Coordination of Transmission and Distribution Operations in A High Distributed Energy Resource Electric Grid

Presentation for PJM Stakeholders

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This report reflects the work of California’s investor-owned electric utilities and the California ISO, in collaboration with the More Than Smart T-D Interface Working group.

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Introduction

- Growth of distributed energy resources ("DERs") – at distribution level, either side of end-use meter
- T-D interfaces are substations where the ISO controlled grid meets the utility distribution system. Also pricing nodes (Nodes) in the LMP wholesale market.
- Where DERs seek to participate in wholesale markets and/or provide services to the distribution system, increased coordination and communication at the T-D interface becomes even more important.
- Need to coordinate and communicate with each other in new ways to maintain reliable operation of their respective systems and, ultimately, of the electric system as a whole.

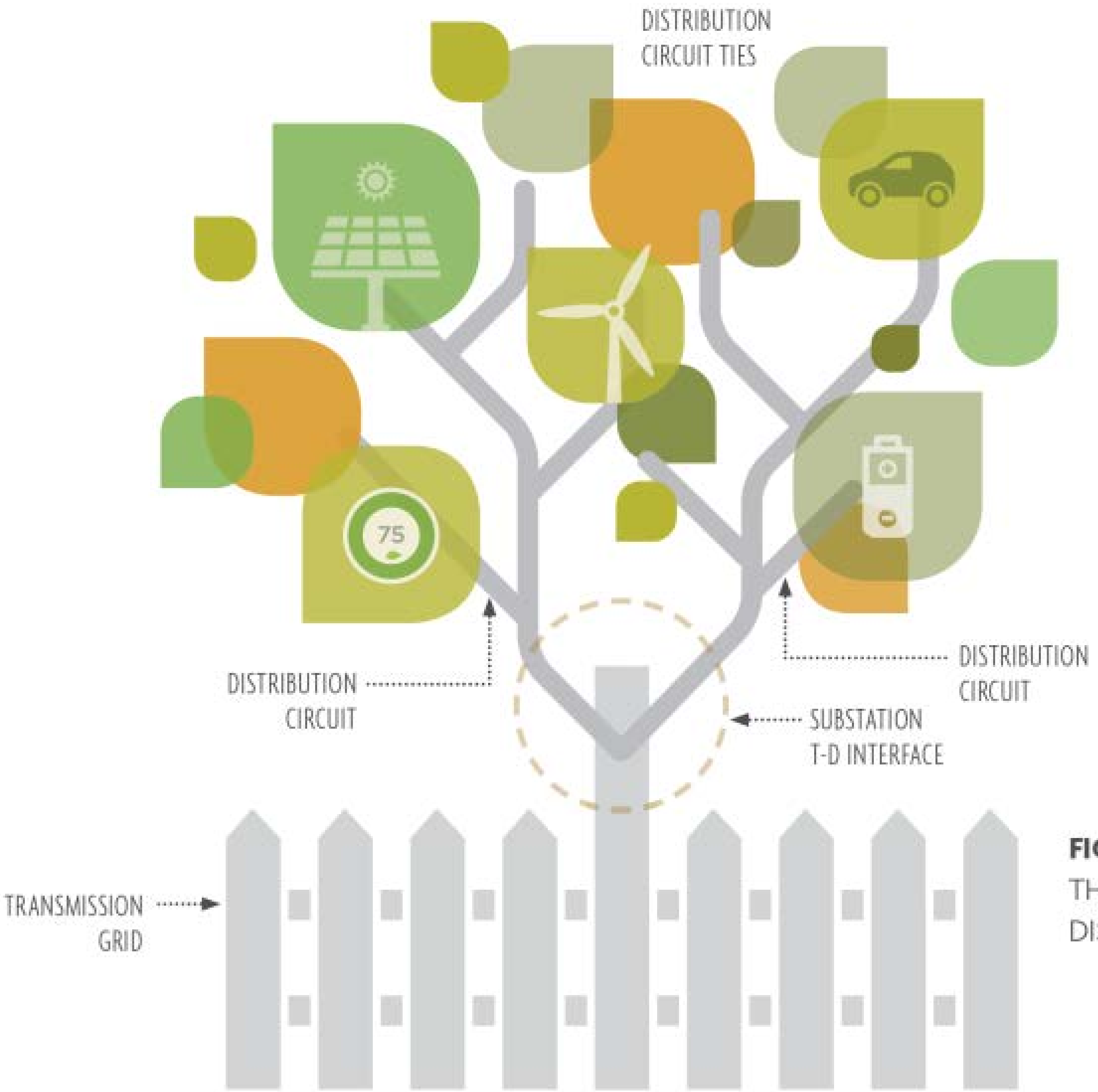

FIGURE 1. STRUCTURE OF THE TRANSMISSION AND DISTRIBUTION SYSTEMS

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Structure of the ISO-UDC collaboration

Two time frames

- Near-term (2017-18) with relatively low volumes of DERs but with some new DER aggregations participating in the ISO wholesale market
- Mid-term (at least 3-5 years into the future and possibly beyond) with much higher volumes and diversity of DERs and DER aggregations

The paper examines three DER scenarios, where DERs

1. Participate exclusively in the ISO market
2. Provide services to the DO (distribution operator, utility distribution company) or to end-use customers, but do not participate in the ISO market
3. Engage in “multiple-use applications” (“MUA”) by offering services from the same facility to the ISO, the DO and end-use customers; i.e., the combination of scenarios 1 and 2.

Two parallel working groups

- IOU distribution companies and ISO => technical/operational focus
- MTS WG including DER providers and other stakeholders => market and business model focus

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Findings

Operational challenges of high DER

- Distribution systems' large and complex topology
- Frequency of distribution outages and use of switching configurations
- DER effects on distribution system phase balance and voltage regulation
- Forecasting the short-term effects of DERs on gross and net load
- Lack of visibility, situational awareness, and control

Transmission-Distribution coordination today

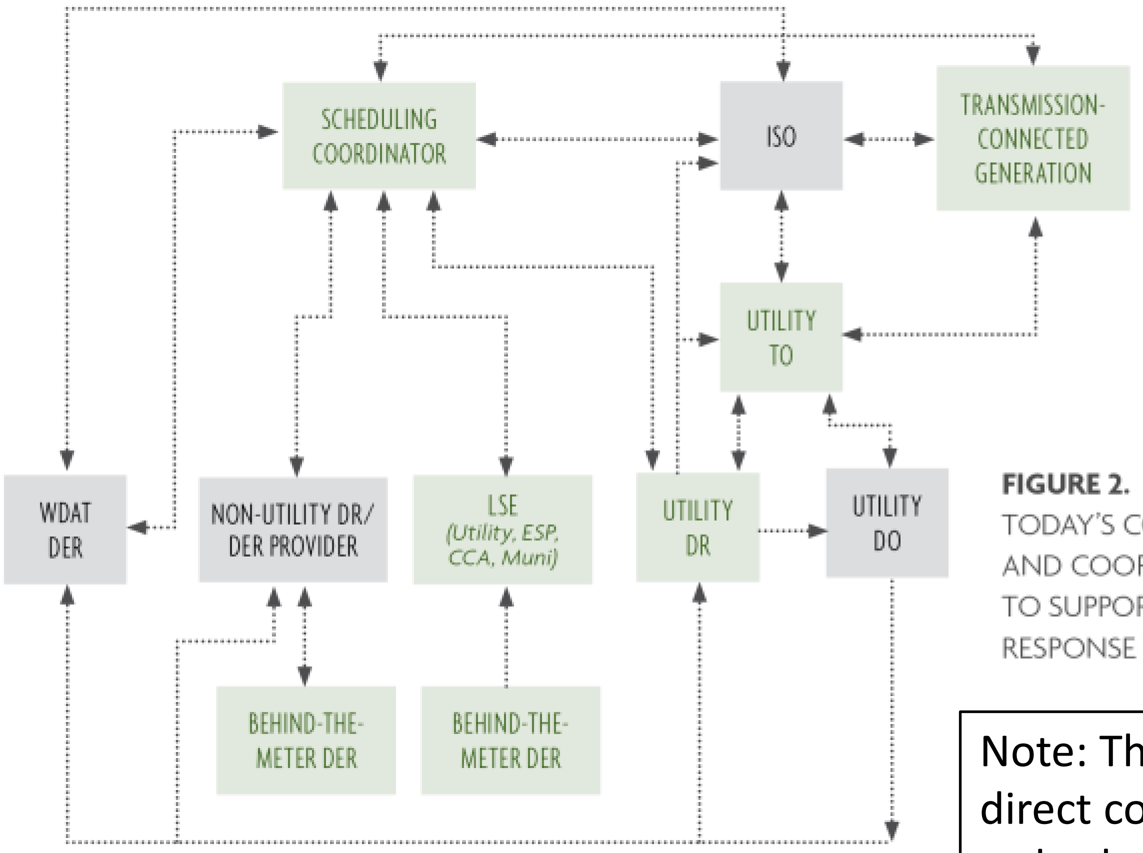

FIGURE 2.
TODAY'S COMMUNICATION AND COORDINATION LINKS TO SUPPORT DEMAND RESPONSE (DR)

Note: There is no direct coordination today between the ISO and utility DO.

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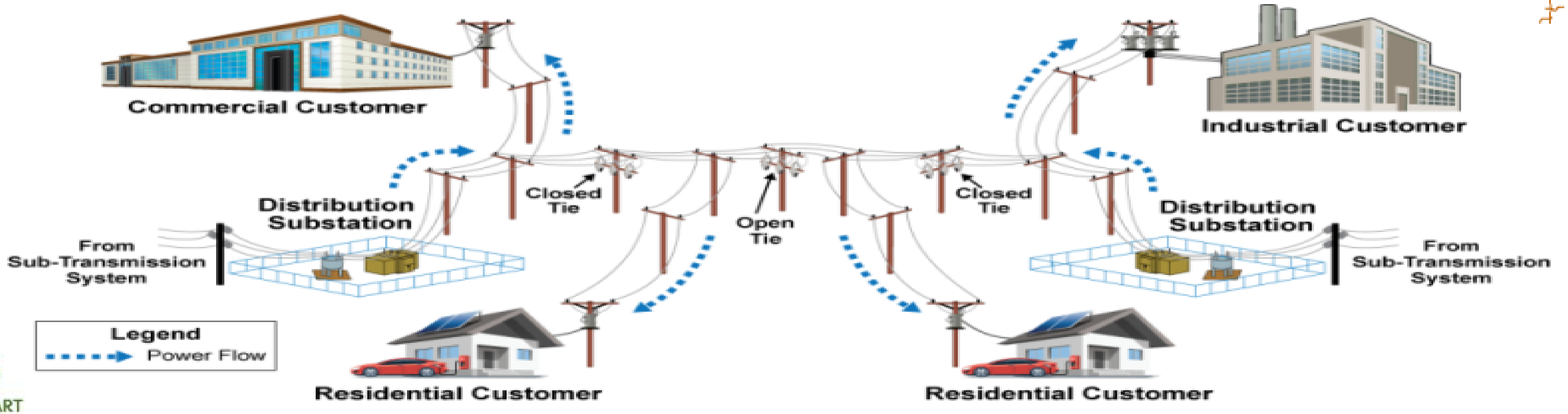
Frequency of Distribution Outages and Use of Switching Configurations

- Radial distribution design is reconfigurable via connections between feeders
- Many possible configurations adding operational complexity
- Outages and abnormal circuit configurations can create capacity constraints, which can affect DERs' ability to participate in wholesale markets



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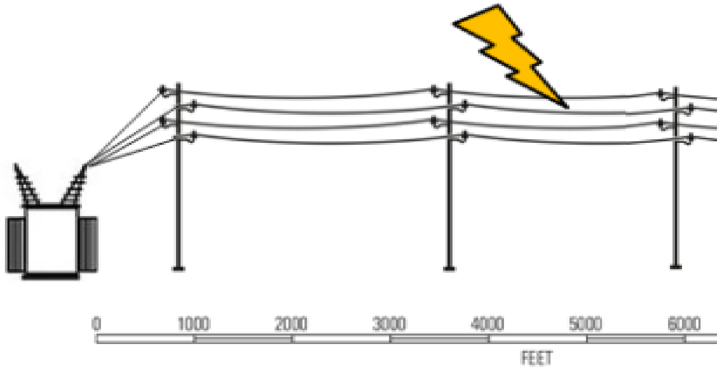
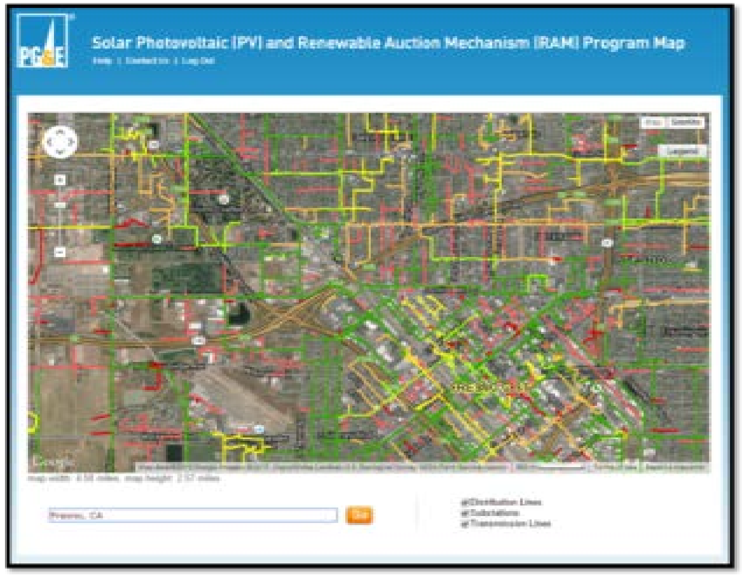
DER Effects on Distribution System Phase Balancing and Voltage Regulation

- Balancing Loads between three phases on distribution grid becomes challenging with higher DER penetration
- Must consider effects of DERs' output, location and characteristics on distribution grid to mitigate phase imbalance and voltage regulation problems
- More sophisticated interconnection, planning, and construction methods will be required to maximize efficient use of distribution grid





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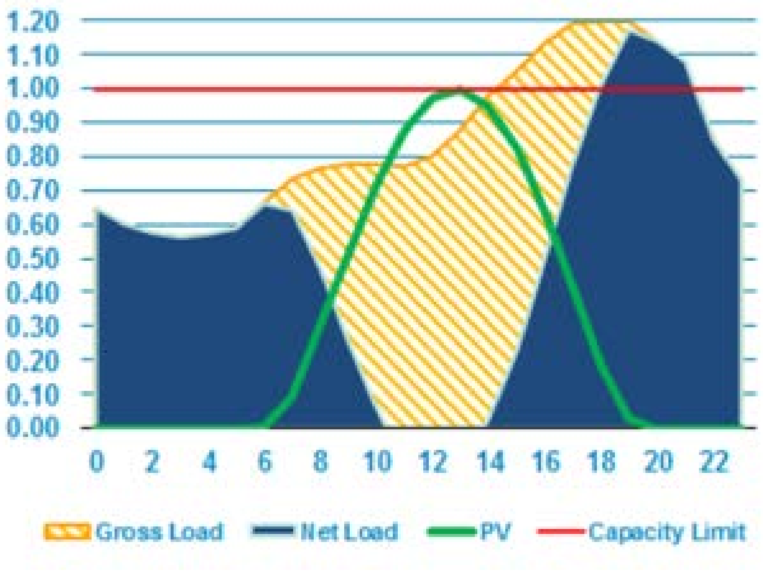
Forecasting Short-Term Effects of DERs on Gross and Net Load

- ISO and DO need accurate short-term forecasts to operate reliably and to run real-time wholesale markets

- Most DERs do not participate in ISO markets as supply resources, but "self-dispatch" as load modifiers, altering overall load shape

- ISO and DO have less certainty about whether sufficient resources are available and committed to serve load and maintain system stability
    - Leads to over commitment of supply resources



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Lack of Visibility, Situational Awareness and Management

- DO and the ISO do not have visibility and situational awareness about status and output of DERs
- DER Provider does not have visibility into distribution system to ensure export via TD Interface is feasible
- DO needs additional granular visibility into distribution system, including tools for:
    - Predicting DER behavior
    - Viewing real time DER response
    - Forecasting DERs’ impact on grid

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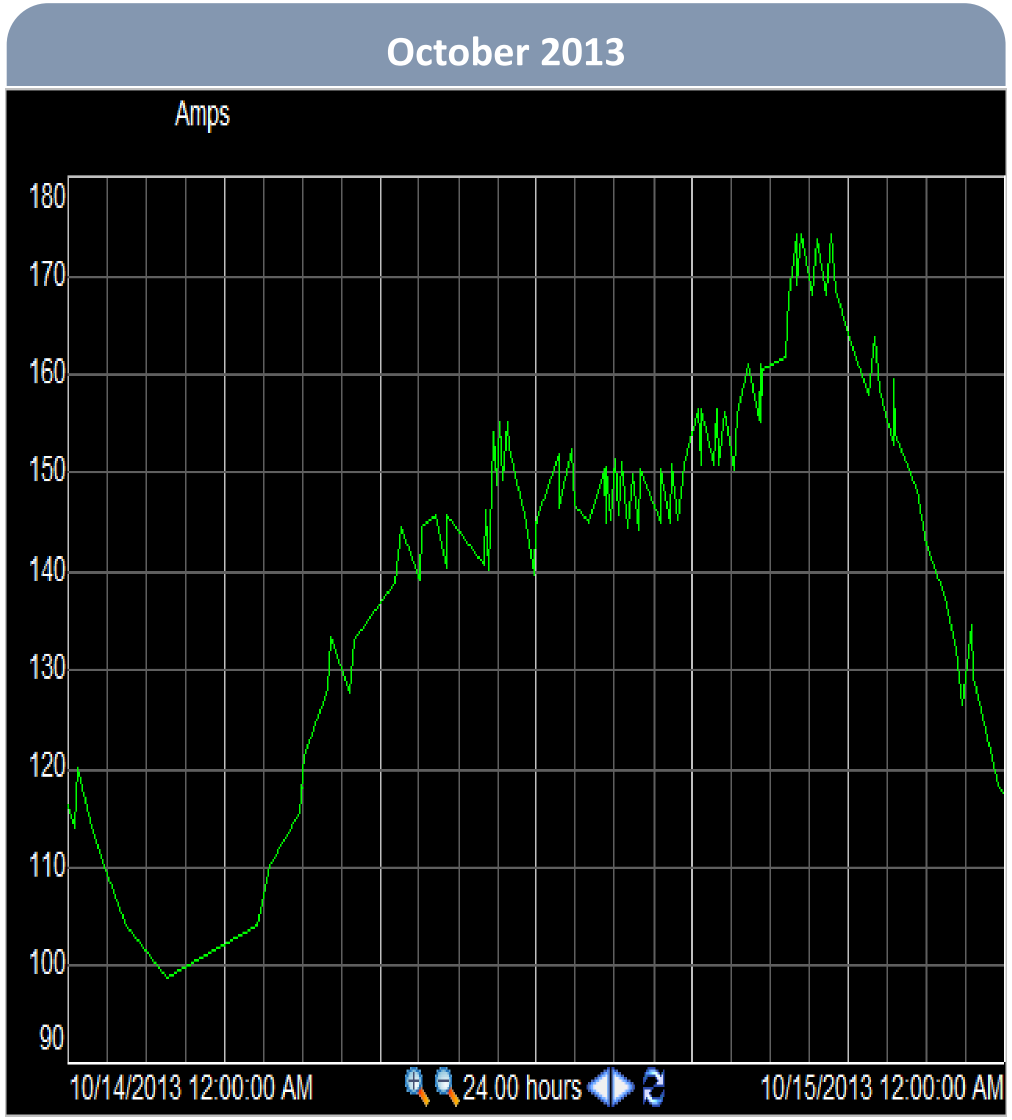
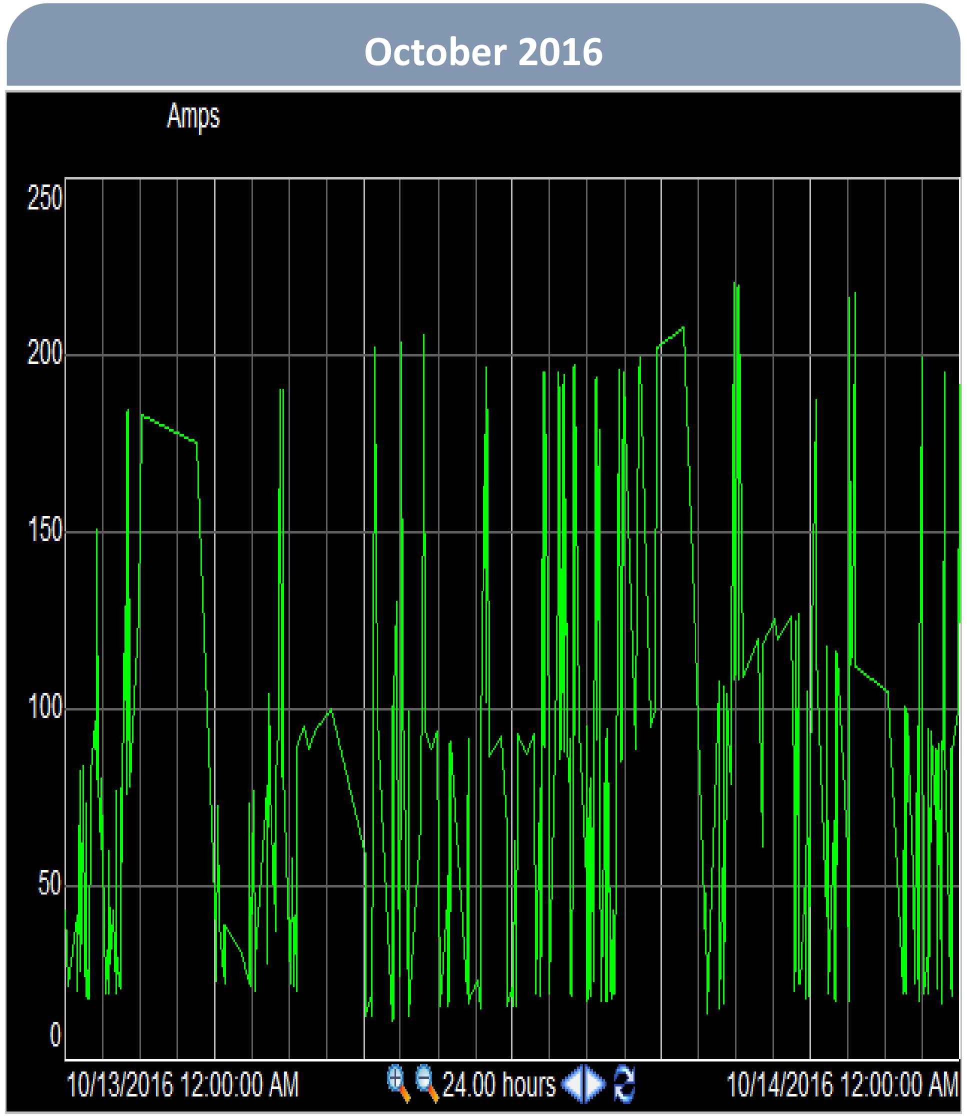
“Before” and “After” Grid Impacts as result of DER Market Participation



“Before”



“After”

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Findings (cont'd)

Objectives of the high-DER future

ISO Objective: Predictability of DER responses to dispatch instructions at the T-D interface; accurate short-term forecasts at the T-D interfaces for running real-time market; long-term forecasts of DER growth for infrastructure planning.

DO Objective: Visibility to the current and predicted behavior of the DERs on its system, and ability to control or dispatch DER when needed to maintain reliability and safety.

DER Provider Objective: Ability of the DER/DER Aggregation to participate in all markets for which it has the required performance and measurement capabilities, and to reasonably manage risks of potential curtailment.

FIGURE 3. NUMBERED DOTS INDICATE POSSIBLE COORDINATION ENHANCEMENTS FOR 2017 (NTE) AND FOR THE MEDIUM-LONG TERM (M/LTE) TO SUPPORT RELIABLE OPERATION WITH HIGH DER

INFORMATION TYPE	ISO	UTILITY TO	UTILITY DO	DERP
1 | DER/DERA bids into ISO market	✔		NTE 2	✔
2 | Installed capacity of each DER and DERA			✔	✔
3 | Total installed DER capacity per T-D substation			✔	
4 | Transmission topology and conditions	✔	✔		✔
5 | Distribution topology and conditions			✔	NTE 1
6 | DA forecasts of DER impacts	M/LTE 9	M/LTE 10	M/LTE 7	
7 | RT forecasts of DER impacts	M/LTE 9	M/LTE 10	M/LTE 8	
8 | DA schedules (results of ISO market)	✔	M/LTE 11	NTE 3	✔
9 | RT dispatches (results of ISO market)	✔	M/LTE 11	NTE 3	✔
10 | Transmission feasibility of schedules	Ensured by ISO market optimization			Ensured by ISO market optimization
11 | Distribution feasibility of schedules	NTE 6		NTE 4	NTE 5
12 | DER/DERA revenue meter data	(for participating DER/DERA)			✔
13 | Generation Telemetry (for real-time observation)	(>= 10 MW or providing AS)		(>= 1 MW)	✔
14 | T and D System Telemetry (for real-time observation)	T system (consistent across the system)	T system (consistent across the system)	D system (inconsistent)	

Recommendations

- DOs should pilot processes to communicate advisory information on current system conditions to DER providers, so that the providers can modify their ISO market bids accordingly and if necessary submit outage or derate notifications to the ISO

- The ISO should initiate processes that provide day-ahead DER schedules to the DO, for the DO to pilot performing a feasibility assessment or review to identify schedules that may create significant distribution system reliability or performance problems. In the longer term, if this procedure seems viable and useful, the ISO could also make available real-time dispatch instructions to the DO for feasibility assessment in conjunction with new DO technical capabilities such as DER Management Systems

Recommendations (cont'd)

- The DER provider should communicate constraints on its resources' performance to the ISO. This could be in the form of updated market bids for market intervals where bid submission is still open, or outage notifications for intervals where dispatch instructions have already been issued and there is no subsequent bidding opportunity

- The DOs should develop a pro forma integration agreement with the DER provider with regard to DER aggregations. The DO will typically have an interconnection agreement with an individual DER on its system, but when multiple DERs are aggregated into a virtual resource for ISO market participation, today there is no comparable agreement between the DO and the DER provider. The agreement could specify, for example, the responsibilities of the parties to support reliability of the system and enable the DER provider to realize the full value of the DER aggregation through provision of the various services its performance characteristics allow.

Topics for continuing working group effort:

1. Distribution utilities educate the WG on grid modernization and consider implications of operational coordination needs on grid modernization.
2. Develop example use-cases reflecting likely DER aggregation scenarios to ground discussion in practical applications. Consider how future pilot proposals may stem from identified use cases.
3. Specify potential real-time coordination procedures to manage potential conflicts between DO needs and ISO dispatches. Begin with scenario approach and then broaden as needed.
4. Identify principles for a DO approach to DER curtailment resulting from distribution level constraints.
5. Consider any unique perspectives or challenges for municipal utilities within ISO footprint
6. Describe the process and timeline for integration of a new DERA into the wholesale market, including utility process for 30-day review of DERA under ISO DERP tariff as well as ISO integration process
7. Develop methods for short-term DER forecasting and impacts at T-D Interfaces
8. Develop method for DO feasibility assessment of ISO's day-ahead DER schedules and real-time dispatches
9. Explore how various DSO models would impact design of the T-D interface coordination framework

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Structure and sequence of use cases

Use Case	DER Configuration	Grid Services Provided
A	Single Resource	Wholesale only
B	Aggregated Resource – single-feeder and multi-feeder sub-cases	Wholesale only
C-1	Single Resource	Wholesale + Distribution Multiple Use Application (MUA), time- or capacity-differentiated
C-2	Single Resource	Wholesale + Distribution MUA using the same capacity in the same time interval
D-1	Aggregated Resource – single-feeder and multi-feeder sub-cases	Wholesale + Distribution MUA, time- or capacity-differentiated
D-2	Aggregated Resource – single-feeder and multi-feeder sub-cases	Wholesale + Distribution MUA using the same capacity in the same time interval
E	Single Resource	Wholesale + Distribution: enhanced DO/DSO functionality
F	Aggregated Resource	Wholesale + Distribution: enhanced DO/DSO functionality

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ACRONYMS

CCA	Community Choice Aggregator
CPUC	California Public Utilities Commission
DA	Day Ahead
DR	Demand Response
DER	Distributed Energy Resource
DERA	Distributed Energy Resource Aggregation
DERP	Distributed Energy Resource Provider
DO	Utility Distribution Owner/Operator
DSO	Distribution System Operator
ESP	Energy Service Provider
FERC	Federal Energy Regulatory Commission
LSE	Load Serving Entity
ISO	Independent System Operator
M/LTE	Medium- /Long-Term Enhancement
MUA	Multi-Use Applications
NERC	North American Electric Reliability Corporation
NTE	Near-Term Enhancement
PV	Photovoltaic
RT	Real Time
RTO	Regional Transmission Organization
SCADA	Supervisory Control and Data Acquistion
T-D	Transmission-Distribution
TO	Utility Transmission Owner
WDAT	Wholesale Distribution Access Tariff