
*Transforming the world of energy using open standards*

# Applying IEC 61850 to Distributed Energy Resources (DER)

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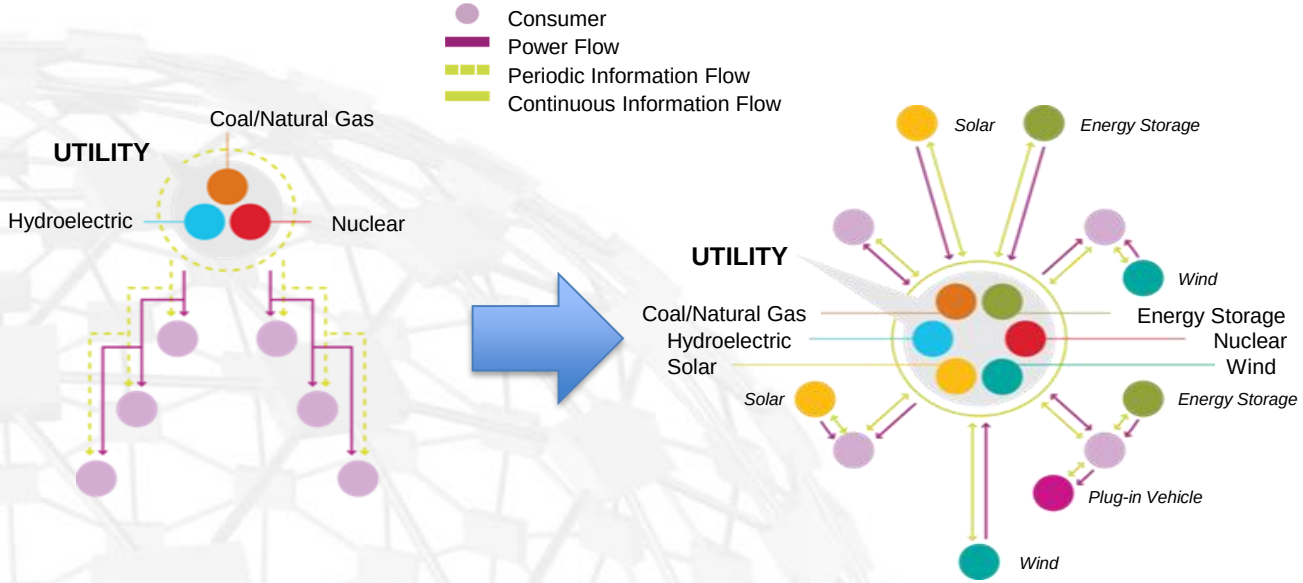
UCAIug at CIGRÉ 2018
Stand 335

# Utility Industry is in Transition



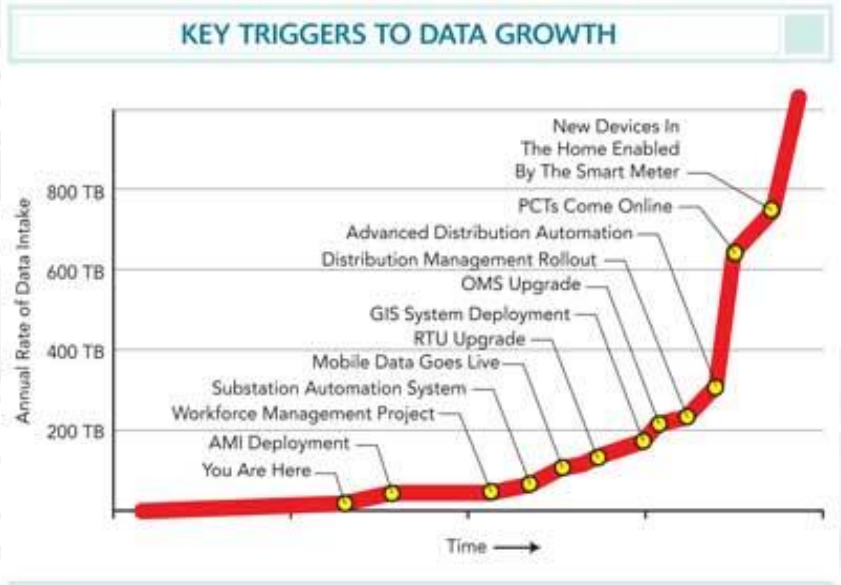

## TRADITIONAL

- Unidirectional power flow
- Large centralized energy resources
- Tag based Operational applications

## TRANSFORMED

- Multi-directional power flow
- Numerous Distributed Energy Resources (DER)
- Model based Operational applications

# Expanding Number of Data Sources and Data Quality Affects the Scope of Utility Applications




$+10^6$ Customer Usage Points

$+10^x$ Social Media Clicks

$+10^4$ Waveform Samples

$+10^7$ Utility Potential points

The growth of data requires a new approach for OT applications:

**Model based integration using CIM and IEC 61850**

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# Drivers for the DER Project

- A large number of small distributed energy resource (DER) projects are being developed and must be connected to the distribution grid:
  - Utility developed and owned solar and wind
  - Outside investor owned solar and wind
- The utility is required to connect and control both utility and third party DER in a neutral manner using existing systems
- The utility is resource constrained to undertake the engineering to interconnect so many different projects

# Complexity

- A common complaint is that IEC 61850 is big, complex and requires a long learning curve. Other protocols are simpler. Simple is better (KISS principle).
- **The complexity of a system is not based on how the bytes are sent on the wire are organized**
- Product implementation complexity does not result in application complexity
- Even though user configuration using numbered tags is understandable (simple) overall system complexity is increased

# Renewable Integration - Solar

- Sun Spec Alliance has developed a Modbus based communication protocol for grid connected inverters

- At a 2010 industry event a Sun Spec representative told me:
  - IEC 61850 was too complex for grid connected inverters
  - Modbus was simple and easy to implement

- Let's look at how "simple" grid connected inverters are using Modbus



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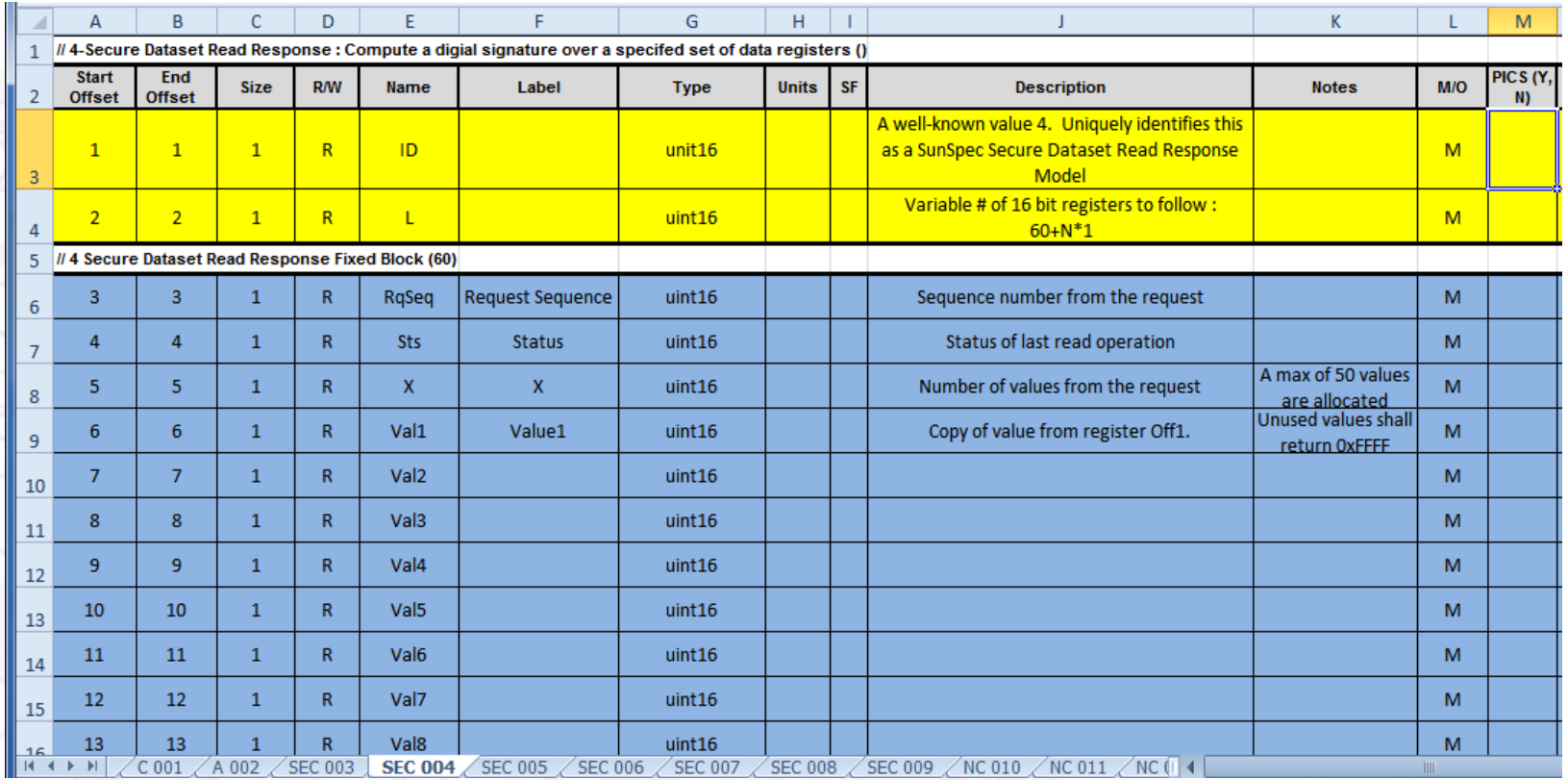
# Sun Spec Protocol Implementation Conformance Statement



| | A | B | C | D | E | F | G | H | I | J | K | L | M |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | // 4-Secure Dataset Read Response : Compute a digial signature over a specifed set of data registers () | | | | | | | | | | | | |
| 2 | Start Offset | End Offset | Size | R/W | Name | Label | Type | Units | SF | Description | Notes | M/O | PICS (Y, N) |
| 3 | 1 | 1 | 1 | R | ID | | unit16 | | | A well-known value 4. Uniquely identifies this as a SunSpec Secure Dataset Read Response Model | | M | |
| 4 | 2 | 2 | 1 | R | L | | uint16 | | | Variable # of 16 bit registers to follow : 60+N*1 | | M | |
| 5 | // 4 Secure Dataset Read Response Fixed Block (60) | | | | | | | | | | | | |
| 6 | 3 | 3 | 1 | R | RqSeq | Request Sequence | uint16 | | | Sequence number from the request | | M | |
| 7 | 4 | 4 | 1 | R | Sts | Status | uint16 | | | Status of last read operation | | M | |
| 8 | 5 | 5 | 1 | R | X | X | uint16 | | | Number of values from the request | A max of 50 values are allocated | M | |
| 9 | 6 | 6 | 1 | R | Val1 | Value1 | uint16 | | | Copy of value from register Off1. | Unused values shall return 0xFFFF | M | |
| 10 | 7 | 7 | 1 | R | Val2 | | uint16 | | | | | M | |
| 11 | 8 | 8 | 1 | R | Val3 | | uint16 | | | | | M | |
| 12 | 9 | 9 | 1 | R | Val4 | | uint16 | | | | | M | |
| 13 | 10 | 10 | 1 | R | Val5 | | uint16 | | | | | M | |
| 14 | 11 | 11 | 1 | R | Val6 | | uint16 | | | | | M | |
| 15 | 12 | 12 | 1 | R | Val7 | | uint16 | | | | | M | |
| 16 | 13 | 13 | 1 | R | Val8 | | uint16 | | | | | M | |

C 001 | A 002 | SEC 003 | **SEC 004** | SEC 005 | SEC 006 | SEC 007 | SEC 008 | SEC 009 | NC 010 | NC 011 | NC (



There are **75** tabs on this spreadsheet

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# Renewable Integration - Solar

- In California:
  - In 2014 there were **2,164** different models of inverters from **151** different manufacturers that were approved for grid connection of solar panels.
- Sun Spec Alliance:
  - **37** manufacturers with 127 models of Sun Spec certified Modbus interfaces.
- According to public sources:
  - There are > **626,000** solar homes in California

- **Will it be "simple" to integrate 600K homes with utility scale applications and build an intelligent grid leveraging solar resources using Modbus?**

- Good news: Standards like IEC 61850-7-420 are being improved to address these needs



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# Why Does This Happen?

- Assuming product implementation complexity results in application complexity
- Assuming that technology constraints today will be valid over the life of the system
- Assumption that user configuration is reasonable because it is understandable
- **User effort costs less than development**



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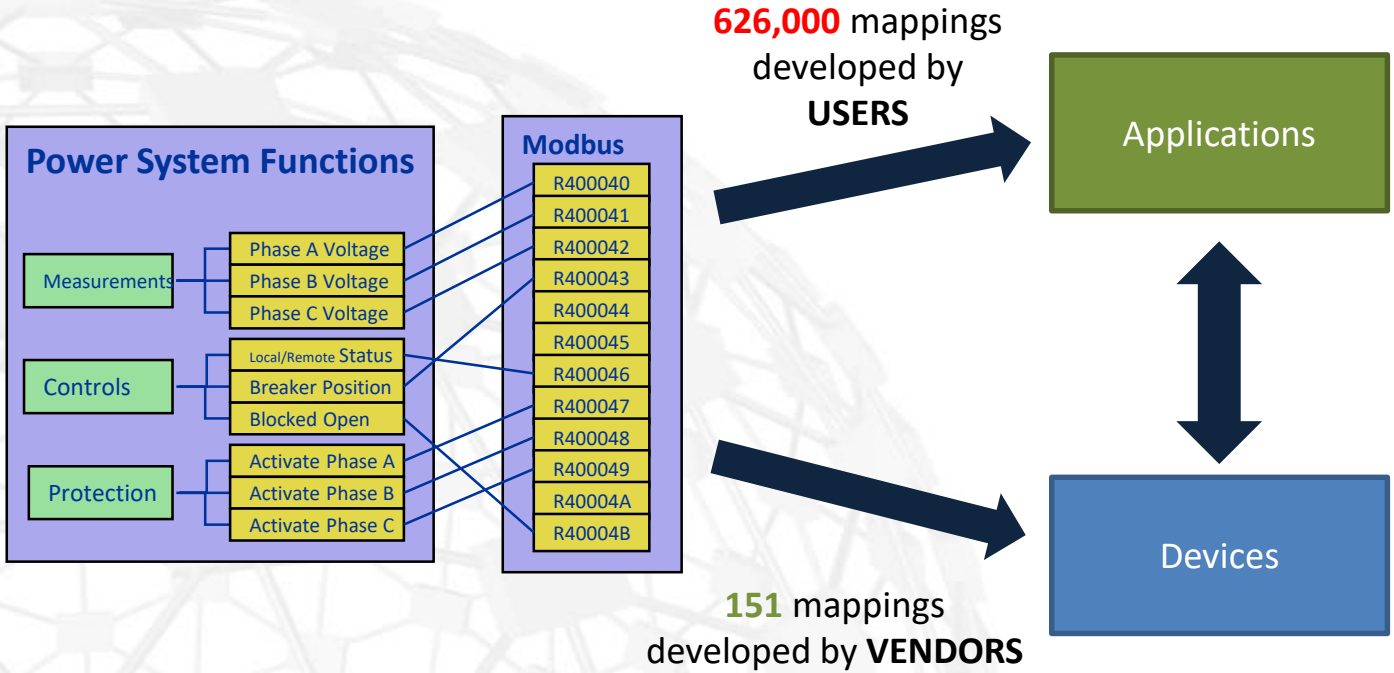
# Where should the complexity be handled?



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# The Key Element of IEC 61850 to Address Complexity

## Semantics

- Semantics to implement an engineering process based on standardized configuration language (Substation Configuration Language – SCL)
- Semantics to eliminate manual mappings and automate configuration
- Semantics to manage the complexity of very large systems that are changing constantly
- How data is sent/received on the wire is not what makes a system complex

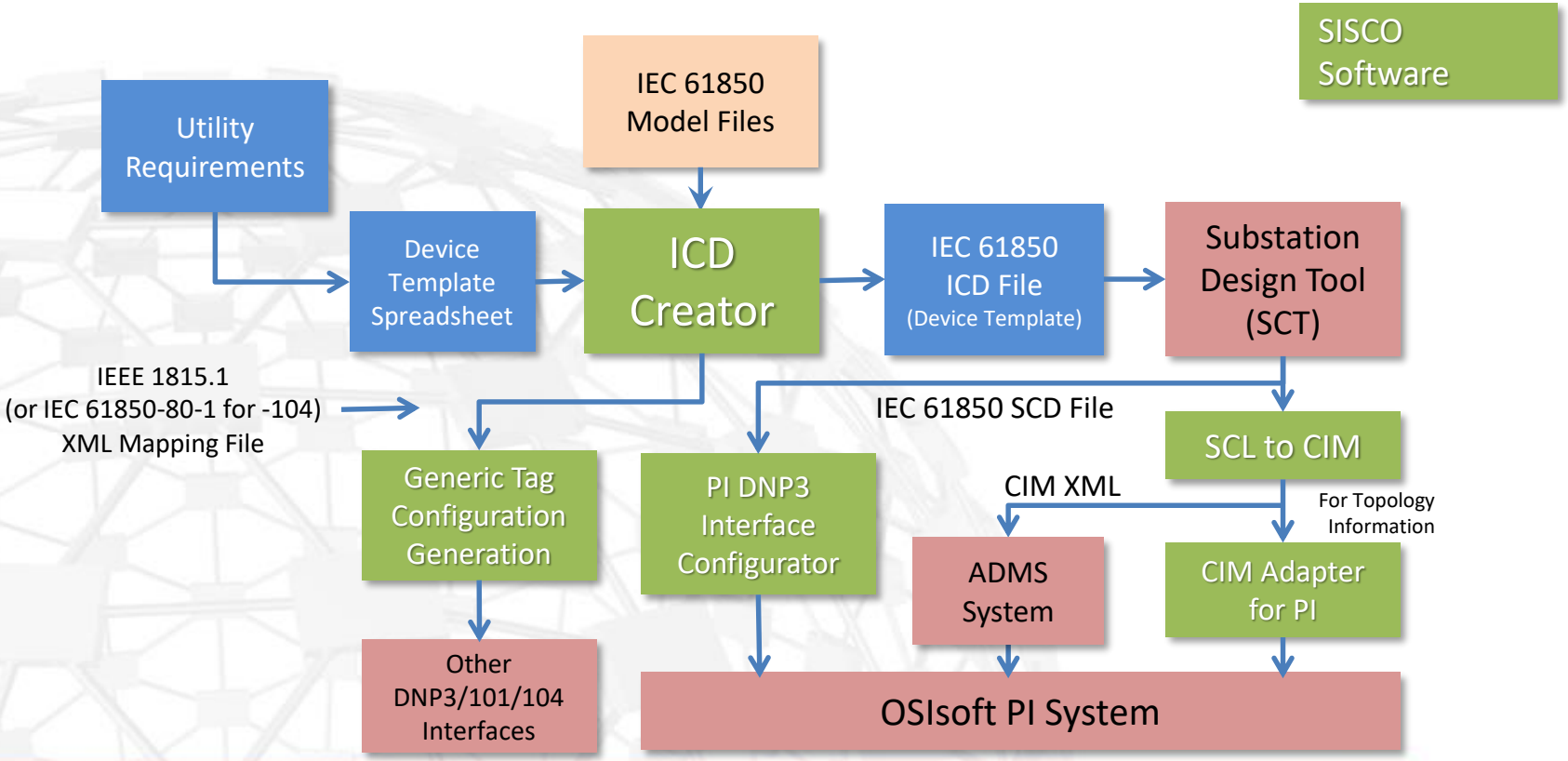
# The Utility Dilemma

- The utility needs to implement complex systems
- Because of the number of project coming on line and complexity of the data they don't have the resources to do much manual configuration
- They don't have budget to replace their communications architecture or to purchase large-scale specialized systems for DER integration

# The Solution: Use IEC 61850 and DNP3 Together

- All system design and naming standards will be done using IEC 68150 engineering tools and data models
- All communications will be through a DNP3 gateway
- Each project owner is required to provide a DNP3 gateway that conforms to a standardized template that conforms to IEC 61850-7-420 and the IEEE 1815 DER profile under development
- SISCO is developing the tooling to support the project

# Using IEC 61850 Semantics and Engineering with DNP3



# Status of Standards

- IEEE 1547 – Grid connected smart inverter standard for the US
- IEC 61850-7-420 – Logical nodes for DER
- DNP Application Note AN2013-001

# IEEE 1547

- IEEE 1547-2013 specified how grid connected inverters operate assuming a low penetration rate of DER
    - Did not support numerous critical features like voltage, frequency ride-through, VAR support, etc.
- Critical standard in the US to meet regulatory requirements
- 2013 version was insufficient for modern DER
- IEEE 1547-2018 addresses these with descriptions and requirements of all DER functions

# IEC 61850-7-420

- IEC 61850-7-420 Ed.1 was insufficient for current DER
- Ed.2 under development to be compatible with IEEE 1547-2018 and other updated standards
- Ed.2 is currently only at CD2 stage but is being used for the project (less incompatibility than using Ed.1)
- Project implementation has identified some inconsistencies and have been incorporated into the next CD

# DNP Application Note AN2013-001

## Profile for Advanced Photovoltaic Generation and Storage

- Specifies mappings between DNP3 and IEC 161850-7-420
- Existing version uses Ed.1 of 7-420

| Point Index | Name / Description | Default Event Class | Name for State when value is 0 | Name for State when value is 1 | IEC 61850 | | | | Inverter Function |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | LN Class | LN Inst | Data Object | CDC | |
| 17 | Current output frequency is too high | 1 | Normal | Alarm | MMXU | 1 | Hz.range | MV | DS93 |
| 18 | Current output frequency is too low | 1 | Normal | Alarm | MMXU | 1 | Hz.range | MV | DS93 |
| 19 | Active power at the connection is high | 1 | Normal | Alarm | MMXU | 2 | TotW.range | MV | DS93 |
| 20 | Active power at the connection is low | 1 | Normal | Alarm | MMXU | 2 | TotW.range | MV | DS93 |
| 21 | Reactive power at the connection is high | 1 | Normal | Alarm | MMXU | 2 | TotVAr.range | MV | DS93 |
| 22 | Reactive power at the connection is low | 1 | Normal | Alarm | MMXU | 2 | TotVAr.range | MV | DS93 |
| 23 | Power factor at the connection is high | 1 | Normal | Alarm | MMXU | 2 | TotPF.range | MV | DS93 |
| 24 | Power factor at the connection is low | 1 | Normal | Alarm | MMXU | 2 | TotPF.range | MV | DS93 |
| 25 | DC Inverter input power too high | 1 | Normal | Alarm | MMDC | 1 | Watt.range | MV | DS93 |
| 26 | DC Inverter input power too low | 1 | Normal | Alarm | MMDC | 1 | Watt.range | MV | DS93 |
| 27 | DC Inverter current level too high | 1 | Normal | Alarm | MMDC | 1 | Amp.range | MV | DS93 |
| 28 | DC Inverter current level too low | 1 | Normal | Alarm | MMDC | 1 | Amp.range | MV | DS93 |
| 29 | DC voltage at inverter too low | 1 | Normal | Alarm | MMDC | 1 | Vol.range | MV | DS93 |

- Project is using in development new version of DNP3 mapping based on Ed.2 of 7-420 and IEEE 1547-2018
- Project usage has helped identify some inconsistencies in the new DNP3 profile

# Project Summary

- IEC 61850 IED Capability Description (ICD) files are used to describe the inverter interfaces for the DER project
- IEC 61850 engineering process using a System Configuration Tool (SCT) is used to configure all the DNP3 communications and mappings for all DER operations
- Result is automated generation of all tag naming, DNP3 interface configuration and DER topology information
- Dramatic reduction in configuration complexity for the utility
- Can be applied to other technologies like IEC 60870-5-10X, etc.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# Thank You

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