Solar Distributed Energy Resources (DER) Study Report

SEPTEMBER 29, 2020

Executive Summary

The objective of this Study is to share ideas about solar Distributed Energy Resources (DER) based on the perspectives of each of the participating parties which include the Indiana Utility Regulatory Commission (IURC), Indianapolis Power & Light Company (IPL), Midcontinent Independent System Operator (MISO), State Utility Forecasting Group (SUFG) and Lawrence Berkeley National Laboratory (LBNL).

The parties considered discussions within the context of three levels of interconnected solar facilities as defined by Indiana Administrative Code (IAC).[1]

Level	Capacity
1	Up to 10 kW
2	11 kW to 2 MW
3	>2 MW

Informal meetings enabled open discussion regarding operating and planning DER. IPL shared its specific experience with nearly 100 MW of solar DER on its distribution grid and explained challenges associated with each interconnection level. For example, visibility improves with larger sites due to potential availability of realtime data sharing.

The Study participants reviewed DER interconnection publications from their respective entities as well as resources from the National Renewable Energy Laboratory (NREL), Institute of Electrical and Electronics Engineers (IEEE), and the National Electric Reliability Corporation (NERC). Collaborative discussions focused on potential DER data model requirements which resulted in a draft Solar DER data collection template shown as **Appendix A**.

Overall, the parties found discussions and exploring DER publications productive and informative. Understanding how IPL manages DER visibility and operational challenges was insightful for the Parties with anticipated increased DER penetration in the MISO footprint and potential future market participation.

[1] See http://inrules.elaws.us/code/170iac4-4.3-4/

Introduction

Following an Integrated Resource Plan (IRP) Contemporary Issues meeting hosted by the Indiana Utility Regulatory Commission (IURC) in early 2019, staff from Indianapolis Power & Light Company (IPL) and Midcontinent Independent System Operator (MISO) recognized an opportunity to learn from each entity's perspective to facilitate the transition and integration of Distributed Energy Resources (DER). IURC, IPL and MISO agreed to a specific Solar DER Study scope. Following initial discussions, the three parties invited Lawrence Berkeley National Laboratory (LBNL) and State Utility Forecasting Group (SUFG) of Purdue University to participate in Study meetings.

Definitions of DER vary among electric industry stakeholders. MISO used this definition in its DER Framing Report: "DERs are power generation, storage, or demand-side management connected to the electrical system, either behind the meter on a customer's premises, or on a utility's distribution system."[2]

Considering the changing resource mix to supply energy on national, regional and local fronts, expected expansion of DER and an opportunity to leverage IPL's experience in distributed solar, the parties shared research and engaged in discussions over several months and complied findings in this document as the Study deliverable.

Resource Mix Changes

Changes in energy markets resource mix are occurring throughout the United States with a higher penetration of intermittent resources as well as interest in DERs.

The SUFG cites increasing renewable energy consumption throughout the United States (U.S.) in its *2019 Indiana Renewable Energy Resources Study*. Graphs provided from the Energy Information Administration (IEA) in this report indicate significant increasing trends in solar, wind and renewable resources in total from 2006 to 2018.[3] In addition, the report shows significant growth in U.S. grid connected photovoltaic (PV) solar from 2009 to Q1 2019.[4]

The MISO footprint resource mix has changed significantly as illustrated in the charts (Figure 1) comparing 2006 to 2019.[5] As a key illustrative observation, the combination of hydro, solar, wind, Demand Response (DR) and Behind the Meter Generation (BTMG) resources grew from 6% to 20% over this thirteen-year period. DR and BTMG assets alone grew from 0% to 8%.

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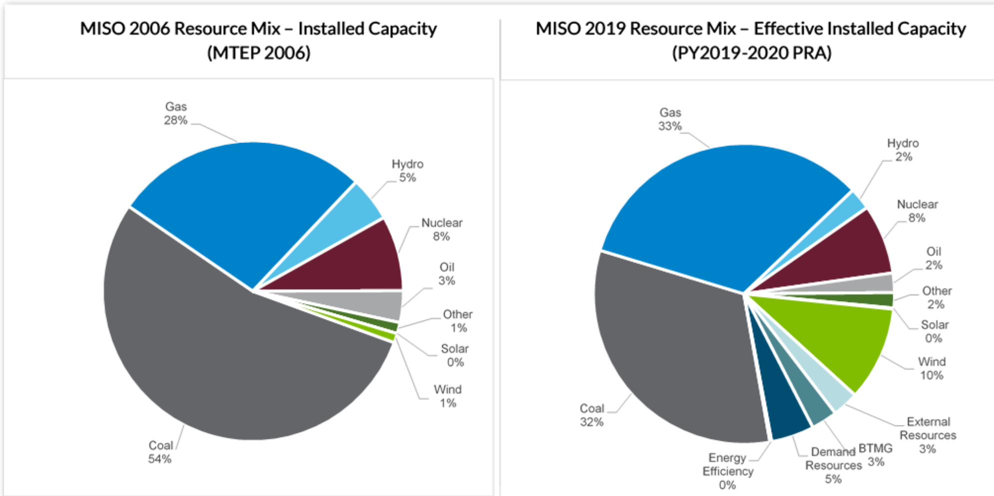
[2] See page 4 of the report at this link:
https://cdn.misoenergy.org//DER%20Framing%20Report%202019397951.pdf

[3] See page 2 of the report at this link:
https://www.purdue.edu/discoverypark/sufg/docs/publications/2019_RenewablesReport.pdf

[4] Ibid, page 105.

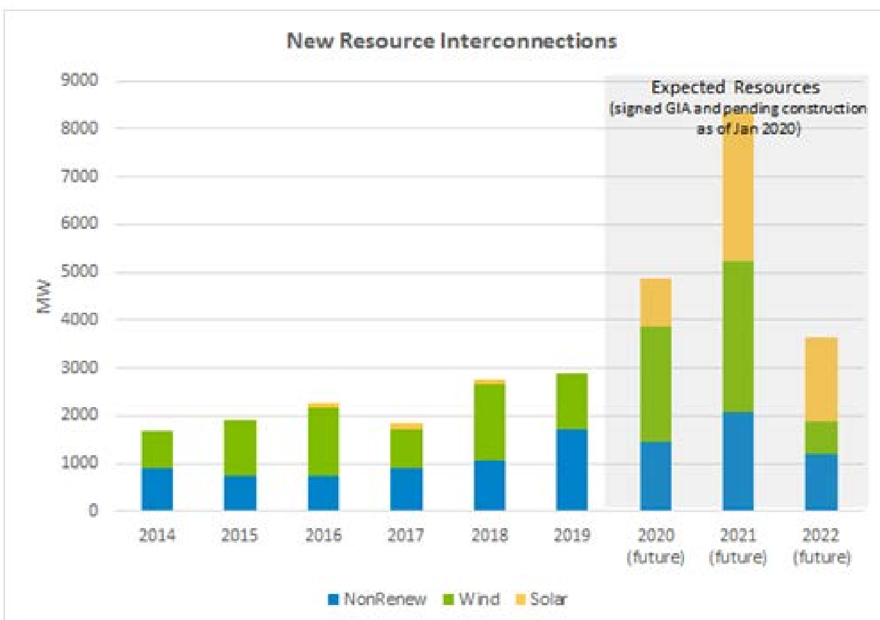
[5] See page 2 of the MISO 2020 Interconnection Queue Outlook report at this link:
https://cdn.misoenergy.org//MISO2020InterconnectionQueueOutlook445829.pdf

Figure 1



MISO expects continued changes in the footprint resource mix based on the generation interconnection queue as shown in Figure 2.[6]

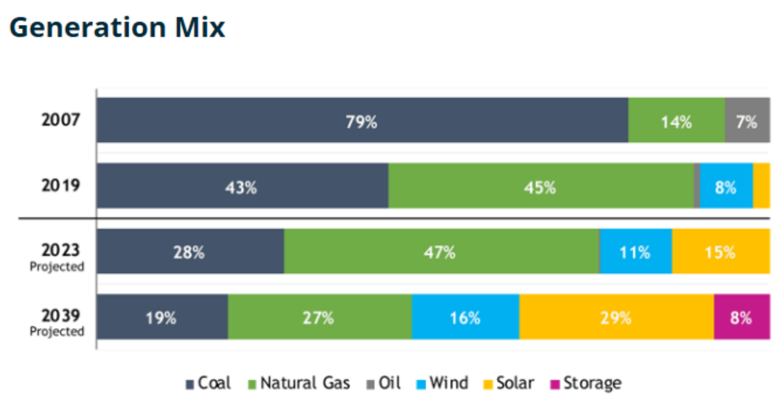
Figure 2



[6] See page 4 of the 2020 MISO Interconnection Queue Outlook report at this link: https://cdn.misoenergy.org//MISO2020InterconnectionQueueOutlook445829.pdf

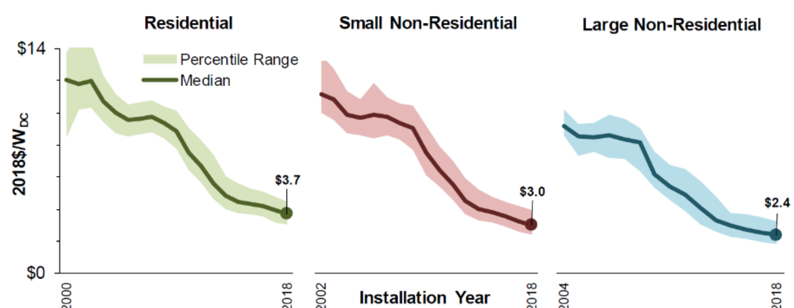
IPL also envisions a vastly different resource mix in 2039 as shown on its website[7] and described in its 2019 Integrated Resource Plan as shown in Figure 3.[8]

Figure 3



National-level trends suggest continued growth in customer adoption of DERs. For example, the installed price of residential distributed solar PV declined 5% between 2017 and 2018 and consistent with price declines since 2014 (see Figure 4) which is a key driver of increase adoption of distributed solar PV.[9] Likewise, electricity efficiency program spending is forecasted to increase from $5.8 billion to $8.6 billion from 2016 to 2030 assuming existing policy and economic drivers.[10]

Figure 4



[7] https://www.iplpower.com/About_IPL/Power_Generation/
[8] See page 3 of the IPL 2019 IRP Public Report (Volume 2 of 3) at this link: https://www.iplpower.com/About_IPL/Regulatory/Filings/Integrated_Resource_Plan/
[9] https://emp.lbl.gov/publications/tracking-sun-pricing-and-design
[10] https://emp.lbl.gov/publications/future-us-electricity-efficiency

Leveraging IPL's Distributed Solar Experience

According to the IPL website, 97 MW of solar and are currently operating or under development throughout its service are in the greater Indianapolis area.[11] Large solar projects participate in a renewable energy production feed-in-tariff to provide energy to IPL customers.[12] A map of IPL's existing large scale solar is included in this report as **Appendix B**. IPL has successfully integrated these projects on its distribution system and adjusted its operations to safely maintain reliability since 2013. MISO appreciated learning from IPL to better understand impacts of solar facilities on distribution grids as it prepares for the expansion of DER in its footprint and potential participation in the wholesale electricity market.

IPL described limited visibility of solar production for Level 1 (< 10kW) interconnected sites which are primarily located at residential customers' homes due to a lack of communications infrastructure connected to inverters and whole house net-metering. IPL accounts for the impacts of this solar energy embedded in its load forecast based on historic patterns. IPL receives realtime production data from the large Level 2 (>500 kW and < 2 MW) interconnected sites and can remotely disconnect them through shunt-trip breakers or automatic reclosers.

Level 3 (> 2MW) interconnected sites provide realtime remote monitoring and control through automatic reclosers. The IPL feed-in tariff, Rate Renewable Energy Production (REP), includes provisions for IPL to purchase the output of the sites; however, there is no dispatch capability. IPL maintains operating agreements to closely coordinate with these sites for the safety of line personnel. The distribution operators receive granular information which is transmitted to the transmission operators. Communications infrastructure throughout the IPL system, including at these sites, is undergoing transition as part of IPL's Transmission, Distribution, Storage Improvement Charge (TDSIC) Plan.[13]

DER Expansion is expected

The Organization of MISO States (OMS) published results of its 2019 DER Survey results which indicate an increase from 2018 of 170% in residential DER capacity and a 62% increase in non-residential DER which is the dominant class of DER within MISO.[14]

MISO and OMS co-hosted a series of DER workshops in 2019 and 2020 to facilitate stakeholder discussions, develop common terminology, identify concerns, understand experiences and determine gaps for further discussions. These workshops addressed a mix of reliability, operations, planning and market concepts and were well attended by people throughout the MISO footprint representing a wide variety of stakeholder sectors. Workshop materials, summary document, and a MISO DER Framing

[11] https://www.iplpower.com/About_IPL/Power_Generation/Solar_Power/
[12] https://www.iplpower.com/My_Account/Service_Options/Renewable_Energy/Renewable_Energy_Production_(REP)/
[13] See IURC Cause No. 45264.
[14] See page 10 of the presentation at this link:
https://www.misostates.org/images/stories/Other_Projects/2019_Survey_Results_Presentation_Public_002.pdf

paper are available at this link. In addition, DER is part of the MISO Integrated Roadmap, so MISO identifies to other stakeholder engagement on the Issue tracking tool which is linked as well.

MISO published a 2019 DER Framing Report[15] in which Vice President, Richard Doying noted:

> "Distributed Energy Resources – in particular, flexible load – will become increasingly important to maintaining reliability during peak system conditions. Looking forward, MISO is focused on continued collaboration with stakeholders to explore how increasing amounts (MW) and types (generation, storage, flexible load, etc.) of DERs can help provide the availability, flexibility and visibility needed for reliable system operations."

Subsequent MISO publications further focus on DER. In the *MISO Forward 2019* publication, MISO describes the potential of DER to increase system risk due to the lack of visibility and the need for increased cooperation and collaboration to optimize the value of DER.[16] This report also refers to planning scenarios in the MISO Transmission Expansion Planning (MTEP) process.

In addition, four of five "Utility of the Future" personas in the *MISO Forward 2020* report include significant growth in DER.[17] This report describes what utilities of the future will need from a grid operator including enhanced communication and coordination to improve real-time situational awareness and forecasting with DER.

IPL projects modest growth of solar PV in its 2019 IRP with an addition of approximately 20 MW by 2040.[18] IPL does not project additional feed-in tariff solar facilities since their current program is fully subscribed.[19]

Study Parties Engagement

Each Study party engaged people from within its organization to provide holistic views of future DER requirements in planning, operations and market areas as described below.

MISO formed a cross-functional Study team with people from Forecasting, Markets, Day Ahead Operations, External Affairs, Modeling and Market & Grid Strategy areas. They reached out to additional people on their teams as well as Resource Planning, Engineering Services, and Model Engineering to gain a companywide perspective.

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[15] https://cdn.misoenergy.org/DER%20Framing%20Report%202019397951.pdf
[16] https://cdn.misoenergy.org/MISO%20FORWARD324749.pdf
[17]See pages 10 to 18 of the MISO Forward 2020 at this link:
https://cdn.misoenergy.org/MISO%20FORWARD_2020433101.pdf
[18] See page 53 of Volume 1 at this link:
https://www.iplpower.com/About_IPL/Regulatory/Filings/Integrated_Resource_Plan/
[19] See page 54 of Volume 1 at this link:
https://www.iplpower.com/About_IPL/Regulatory/Filings/Integrated_Resource_Plan/

IPL's team included members from the Regulatory & RTO Policy team, Resource Planning and Distribution & Transmission Planning teams.

IURC staff from the Research, Policy, and Planning Division, the SUFG Director and LBNL staff in the Energy Technologies Area as well as the Electricity Markets and Policy Department participated in this Study.

The DER Study group met four times between October 2019 and March 2020. During the kickoff meeting on October 3, 2019, IPL presented a summary of DERs on the IPL system. MISO discussed possible data parameters that could be collected in a future MISO DER data gathering template. The team established a scope, timeline and goals for the DER Study group. At the January 8, 2020 meeting at MISO, a draft data template was created and socialized, with the agreement that IPL would review and preliminarily complete for future discussion purposes. IPL hosted the February 11, 2020 meeting where the group discussed the completed template. IPL completed template parameters for information which was otherwise available; certain distribution interconnection customer data was not available. During this meeting, the study group participants discussed processes for forecasting EVs and DERs. On March 16, 2020, the DER Study group met to finalize the scope for this summary document that captures and documents the collaboration efforts of the group up to this point in time.

Document Review

As part of the study process, parties reviewed materials from various sources including LBNL, IEEE, and NERC as described below.

LBNL shared reports by the National Renewable Energy Laboratory (NREL) that provide: 1) a broad overview of DER interconnection rules and current practices with chapters devoted to specific standards and systems[20], 2) a comparison of state interconnection requirements in the West with total and average interconnection costs[21], and 3) recent information on some of the state-level efforts related to locational valuation and advanced inverters, among other topics.[22] LBNL also shared resources on modeling solar PV production and its use in utility planning and valuation studies.[23]

[20] Horowitz, Kelsey, Zac Peterson, Michael Coddington, Fei Ding, Ben Sigrin, Danish Saleem, Sara E. Baldwin, et al. 2019. *An Overview of Distributed Energy Resource (DER) Interconnection: Current Practices and Emerging Solutions*. Golden, CO: National Renewable Energy Laboratory. NREL/TP-6A20-72102. Available at: https://www.nrel.gov/docs/fy19osti/72102.pdf.

[21] Bird, Lori, Flores, Francisco, Volpi, Christina, Ardani, Kristen, Manning, David, and Richard McAllister. 2018. *Review of Interconnection Practices and Costs in the Western States*. Golden, CO: National Renewable Energy Laboratory. NREL/TP-6A20-71232.

[22] McAllister, Richard, David Manning, Lori Bird, Michael Coddington, and Christina Volpi. 2019. *New Approaches to Distributed PV Interconnection: Implementation Considerations for Addressing Emerging Issues*. Golden, CO: National Renewable Energy Laboratory. NREL/TP-6A20-72038. Available at: https://www.nrel.gov/docs/fy19osti/72038.pdf.

[23] https://emp.lbl.gov/publications/integrating-solar-pv-utility-system and https://emp.lbl.gov/publications/evaluation-solar-valuation-methods

The Indiana Administrative Code (170 IAC 4-4.3- *Customer-Generator Interconnection Standards*) specifies that a customer-generator facility shall not violate any applicable provisions of IEEE 1547, Standard for Interconnecting Distributed Resources with Electric Power Systems. In April 2018, IEEE published an update to the previous version of IEEE 1547.[24] IEEE 1547 is the Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interface. Though this updated standard was approved in April of 2018, utilities could not immediately require Distributed Energy Resources (DERs) to meet the requirements of the updated standard because the test procedures IEEE1547.1 and UL 1741[25] needed to be updated subsequently.

IEEE 1547.1 is the standard that specifies the type, production, commissioning and periodic tests, and evaluations that shall be performed to confirm that the interconnection and interoperation functions of equipment and systems interconnecting distributed energy resources with the electric power system to conform to the IEEE 1547 Standard. On March 5, 2020, 1547.1-2020 [26]was officially approved for publication. UL 1741 Supplement A (UL 1741 SA) is an addition to the existing UL 1741 product safety standard that establishes manufacturing and testing requirements for Inverters, Converters, Controllers and Interconnection System Equipment for Use with Distributed Energy Resources. UL 1741 updates are expected to be available by the second quarter of 2020. Once these standards are updated, inverters that meet the requirements of IEEE 1547-2018 are then expected to be commercially available by the fourth quarter of 2020.

MISO also discussed MISO's IEEE-1547 Guideline document developed through Distribution Interconnection Coordination stakeholder workshops in 2019. Materials may be found at this link.

NERC's System Planning Impacts of Distributed Energy Resources Working Group (SPIDERWG) is a stakeholder forum focusing on DER from a transmission planning and system analysis perspective. Primary focuses of the working group include DER data collection, modeling practices, model improvements, and steady-state and dynamic simulation assessments. One recent deliverable of the SPIDERWG is the *Reliability Guideline, DER Data Collection for Modeling.* [27] It contains guidance for Transmission Planners and Planning Coordinators in establishing modeling data requirements for the collection of aggregate DER data for use in reliability studies. Data collection requirements include steady-state data, dynamics data, short-circuit data, GMD data and EMT data. This document was reviewed by the parties and is undergoing stakeholder review prior to recommending publication by NERC.

[24]https://standards.ieee.org/standard/1547-2018.html
[25]https://site.ieee.org/sagroups-scc21/standards/1547rev/
[26] https://site.ieee.org/sagroups-scc21/standards/standards-1547-1/
[27] See www.nerc.com

Data Collection template development

An outcome of this Study was to create a draft Solar DER data collection template (**Appendix A**) to capture information for future MISO use. The template was generated after an internal outreach to MISO Resource Planning, Engineering Services, Model Engineering, Market Strategy and Development and Operational Forecasting to ensure it captures all aspects of data requirements that will be useful to various teams within MISO to maintain proper visibility.

MISO used the existing Solar Forecasting Data Requirements template for Grid Solar as a starting point to formulate this new Solar DER template. This existing template is used by MISO to gather operational information regarding the solar facility and to establish operating parameters for the resource, needed for the creation of hourly and five-minute renewable forecast, which is used in the real time reliability, commitment and dispatch processes. IPL provided MISO with lists of data it collects for solar DER based on the three levels of interconnection defined by the Indiana Administrative Code[28] which were incorporated. The IPL exhibits and example data noted for each data parameter represents an example of solar registration data that utilities may already be capturing. While energy storage resources were discussed, the parties determined additional time is needed to fully vet potential data requirements, prior to incorporating them in the data collection template.

Several areas within MISO provided input to the template based on varying viewpoints as described below.

- Modeling team: This team receives initial data for units that are registered in the Commercial model and included in the Network model. In addition, as they work on the Model Manager project, it made sense to seek verification of the DER data provided by current asset owners, understand how it is used and avoid duplicative effort across different work streams.
- Market Strategy: This team is engaged with Resource Availability and Need (RAN) projects. They reviewed the data to leverage the information for future planning purposes.
- Resource Planning: This team reviewed the DER template for compatibility with the IEEE 1547 interconnection standard.
- Operations Engineering: This team provided input to the template based on preparing for storage participation as outlined in FERC Order 841 for ESR (Energy Storage Resources).[29]
- Operational Forecasting: This team considered how to use the information on the template to generate forecasts with DER.

Detailed discussions were held between the parties to identify the data requirements that would be helpful; both from a Utility's perspective and from an RTO perspective. The final version of the template was created based on a mutual agreement on selecting only those data parameters that were useful. MISO envisions the template to be a document that could be further developed with additional stakeholder input as energy industry gains more experience with the operation of DER.

[28] http://inrules.elaws.us/code/170iac4-4.3-4/

[29] See MISO's issue tracking page for FERC Order 841 information here: https://www.misoenergy.org/stakeholder-engagement/issue-tracking/storage-participation--ferc-order-841-compliance/

The draft Solar DER template lists types of information that will be useful as a starting point for future iterations. MISO has found the template framework helpful to consider software and system enhancements in planning for a future with DER market participation.

Findings/Key Takeaways

The parties found the open dialog and discussion productive to understand multiple perspectives and challenges associated with DER. Variability in DER interconnection processes among states and individual utilities will require establishing a “least common denominator” approach to begin to build requirements and best practices. The parties recognize legacy agreements may limit DER market participation.

The parties discussed the need for future changes to settlements processing at a high level as well as forecasting enhancements. In addition, it was helpful to understand that each state has DER classifications with related interconnection requirements.

Forecasting Considerations

For reference, IPL used a bottom-up forecasting estimation to plan for future DERs, specifically distributed solar and electric vehicles (EVs) on the IPL System. The modeling effort utilized existing and recent forecasts for EV growth and adjusted them to the IPL service territory. The forecasted growth of EVs on IPL’s system was then matched with the load shapes of existing IPL EV customers. Similarly, for distributed solar, IPL relied on aggregated net energy metering customer data and industry forecasts to project the number of new distributed solar customers during the IRP study period. IPL relied on Rate Renewable Energy Production (REP) solar data to account for the solar on a monthly PV forecast basis for every hour in the IRP model. For more information on the most recent IPL distributed solar and EV forecast, please see Section 4.4.1 of the 2019 IPL IRP.

State by State Variances

Per Indiana Administrative Code 170 IAC 4-4.3- Customer-Generator Interconnection Standards, there are three (3) applications for interconnection of customer distributed generation facilities (Levels 1, 2 & 3). Level 1 Customers must have a nameplate capacity of ten (10) kilowatts or less and meet certification requirements. Level 2 Customers must have a nameplate capacity of two (2) megawatts or less and meet certification requirements. Level 3 Customers must have nameplate capacity greater than two (2) megawatts or do not qualify for either Level 1 or Level 2 interconnection. The Indiana Administrative Code further lays out the process the utility and customer partake in start and complete an interconnection application and execute an Interconnection Agreement. The state, in part, regulates the interconnection of energy resources of various kinds to the utility distribution system. While the utility implements some interconnection policies that are based on specific utility operating practice, much of the interconnection process is dictated by the state and the utility simply implements the law.

These requirements and defined types of interconnections are specific to Indiana. Other states have varying requirements and processes. IPL’s unique experience with 25 sites of distributed solar of 500 kW to 10 MW provides insights into operations coordination. The IPL transmission system is not designed to support backfeed from the distribution system, so solar energy produced is utilized at each substation at the distribution voltage level.

MISO's Interest

MISO and DER Framing and Discussion Document published in 2019[30], covers the importance of why to focus on Distributed Energy Resources such as Solar PV. The discussion document touches upon the growing number of DER in-MISO's footprint. In addition, the growth of DERs will only continue to increase so MISO's is asking questions related to planning and modeling DER, the effects of DER on Operations, market considerations of DER. As stated in the report:

> "As the number of DERs increase, reliability will depend increasingly on local distribution and weather conditions, including sun, clouds, rain, ice and snow. DERs introduce an additional level of uncertainty to MISO Real-Time Operations. New DER tools and forecasting methodologies must be introduced to better manage this uncertainty. Accurate and aligned price signals at the distribution and transmission interface may also assist in managing this uncertainty.
>
> Such risk can begin to be better managed through improved DER visibility, which could help MISO see what is happening at the local level, as well as provide insights on capacity, capability and generation. With this knowledge, MISO and/or Local Balancing Authorities may communicate with and receive realtime information from the DERs. Visibility information on the electrical location and size of the DER would allow MISO to apply forecasting methodologies to determine the expected DER generation. MISO would need to establish new tools for DER situational awareness to compare forecasts to actual output. This will allow analysis and better informed future decision-making, including response to abnormal events. Finally, MISO would need to maintain visibility related to DER availability, including awareness related to large-scale DER outages and returns to service. "[31]

The effort undertaken by the Study parties complements well the framing and discussion document and establishes an initial take on a possible DER data gathering template, that over time can be edited and possibly used in the future by MISO.

Benefits of this collaboration effort

The process, discussion, and outputs of this study group are both useful and timely to IPL and MISO. As IPL continually plans for distribution modernization and enhanced customer experience, this effort provided context on multiple variables to consider as the proliferation of DERs accelerate. The open

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[30] MISO and DER Framing and Discussion Document
https://cdn.misoenergy.org/DER%20Framing%20Report%202019397951.pdf
[31] Ibid

dialogue and information transparency allowed IPL to share perspectives and data with study group participants. IPL is optimistic that this collaboration will benefit other MISO market participants, as well as regulators and MISO, to consider the complexities associated with increased DER penetration our individual systems, as well as its impact on the footprint. This visibility and insight appropriately set the stage for further DER collaboration.

To capture the value of DER, coordination between Transmission and Distribution (T&D) is critical to meet resource availability and flexibility needs at all grid levels while avoiding reliability risks such as imbalances or congestions in the distribution system. This work sets the initial step for MISO and other Utilities to understand the complexities of such coordination, collaboratively understand communication requirements and technologies and data analytics/synthesis to improve realtime situational awareness and enhance operational forecasting. Discussions around the DER interconnection process including IPL's Net Metered Customers and Rate Renewable Energy Production (REP) provided MISO with a lens to Utility's practices with DER ranging from less than 10 kW up to 10 MW in size. The parties also discussed future development of visibility requirements at a high level.

IPL shared distribution operations experiences with DER such as line switching, remote monitoring and control capabilities, metering options, inverter capabilities, and situational awareness and behind-the-meter solar forecast challenges which the parties found informative for future DER design.

Recommendations/Next Steps

MISO expects to continue to engage with stakeholders to prepare for DER participation in wholesale electricity markets as the industry awaits a DER FERC order. MISO is in the process of developing a DER Visibility whitepaper to be published in the second half of 2020. While no specific DER workshops are currently scheduled, future meetings will certainly address DER in the MISO footprint.

IPL plans to continue to incorporate DER and related impacts in future Integrated Resource Plans (IRPs). In addition, it initiated a Request for Proposal (RFP) process for approximately 200 MW of replacement capacity which is currently underway.[32]

The IURC prepared comments related to this Study and future research which comprise **Appendix C**.

[32] See https://www.iplpower.com/About_IPL/Regulatory/Filings/IRP_2019/Request_for_Proposals/

Appendices

A. Draft Solar DER Data Collection Template
B. IPL Rate REP Solar Map
C. IURC Comments

Appendix A

MISO Solar DER Template

This draft list represents initial thoughts from MISO for a solar DER study with IPL.

Parameters for all DER Assets - DRAFT

Parameter Name	Parameter Description	Required / Optional / Dependent
Date information provided	Date of most recent revision	Required
Contact Name	name of person completing this template	Required
Contact email address	contact email address	Required
Resource Name	common name for facility	Optional
Date of Interconnection Agreement	Execution date	Required
NERC Entity Code of MP	required if MP is populated	Dependent
Market Participant Name	if applicable	Required
Asset Owner	Company or individual owner	Required
Type of Generator	Inverter-Based, Synchronous, Induction	Optional
Resource Type	Type of resource: Solar PV, Wind, ESR, Demand Response	Required
CPnode Name	CPnode name associated with this asset in MISO model	Required
EPnode Name	Elemental Pricing node if known	Optional
Location (physical address) of the Asset	DER street address	Required
City/State/Zip (physical address)	DER street address	Required
Latitude (in degrees with a least 4 decimal points)	Centralized geographic co-ordinate information of the Asset	Required
Longitude (in degrees with a least 4 decimal points)	Centralized geographic co-ordinate information of the Asset	Required
Distribution substation name	If applicable	Optional
Primary Point of Interconnection (POI)	Current POI or expected POI - transmission buss	Required
Alternate POI	If applicable	Optional
System Protection device	none, relay, recloser, shunt trip breaker?	Required
Site capacity	measured in MW	Required
Operational Status	drop downs - proposed, in utility queue, in MISO queue, in service, cancelled, decommissioned, out of service	Required
Expected Operational date	Date that resource will be operational	Required
Actual operational date	Date that resource became operational	Dependent
Date of decommissioning	Date that resource was decommissioned	Optional
Grid connectivity	behind the customer meter or fed onto grid directly	Optional

Appendix A

Parameters for Solar DER Assets - DRAFT

Parameter Name	**Parameter Description**	**Required / Optional / Dependent**
Indiana Interconnection Level 1-<10 kW, 2=>10 kWand <2 MW, 3 = >2MW	drop downs	Required
Phase connectivity	drop down - single phase or three phase	Required
Inverter type	Smart Inverter Y/N?	Required
Inverter Manufacturer and Model number	ex. Enphase Energy - IQ7-60-x-US[240V]	Required
Inverter settings	TBD - e.g. power factor correction, dead bands, etc.	Required
Number of inverters	ex. 1 (macro inventor) or 22 (micro inverter for each of the 22 panels)	Optional
Maximum Capacity of each inverter	in MW	Optional
Maximum Capacity of all modules	in MW	Required
Number of PV cells	Total number of PV cells in the solar farm	Optional
Tilt	Vertical orientation of panels	Optional
Azimuth	Horizontal orientation of panels	Optional
Autotracking	Indicates tracking mode - yes/no	Required
Obstructions	Is there tree cover or buildings in way?	Optional
Operational Practices for synchronization	Please describe synchronization protocol - exStep in after loss of source - dropdowns?	If Applicable
Indicate all possible operating modes for this generator facility	Emergency/Standby, Peak Shaving, Base Load Power, Cogeneration Renewable, Non dispatch etc	Optional
Indicate the intended use of power generated from the proposed facility, subject to all applicable	Net Metering, Internal Usage only, Demand Response Resource, Other- Explain	Required
Interconnection capability		
IEEE 1547-2018 Category	category 1, 2, 3 - dropdowns	Required
Remote monitoring	yes/no	Required
Remote control capability	yes/no	Required
Telecom path	drop downs - ICCP, 4G, 5G, fiber, mesh network? Other?	Optional
Comm protocol	DNP3, etc	Optional
Comm scan rate	x minutes or seconds	Optional
Real-time production	Actual output for sites above x MW? time interval? TBD	If Applicable
Irradiance	Measured in Watts per square meter	Optional

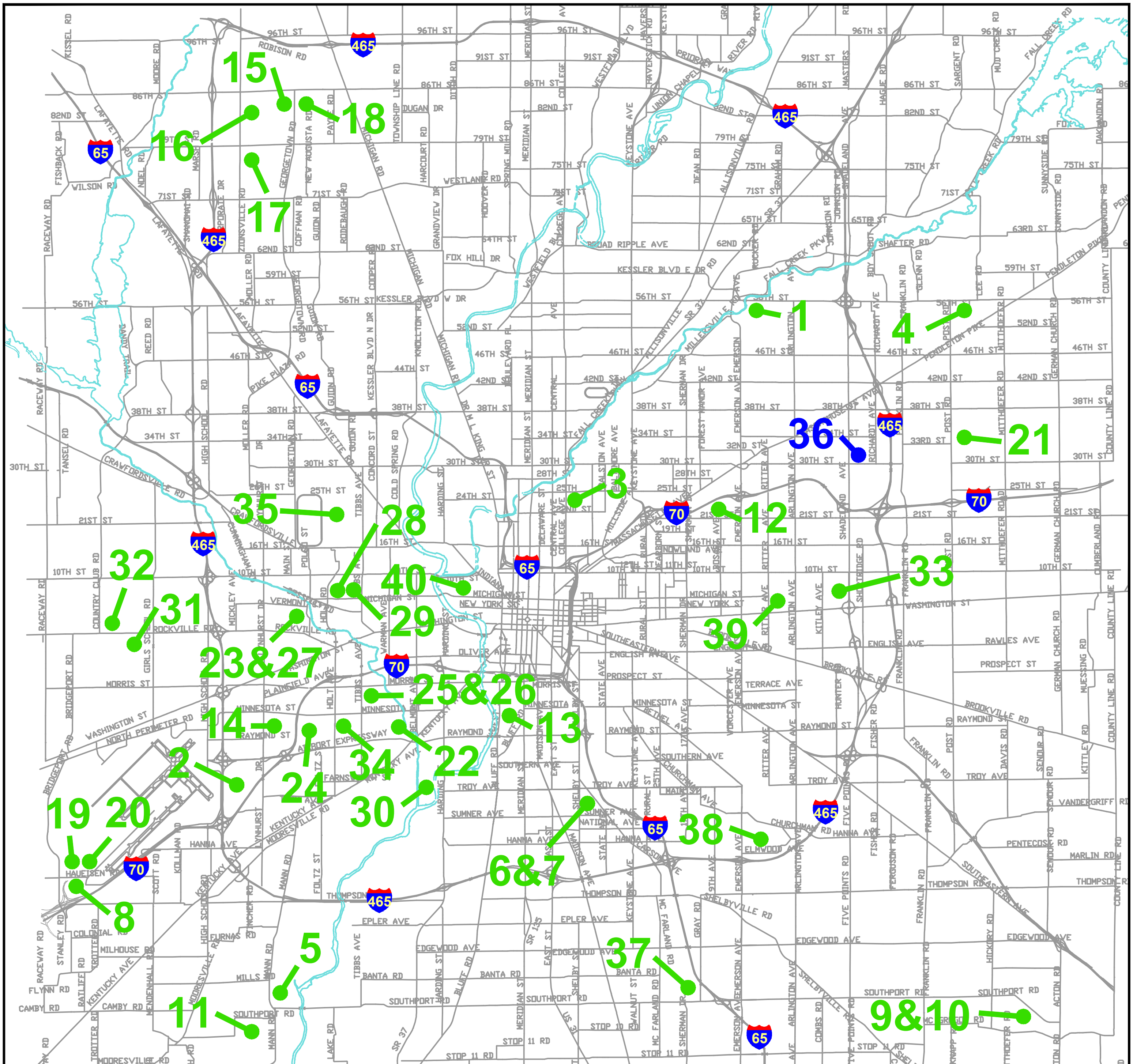
Appendix A

Other items		
Expected production 8760 hours in year	Forecast	Optional
Historic production data?	Actual output, if available	Optional
associated weather/cloud/insolation data?	Actual weather data, if available	Optional
Any additional information	Please provide any comments	Optional

Appendix A

FOR PURPOSES OF THIS STUDY ONLY	
IPL provided information - Level 1 - 10kW or less	
IPL Level 1 Interconnection Agreement	**Information Included in Exhibits**
Exhibit 1B - Single Line Drawing	# of solar panels, series or parallel connected system (style of connection), # of inverters and # of panels per inverter, types and locations of AC and DC disconnects (fusing or switches), connection point (breaker box or high side of breaker box), type of wire, and grounding (for Level 1, typically inverters have basic grounding through the house main)
Exhibit 1C - Inverter Specifications	DC inputs (Max DC input, Nominal DC Inputs, Reverse-Polarity Protection, Efficiency and Night time power consumption), AC inputs (Rated AC power output, Maximum AC power output and Maximum Continous Output). If system included a battery, Battery specs include the Maximum Continuous Power - (i.e. islanding inverters such as Pika Islanding X series)
Exhibit 1E - Miscellaneous Attachments	
IPL provided information - Level 2 and 3 > 2MW	
Exhibit 1B - Single Line Drawing	
Exhibit 1C - Site Plan Drawing	Aerial view of customer's house and layout of solar panels and inverter
Exhibit 1D - Inverter Specifications	
Exhibit 1F - Miscellaneous Attachments	Solar Spec Sheet: Operating conditions (Temp, System Voltage, Hail or Cloud coverage), Power outputs (watts, efficiency, rated current, rated watts) Short Circuit (maximum amps that a panel or inverter could provide during a fault), and Physical Dimensions
	Power optimizer (another device - usually set between the inverter and solar panels): DC power input, AC power output (standby and operation modes), and Efficiency (maximum and weighted)

Appendix B



1. CATHEDRAL HIGH SCHOOL
2. ES by JMS
3. INDIANA VENEERS
4. GSA BEAN FINANCE CENTER
5. MELLOH ENTERPRISES
6. L&R #1 (LAURELWOOD APTS.)
7. L&R #2 (LAURELWOOD APTS.)
8. AIRPORT I
9. INDY SOLAR I
10. INDY SOLAR II
11. INDY SOLAR III
12. INDY DPW
13. INDY DPW
14. SCHAEFER TECHNOLOGIES
15. CITIZENS ENERGY (LNG NORTH)
16. DUKE REALTY #98
17. DUKE REALTY #87
18. DUKE REALTY #129
19. AIRPORT PHASE IIA
20. AIRPORT PHASE IIB
21. CELADON TRUCKING SERVICES
22. VERTELLUS
23. MERRELL BROTHERS
24. GROCERS' SUPPLY CO.
25. A-PALLET CO.
26. A-PALLET CO.
27. TOWN OF SPEEDWAY, IN
28. GenNx PROPERTIES VI, LLC. (MAPLE CREEK APTS.)
29. GenNx PROPERTIES VI, LLC. (MAPLE CREEK APTS.)
30. CITIZENS ENERGY/CWA AUTHORITY
31. REXNORD INDUSTRIES
32. EQUITY INDUSTRIAL A-ROCKVILLE LLC.
33. LIFELINE DATA CENTERS
34. OMNISOURCE
35. INDIANAPOLIS MOTOR SPEEDWAY
36. DEEM
37. INDY SOUTHSIDE SPORTS ACADEMY
38. MARINE CENTER OF INDIANA
39. 5855 LP
40. IUPUI

LEGEND

- OPERATING

- UNDER CONSTRUCTION

- IN DEVELOPMENT

ipl an AES company

INDIANAPOLIS POWER & LIGHT CO.

SOLAR FACILITIES

DRAWN BY: RLW
5-18-15

solar-REP-GIS-map

REV. 11-1-19 WJK

FERC's Energy Storage and DER Aggregation NOPR

Docket Nos. RM16–23–000; AD16–20–000

From a regulatory perspective, the efficient development of all forms of Distributed Energy Resources (DERs) and the integration of Electric Vehicles (EVs) should be regarded as a shared federal and state objective. From a regulatory and public policy perspective, DERs and EVs have implications for the FERC / NERC [1][2] and state commissions because this affects the operations and planning of RTOs / ISOs and distribution utilities.

In a concerted effort to maximize the reliability and economic benefits of DERs and EVs, the Indiana Utility Regulatory Commission staff is promoting well-designed research projects that include the RTOs, distribution utilities, stakeholders, and outside experts such as the National Laboratories. The results of such projects will be generally transferable to other utilities.
Initially, the Commission staff expects Indiana utilities will want to design their own pilot programs to meet their unique circumstances. The Commission staff would also anticipate that their respective RTOs

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[1] "NERC has focused on ensuring the reliable operation of the BPS under increasing penetrations of BPS-connected inverter-based resources as well as distributed energy resources (DERs)…[T] he NERC Load Modeling Task Force (LMTF) developed a modeling framework and recommended adopting practices for studying the aggregate impacts that DERs may have on the BPS. The NERC System Planning Impacts of Distributed Energy Resources Working Group (SPIDERWG) is further analyzing these impacts and developing recommended practices and industry guidance.

IEEE Standard 1547-2018 *Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces…*was published in April 2018 and significantly enhanced the performance and functional capability of DERs connecting specifically to primary and secondary distribution systems. IEEE 1547-2018 is intended to apply only to DERs connected to the distribution system and is generally not suited for other interconnection levels (i.e., resources connecting to the subtransmission or transmission systems). These new capabilities align with the BPS reliability needs and present opportunities for maintaining or improving BPS reliability with increasing penetration of DERs…

The timely adoption and implementation of IEEE 1547-2018 for DERs connected to the distribution system across North America is strongly encouraged. The specifications for DERs in IEEE 1547-2018 include performance capability categories and allowable ranges of functional settings that provide flexibility to align with specific system needs. However, these flexibilities require coordination between distribution and transmission entities for effective adoption. The adoption of IEEE 1547-2018 requires the authority governing interconnection requirements (AGIR)10 and various stakeholders to get involved at a deeper technical level than in the past. Due to the required amount of coordination in IEEE 1547-2018, it is expected that AGIRs may need around two years to develop an effective implementation plan…"

[2] Authority Governing Interconnection Requirements (AGIR): **"**A cognizant and responsible entity that.. administers, and enforces the policies and procedures for allowing electrical interconnection of DER to the area Electric Power System (EPS). This may be a regulatory agency, public utility commission.., The degree of AGIR involvement will vary in scope of application and level of enforcement across jurisdictional boundaries. This authority may be delegated by the cognizant and responsible entity to the Area EPS operator or bulk power system operator."

may have their own objectives. However, there is an overlap of interests that warrant Indiana utilities and their RTOs to work together on common concerns. The IURC anticipates that, over time, the extent of the overlap of interests will increase.

Consistent with the IURC's public policy objectives, the IURC is generally supportive of the FERC's Notice of Proposed Rulemaking (NOPR) to "remove barriers to the participation of electric storage resources and Distributed Energy Resource (DER) aggregations in the capacity, energy, and ancillary service markets" run by ISOs/RTOs. The IURC encourages Indiana utilities to coordinate the use of all forms of DERs with the RTOs. It is gratifying that IPL recognizes the importance of integrating DERs into distribution system planning and IPL's Integrated Resource Planning as well as incorporating information from the MISO's long-term planning.

IPL and MISO have engaged in DER discussions through 2019 and 2020 to understand experiences and pose questions related to future DER integration in wholesale markets. The parties developed a draft Solar DER data collection template as a foundation for broader stakeholder input. Over time, utility/RTO coordination will address the common near-term interests as well as the interests articulated by the FERC and NERC in the following areas.

- Evaluation of electric storage resources and DERs on the distribution system as well as the MISO's system – including dispatchability. In the longer-term, the effects of EVs on the distribution system may become an increasing interest for bulk power system planning and operations (e.g., transmission planning, providing capacity, energy and ancillary services);

- Information and data for all forms of DERs and EVs will be a short and long-term effort. Utility deployment of AMI metering will provide a wealth of information, including real-time data about the DERs and EVs, will enhance understandings of customers' use, load forecasting and verification of DER capabilities in the wholesale and retail markets.

To reiterate, the IURC has been supportive of well-designed pilot programs. Pilot programs that address potential ramifications of changing technologies and changing needs of customers are particularly propitious. Ideally, this research will be transferable to other utilities and inform the planning and operations of IPL and MISO.