distribution utilities, and DER aggregators. ISOs' primary method of operating the transmission system is done through dispatch signals, with real-time load-resource balancing completed through 5-minute automated dispatch signals. The final balancing within these dispatch intervals operates through frequency regulation reserves and automatic generation control systems. They do not exercise direct control over resource dispatch. ISOs also differ in their telemetry, data quality, metering, and frequency requirements for participation in wholesale markets (Eldridge and Somani 2022).

Order No. 2222 requires coordination between distribution utilities, the ISOs, and DER aggregators that will require new mechanisms of communication between entities that have not typically worked together. Distribution utilities are not historically involved as active system operators and are mostly concerned with dispatching crews to wherever outages occur to restore service. Similarly, they are not involved in dispatching or controlling DERs, although Order No. 2222 incorporates the need to override ISO schedules and DER dispatch to manage planned or forced outages and weather reliability violations under abnormal conditions (McDonnell et al. 2022).

The diversity of available markets for distributed resources participation also presents a split incentive; they may receive higher levels of compensation and greater value in retail markets rather than as part of an aggregation, disincentivizing participation in wholesale markets that prohibit double counting of services. Throughout the rulemaking process, provisions of Order No. 2222 have raised questions about the bounds of FERC's jurisdiction and authority to regulate certain types of DERs and where that contravenes the ability of states to regulate them due to the broad, technology-agnostic nature of the rule.

Payment interactions between distributed utilities and ISOs are not currently coordinated. Retail tariffs for distribution-level generation and storage are poorly aligned with wholesale market prices, creating differences in wholesale, retail, and DER owner or aggregator valuation. Distribution system peaks and transmission system peaks do not necessarily occur at the same time, so tariffs that incentivize generation may affect siting (McDonnell et al. 2022).

Double counting and the Order 719 and 719-A opt-out provision are clarified in Order No. 2222-B (FERC 2021). Reductions in load consistent with the definition of demand response have to be compensated consistent with Orders No. 745 and 745-A. FERC clarified in Order No. 2222-B that behind-the-meter DERs that participate as demand-response resources in DER aggregations do not qualify as double-counting. Order 745 applies to demand-response resources in heterogeneous aggregations. They will evaluate other applications of behind-the-meter resources that participate in DER aggregations on their compliance as new technologies arise in the future (FERC 2021).

There are also states' rights issues associated with changing the opt-out rule for heterogeneous aggregations. FERC is authorized to regulate the bulk power system, but states have authority over other parts of the energy system, including their role in overseeing demand-response activities (Dennis et al. 2016). In order to balance the requirements of Order No. 719, FERC adjusted their definition of heterogeneous aggregations to accommodate Order No. 719, which allows small utilities to opt-out of accommodating aggregations that are composed solely of

demand-response resources. Individual demand-response resources in areas where RERRAs have opted out (or not opted in) to Orders No. 719 and 719-A can only participate in heterogeneous DER aggregations (FERC 2021).

6.0 Conclusions

As ISOs continue the process of establishing compliance with FERC Order No. 2222, distributed wind stakeholders can stay involved with stakeholder engagement processes to best understand how planning for future wholesale market systems may affect their industry. There are a number of technical and regulatory steps yet to be fully fleshed out across the ISO landscape as implementation deadlines begin to approach.

Distributed wind has significant deployment potential as both behind-the-meter and front-of-the-meter installation to contribute to the clean energy economy and provide benefits, including meeting clean electricity goals, meeting local load needs, and improving grid resilience. As ISO compliance plans are finalized and implemented, research on whether distributed wind market participation is more profitable under retail or wholesale markets and which market function provides the greatest value to members of the distributed wind industry would be valuable.

7.0 References

Americas, EY. 2021. Landmark FERC decision opens market for distributed energy resources.

Aniti, Lori. 2018. Major utilities continue to increase spending on U.S. electric distribution systems.

Bhatti, Bilal Ahmad, Andrew P. Reiman, Daniel S. Boff, Sarah E. Barrows, and Alice C. Orrell. 2023. "Valuation of Distributed Wind Turbines Providing Multiple Market Services." 2023 IEEE Power & Energy Society Innovative Smart Grid Technologies Conference, Washington, D.C., 16-19 January 2023. https://ieeexplore.ieee.org/document/10066377.

Bukowski, Steve A., Megan A. Culler, Jake P. Gentle, John C. Bell, Craig R. Rieger, and Everett Bukowski. 2021. *Distributed Wind Resilience Metrics for Electric Energy Delivery Systems* Idaho National Laboratory. https://resilience.inl.gov/wp-content/uploads/2021/06/INL_21-50152_Distributed-Wind_Resilience-Metrics_Final_Online-1.pdf.

Cleary, Kathryne, and Karen Palmer. 2020. *US Electricity Markets 101.* Resources for the Future. https://www.rff.org/publications/explainers/us-electricity-markets-101/.

Cory, Karlynn. 2020. "Behind-the-Meter Projects: Overview." 2020 Tribal Energy Webinar, August 26, 2020. https://www.energy.gov/sites/default/files/2020/08/f77/1_Cory-NREL.pdf.

Dennis, Jeffery S. , Suedeen G. Kelly, Robert R. Nordhaus, and Douglas W. Smith. 2016. *Federal/State Jurisdictional Split: Implications for Emerging Electricity Technologies.* Lawrence Berkeley National Laboratory Energy Analysis and Environmental Impacts Division. https://www.energy.gov/sites/prod/files/2017/01/f34/Federal%20State%20Jurisdictional%20Split--Implications%20for%20Emerging%20Electricity%20Technologies.pdf.

EIA. 2015. *Electric Power Monthly with Data for October 2015.* U.S. Energy Information Administration. https://www.eia.gov/electricity/monthly/archive/december2015.pdf.

---. 2023. Table 6.1.A Net Summer Capacity for Utility Scale Solar Photovoltaic and Small Scale Solar Photovoltaic Capacity (Megawatts). In *Electric Power Monthly*, edited by U.S. Energy Information Administration.

Eldridge, Brent, and Abhishek Somani. 2022. *Impact of FERC Order 2222 on DER Participation Rules in US Electricity Markets.* Pacific Northwest National Laboratory. https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-33383.pdf.

EPA. 2023. "U.S. Electricity Grid & Markets." United States Environmental Protection Agency. https://www.epa.gov/green-power-markets/us-electricity-grid-markets.

Fasching, Elesia. 2023. Wind, solar, and batteries increasingly account for more new U.S. power capacity additions. Accessed June 5, 2023.

FERC. 1996. Promoting Wholesale Competition Through Open Access Non-Discriminatory Transmission Services by Public Utilities; Recovery of Stranded Costs by Public Utilities and Transmitting Utilities. edited by Federal Energy Regulatory Commission: Federal Register.

---. 2011. Demand Response Compensation in Organized Wholesale Energy Markets. edited by Federal Energy Regulatory Commission: Federal Register.

---. 2015. Regional Transmission Organizations. Federal Energy Regulatory Commission.

---. 2019. Electric Storage Participation in Markets Operated by Regional Transmission Organizations and Independent System Operators. edited by Federal Energy Regulatory Commission: Federal Register.

---. 2020a. *Federal Energy Regulatory Commission Reliability Primer.* Federal Energy Regulatory Commission. https://www.ferc.gov/sites/default/files/2020-04/reliability-primer_1.pdf.

---. 2020b. Participation of Distributed Energy Resource Aggregations in Markets Operated by Regional Transmission Organizations and Independent System Operators. edited by Federal Energy Regulatory Commission. Federal Register.
---. 2021. Participation of Distributed Energy Resource Aggregations in Markets Operated by Regional Transmission Organizations and Independent System Operators. In *Order No. 2222-B*, edited by Federal Energy Regulatory Commission: Federal Register.
---. 2022. "What FERC Does." Federal Energy Regulatory Commission. Last Modified August 16, 2022. https://www.ferc.gov/what-ferc-does.
---. 2023a. "Electric Power Markets." Market Assessments. Last Modified May 16, 2023. https://www.ferc.gov/electric-power-markets.
---. 2023b. Federal Energy Regulatory Commission eLibrary.
Gallo, Ava. 2022. "What are Regional Transmission Organizations and How do They Interact with State Climate Goals?" *NCEL Blog* (blog), *National Caucus of Environmental Legislators*. https://www.ncelenviro.org/articles/what-are-regional-transmission-organizations-and-how-do-they-interact-with-state-climate-goals/.
George, Stephen. 2022. *Overview of Distributed Energy Resource Integration in ISO New England.* UConn Center for Clean Energy Engineering. https://www.iso-ne.com/static-assets/documents/2022/06/iso_new_england_uconn_5_20_2022.pdf.
GL, DNV. 2014. *A Review of Distributed Energy Resources.* New York Independent System Operator. https://www.nyiso.com/documents/20142/3065827/A_Review_of_Distributed_Energy_Resources_September_2014.pdf/.
IEA. 2022. *Unlocking the Potential of Distributed Energy Resources.* IEA (Paris). https://www.iea.org/reports/unlocking-the-potential-of-distributed-energy-resources.
ISO-NE. 2022. Re: Revisions to ISO New England Inc. Transmission, Markets and Services Tariff to Allow for the Participation of Distributed Energy Resource Aggregations in New England Markets; Docket No. ER22-___-000. edited by New England Power Pool: ISO New England.
---. 2023. "Distributed Generation Forecast." ISO New England. https://www.iso-ne.com/system-planning/system-forecasting/distributed-generation-forecast/.
Jamison, Lolita. 2022. Record numbers of solar panels were shipped in the United States during 2021.
Kazimierczuk, K. , K. Mongird, and S.E. Barrows. 2022. "Stronger together: The value impacts of hybridizing distributed wind." *The Electricity Journal* 35 (8). https://doi.org/https://doi.org/10.1016/j.tej.2022.107191.
McCabe, Kevin, Ashreeta Prasanna, Jane Lockshin, Parangat Bhaskar, Thomas Bowen, Ruth Baranowski, Benjamin Sigrin, and Eric Lantz. 2022. *Distributed Wind Energy Futures Study.* National Renewable Energy Laboratory. https://www.nrel.gov/docs/fy22osti/82519.pdf.
McDonnell, Matt, Jennifer Gorman, Fredrich Kahrl, Lorenzo Kristov, Josh Keeling, and Priya Sreedharan. 2022. *DER Integration into Wholesale Markets and Operations.* Distributed Energy Resources Task Force, Energy Systems Integration Group (Reston, VA). https://www.esig.energy/wp-content/uploads/2022/01/ESIG-DER-Integration-Wholesale-Markets-2022.pdf.
NGA. 2023. "Electricity Markets 101." National Governors Association. https://www.nga.org/electricity-markets/.
NREL. 2022. "Distributed Wind." Annual Technology Baseline. National Renewable Energy Laboratory. Last Modified July 21, 2022. https://atb.nrel.gov/electricity/2022/distributed_wind.
Orrell, Alice, and Juliet Homer. 2022. *Value Case for Distributed Wind in Rural Electric Cooperative Service Areas.* NRECA. https://www.cooperative.com/programs-

services/bts/radwind/Documents/Radwind-Value-Case-Report-Rev-1-December-2022.pdf.

Orrell, Alice, Kamila Kazimierczuk, and Lindsay Sheridan. 2022. *Distributed Wind Market Report: 2022 Edition.* U.S. Department of Energy Office of Energy Efficiency & Renewable Energy. https://www.energy.gov/eere/wind/articles/distributed-wind-market-report-2022-edition.

Register, Office of the Federal. 2011. *A Guide to the Rulemaking Process.* https://www.federalregister.gov/uploads/2011/01/the_rulemaking_process.pdf.

Federal Power Act. June 10, 1920.

Walton, Rod. 2022. EnergyTech: ERCOT moves forward on pilot to evaluate DERs in wholesale markets.

Zhou, Ella, David Hurlbut, and Xu Kaifeng. 2021. *A Primer on FERC Order No. 2222: Insights for International Power Systems.* National Renewable Energy Laboratory (Golden, CO). https://www.nrel.gov/docs/fy21osti/80166.pdf.

Appendix A – Order No. 2222 Directives

Order No. 2222 included eleven specific directives for RTOs/ISOs:

> "(1) allow distributed energy resource aggregations to participate directly in RTO/ISO markets and establish distributed energy resource aggregators as a type of market participant
>
> "(2) allow distributed energy resource aggregators to register distributed energy resource aggregations under one or more participation models that accommodate the physical and operational characteristics of the distributed energy resource aggregations
>
> "(3) establish a minimum size requirement for distributed energy resource aggregations that does not exceed 100 kW
>
> "(4) address locational requirements for distributed energy resource aggregations
>
> "(5) address distribution factors and bidding parameters for distributed energy resource aggregations
>
> "(6) address information and data requirements for distributed energy resource aggregations
>
> "(7) address metering and telemetry requirements for distributed energy resource aggregations
>
> "(8) address coordination between the RTO/ISO, the distributed energy resource aggregator, the distribution utility, and the relevant electric retail regulatory authorities
>
> "(9) address modifications to the list of resources in a distributed energy resource aggregation; and
>
> "(10) address market participation agreements for distributed energy resource aggregators.
>
> "(11) Additionally, each RTO/ISO must accept bids from a distributed energy resource aggregator if its aggregation includes distributed energy resources that are customers of utilities that distributed more than 4 million megawatt-hours in the previous fiscal year."

Source: (FERC 2020b)

Pacific Northwest National Laboratory

902 Battelle Boulevard
P.O. Box 999
Richland, WA 99354

1-888-375-PNNL (7665)

www.pnnl.gov