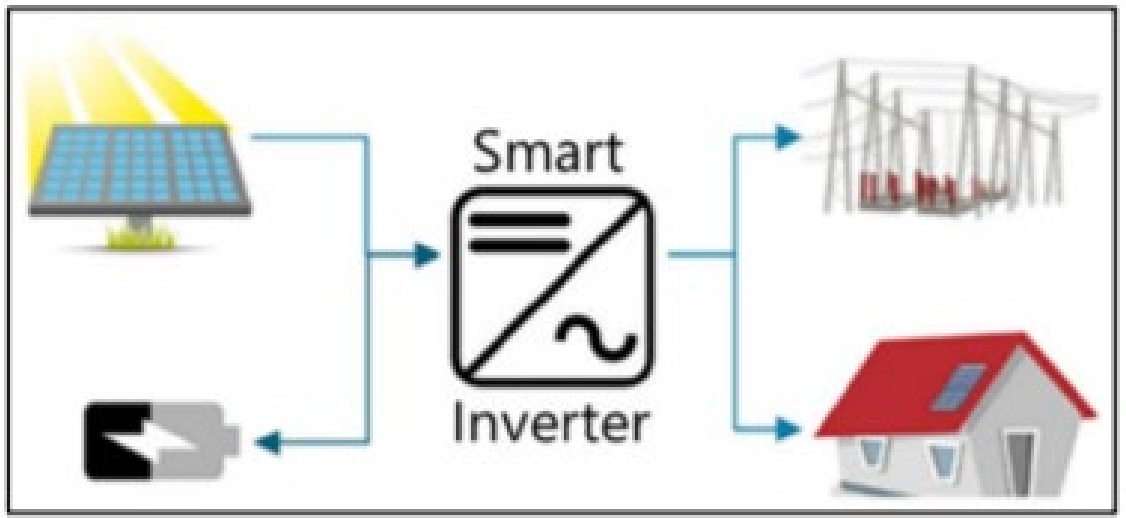
Smart Inverters Role in Modern Electric Grid

Shahin Abdollahy, PhD, PE

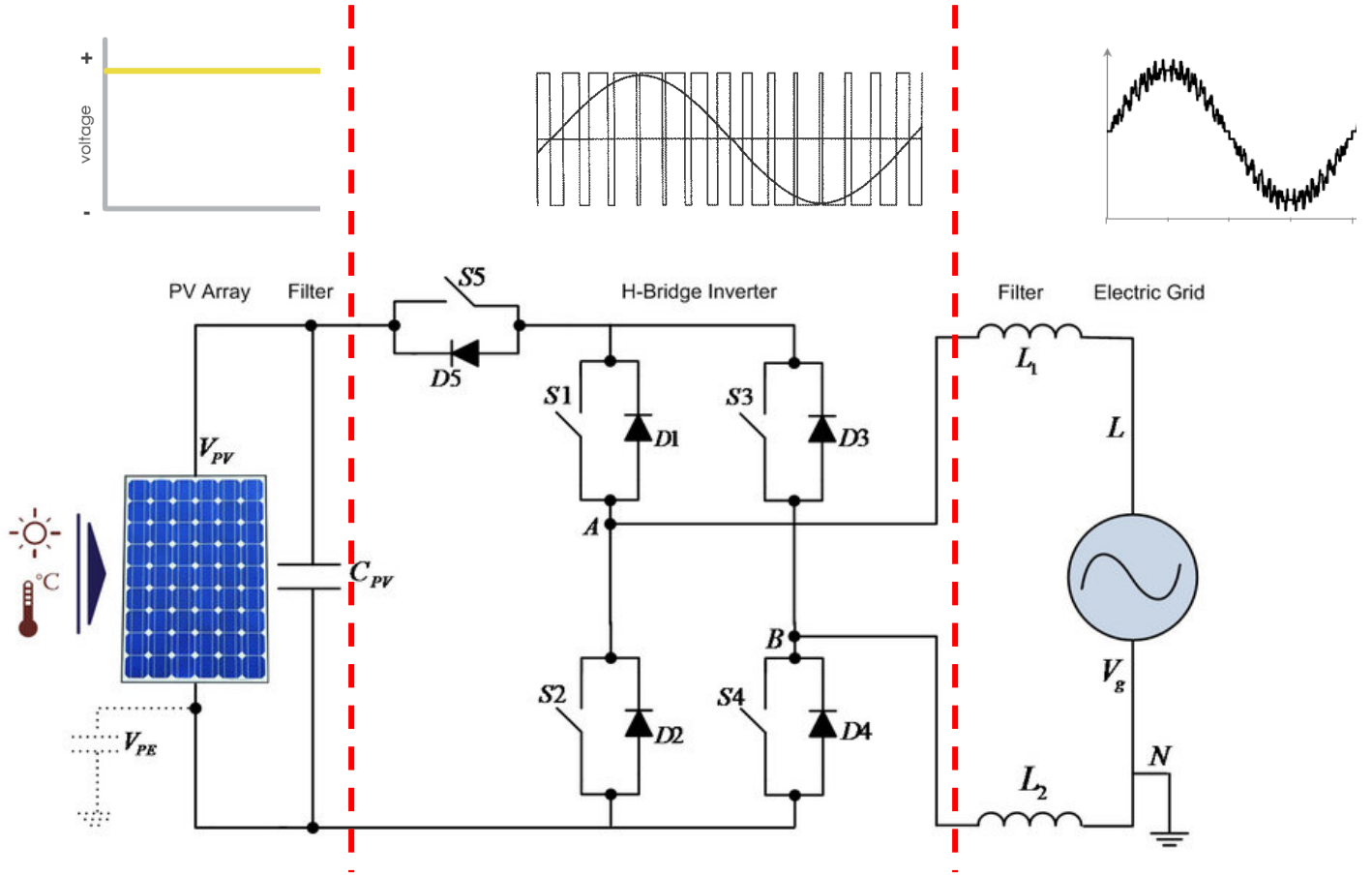
Outline

- **Introduction to Smart Inverters**
- **Autonomous Functions**
- **Smart Functions**
- **Historical Problems and New Solutions (An Example)**
- **A Utility Roadmap for Successful Deployment of Smart Inverters**
- **Takeaways**



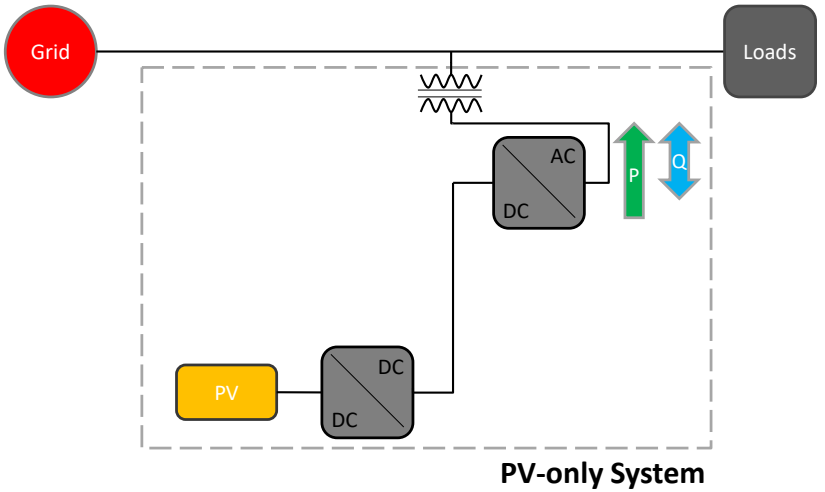
Inverters

- **For many DER types, inverters are the interface to AC grid**



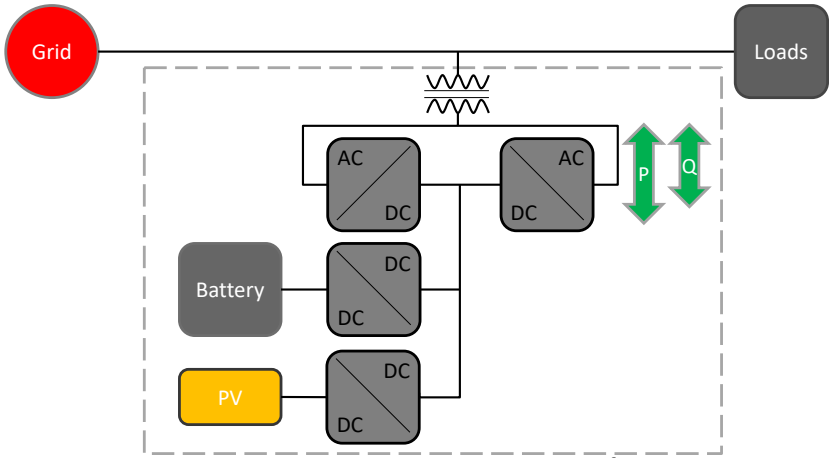
Advanced Inverters

- **Provide functionalities in addition to converting input real power to output real power (such as reactive power capabilities)**



PV-only System

- **With battery storage can independently control the active and reactive power output (four power quadrant operation)**

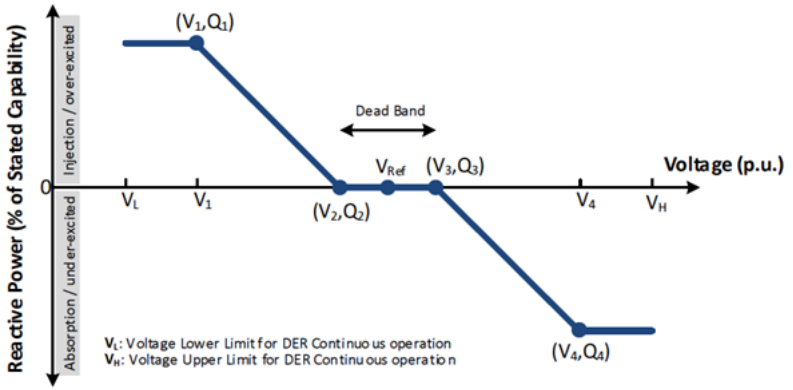


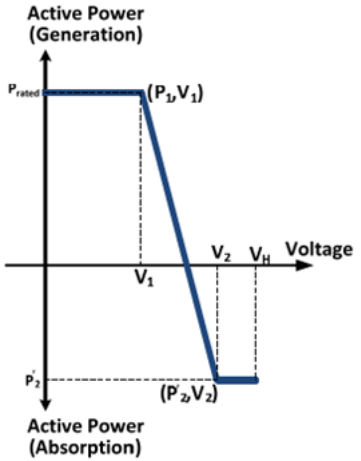
DC-DC Connected System with PV and Storage

Advanced Autonomous Inverters

- **Advanced inverters can perform autonomous functions**

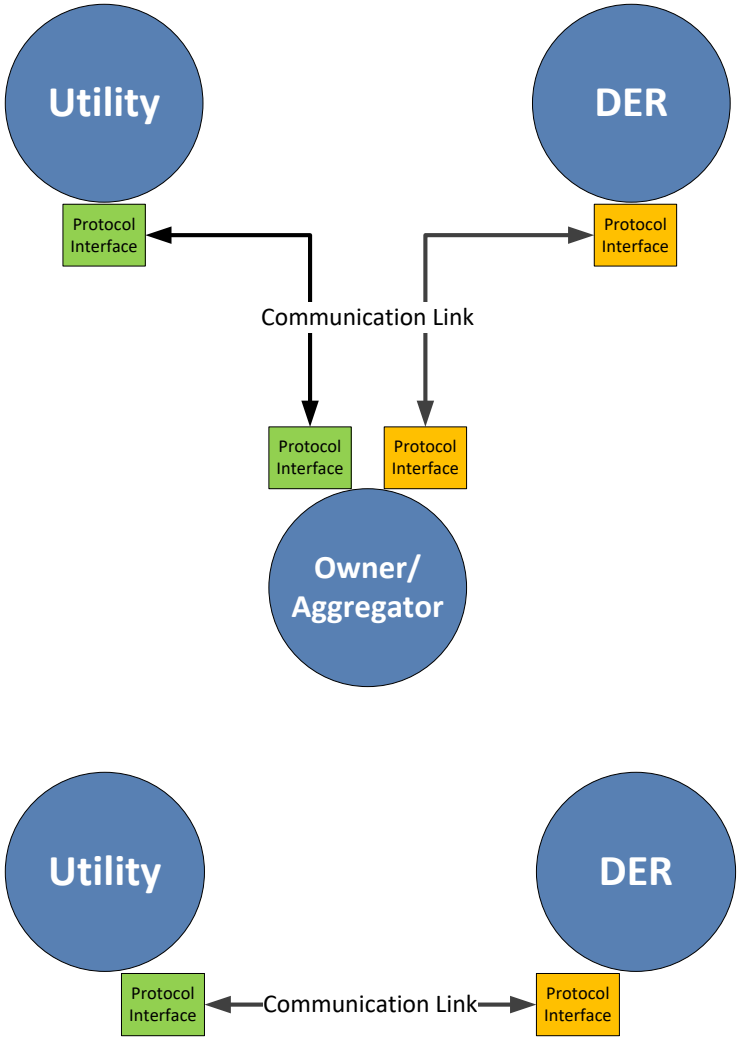
Advanced Function	Application
Anti-islanding	No Generation when Grid is Down
Low/High Voltage Ride Through	Support Grid during Disturbances
Low/High Frequency Ride Through	Support Grid during Disturbances
Volt/VAR, Volt/Watt Curve Setting	Grid Voltage Support
Ramping	Set the Rate of Change of Power
Fixed Power Factor	Grid Voltage Support
Reconnect on Restoration	Assist Power Restoration after Blackout





“Smart” Inverters

- **Adding real-time interactive communication capabilities makes inverters smart**
- **Smart inverters enable utilities/ aggregators/owners to command and control real and reactive power of DERs**
- **The communication capability also allows users to set operational modes, settings, and configuration**



Smart Inverter Services

- **Through the use of smart inverter functionalities, additional services can be realized.**

  Frequency Response (FR)

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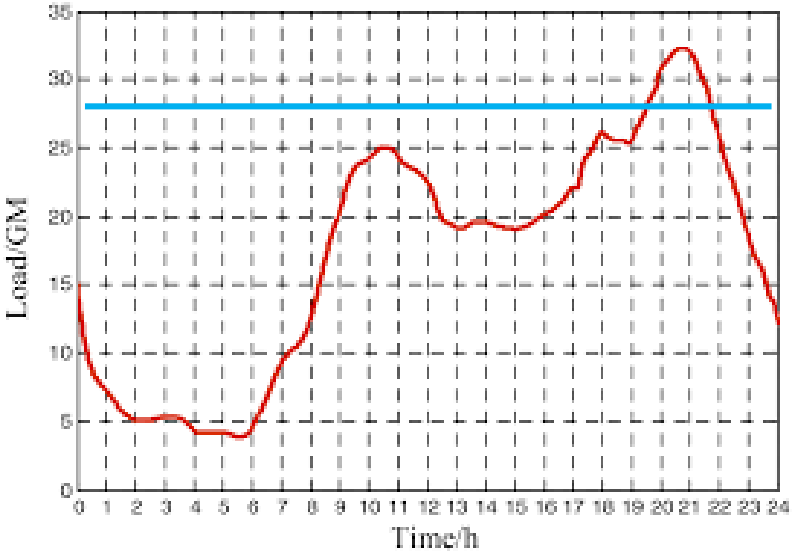
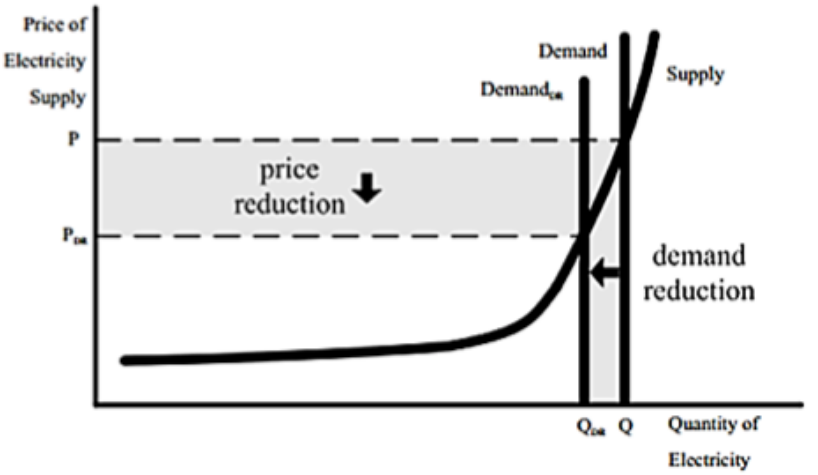
Peak Shaving

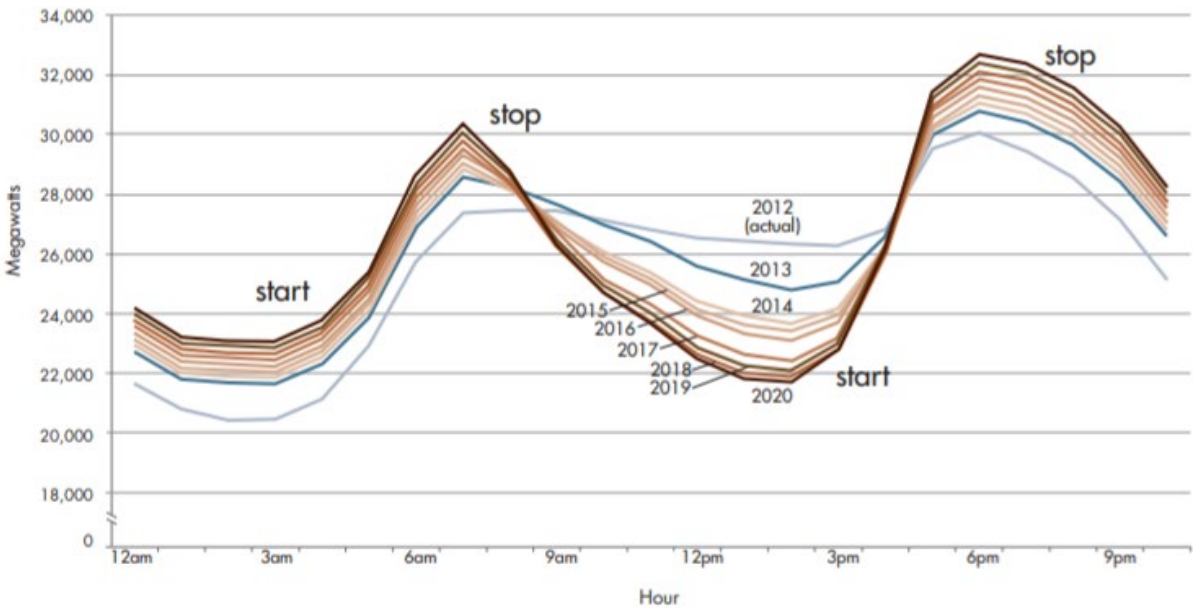




Other services such as:

- Reliability / Resiliency
- Power Factor Correction
- Load/Generation Following
- VVO (Volt-Var Optimization)

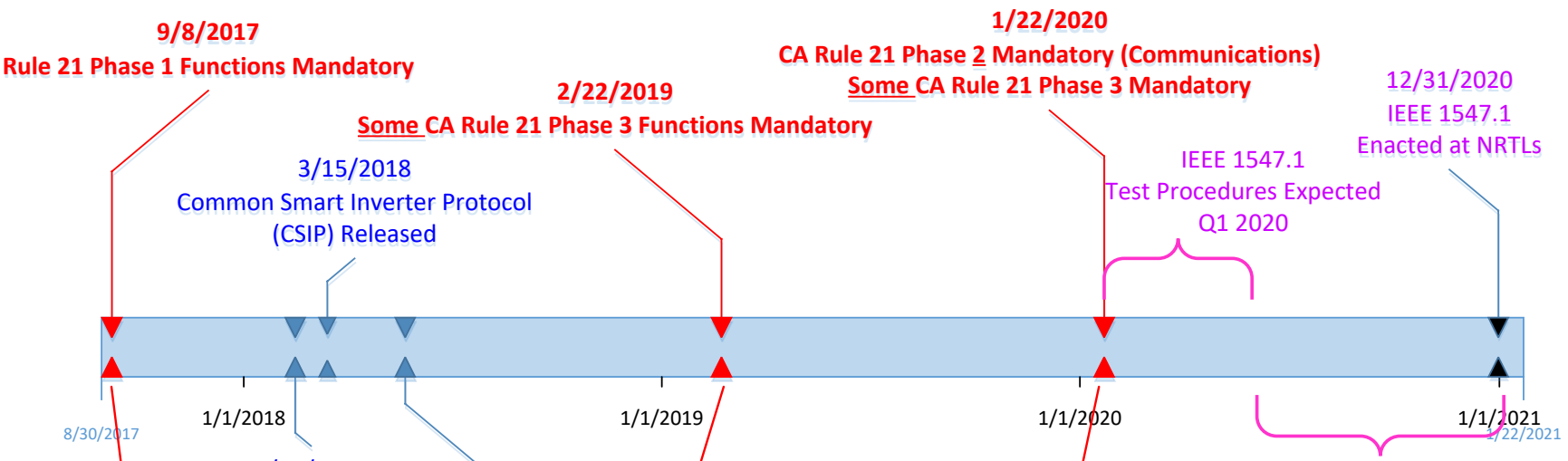
Historical Problems and New Solutions (An Example)



Net Load on January 11
(Source: California Independent System Operator)

- Various projection levels of the “belly” of the Duck Curve
- Each subsequent year showing a lower and lower projected value of net demand
- Using smart inverter functions, the inverter can be commanded to
  - appear as a load (charging the batteries to increase load during low demand)
  - appear as a generator (discharging the energy storage to offset higher demand)
- Those services can flatten the aforementioned Duck Curve

California is Setting the Stage in Standardization



Rule 21 Phase 1 Functions (Mandatory)

- (1) Anti-Islanding,
- (2) LHVRT,
- (3) LHFRT,
- (4) Volt/VAR,
- (5) Ramping,
- (6) Fixed Power Factor, and
- (7) Reconnect on Restoration.

Rule 21 Phase **3** Functions (Mandatory)

- (Fn 5) Frequency/Watt Mode,
- (Fn 6) Voltage/Watt Mode,

Rule 21 Phase **3** Functions (Mandatory)

- (Fn 1) Monitor Key DER Data,
- (Fn 2) DER Disconnect and Reconnect
- (Fn 3) Limit Max Active Power Mode,
- (Fn 8) Scheduling Power Values and Modes

- (Fn 4) Set Active Power Mode,
- (Fn 7) Dynamic Reactive Current Support

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Successful Deployment of Smart Inverters

Utilities are facing challenges that can potentially impede successful and effective deployment of smart inverters

- Evolving Standards and Certifications
  - UL 1741SA is the current governing standard
  - Certifications are available today for UL 1741 based on IEEE 1547-2003
  - IEEE 1547-2018 standard is approved
  - IEEE P1547.1 is in final balloting and should be approved by Q1 2020

- Manufacturer / Certification Body Readiness
  - In many states, applicable standards are not yet identified
  - Adequate certification facilities may not exist for testing and certifying to state specific standards/regulations

- Back-office Technology Readiness for Integrating Smart Inverters
  - Infrastructure for data capture, communications, cybersecurity, and customer acquisition of data is required
  - Stipulating requirements in communications, cybersecurity, and public/private networks is still work-in-progress

Successful Deployment of Smart Inverters

Utilities are facing challenges that can potentially impede successful and effective deployment of smart inverters

- Impact on Distribution Protection and Distribution Automation
  - Large-scale deployment of smart inverters changes the distribution network behavior
- Unclear Cost/Consequences of Improper Sequencing in Grid Modernization
  - Required support systems are necessary
  - Deployment of smart inverters without the required support systems is not effective
  - Without a full solution architecture, risk of stranding assets or capabilities is high
- Unclear Boundary Between DERMS and ADMS
  - DERMS and ADMS may have conflicting impacts on the distribution assets
  - Utilities may have different approaches towards DERMS

DERMS: DER management system
ADMS: Advanced distribution management system

Takeaways

UTILITIES NEED TO ENSURE THEIR SI STRATEGY CAN ADDRESS THESE CHALLENGES

- With proper settings, autonomous functions are “no regret” solutions
- Autonomous functions do not require interactive communication
- Development of a smart inverter roadmap should be an interactive process in which all stakeholders should participate
- Defining a “one size fits all” solution is not feasible
- Benchmarking of existing approaches is crucial

Questions?