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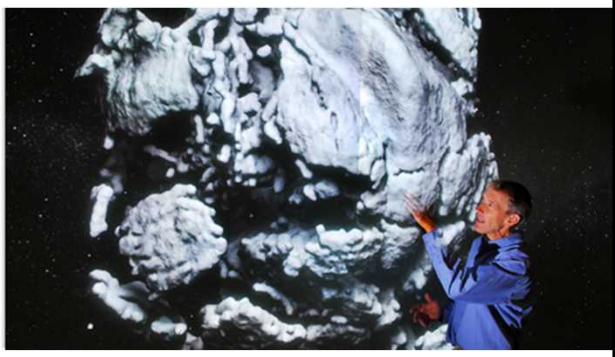

# SunSpec System Validation Platform and SIRFN Research

SunSpec Alliance Members Meeting

San Francisco – 15 March, 2016


## Jay Johnson

***Photovoltaic and Distributed Systems Integration***


U.S. DEPARTMENT OF ENERGY

NNSA National Nuclear Security Administration

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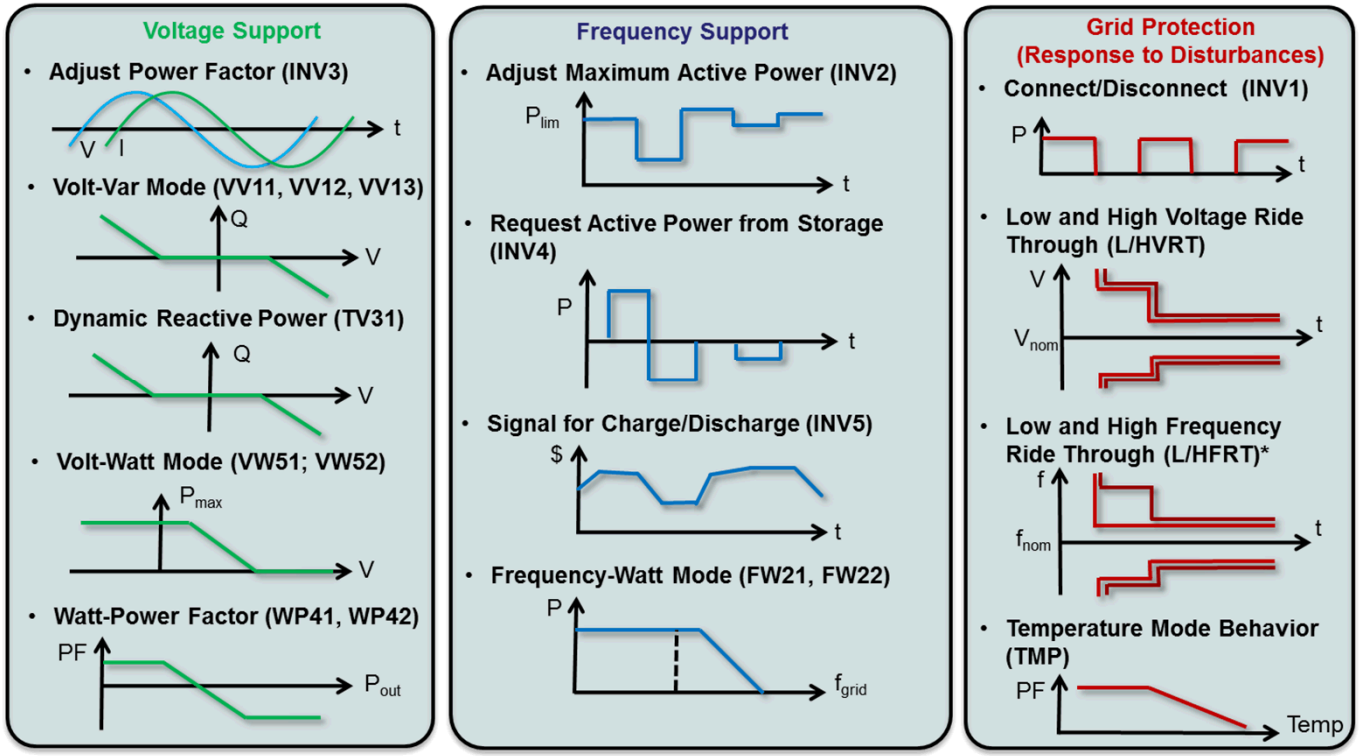
# Background

- Total installed capacity of renewables is growing fast in the US
  - The distributed and variable nature of these resources cause a range of challenges for grid operators
- Distributed Energy Resources (DERs) have the ability to help by:
  - **Supporting voltage and frequency** by modulating active and reactive power output
  - **Tolerating grid disturbances**
  - Interacting with grid operations via **communications**
- These capabilities are enabled through **multiple advanced DER functions**
  - They are being **codified in a number of standards development organizations** (SDOs)
  - It's necessary to **verify their functionality prior to wide-spread deployment** in the US
  - Testing will be conducted according to **UL 1741 SA**
- Smart inverters have dozens of operating modes and 100s of parameters
  - Verifying the operation of all the combinations of functions and parameters would be **cost and time prohibitive without test automation**.
  - Sandia and SunSpec Alliance are creating a tool called the **System Validation Platform (SVP)** to perform this automation.

# Advanced Interoperability Functions

- New 'smart' inverters will include multiple advanced functions
  - Autonomous: Inverter response to local voltage and frequency conditions
  - Commanded: Remote control (e.g., on/off, set power factor)
- Utilities will modify distributed energy resource (DER) behavior using communications.




**Similar functions are in California Electric Rule 21, UL 1741 SA, and IEEE 1547 full revision.**

**Many countries in Europe have defined similar functions.**

**Advanced functions as defined in IEC TC 61850-90-7, *with the exception of FRT.**

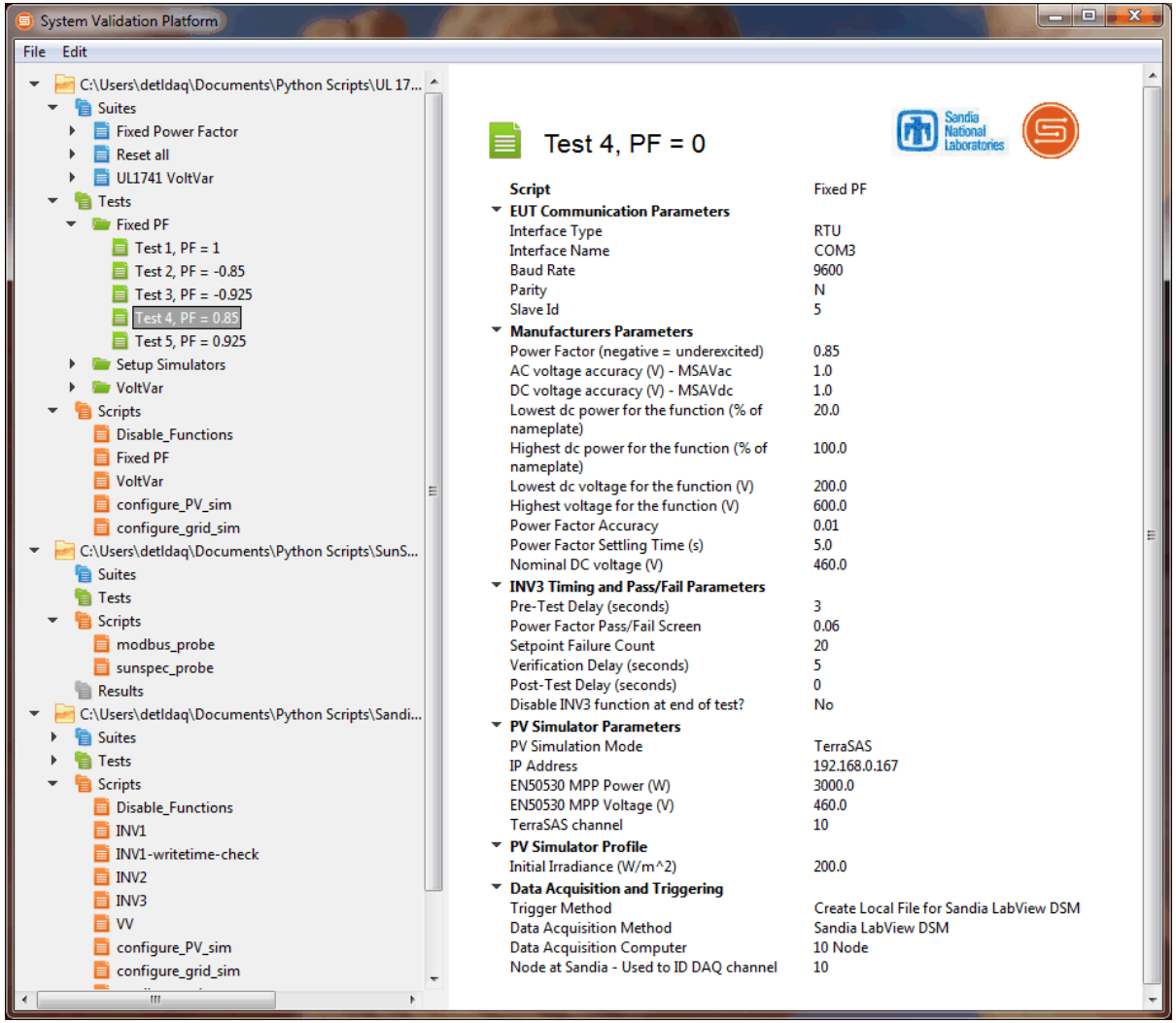
# Development of Rule 21 Certification Procedures

Sandia National Laboratories

- UL 1741 Supplement A (SA) – "Grid Support Utility Interface Inverters and Converters" has been drafted!
  - Designed based on the CA Rule 21 Phase 1 functions, but will evolve with IEEE 1547 revision.
  - UL expects STP approval in the April timeframe.
  - Tests include:
    - Anti-islanding Protection
    - Low and High Voltage Ride-Through
    - Low and High Frequency Ride-Through
    - Normal Ramp Rate
    - Soft-Start Ramp Rate
    - Specified Power Factor
    - Volt/Var Mode
    - Frequency-Watt (optional)
    - Volt-Watt (optional)

# SunSpec/Sandia System Validation Platform

- System Validation Platform (SVP) is an automated certification interoperability platform
  - Fully scriptable
  - Interacts with DAQs, PV and grid simulators, and DER.




http://sunspec.org/sunspec-svp/
http://sunspec.org/download-svp/
https://github.com/sunspec/svp_directories

# Status of SVP Python Scripts

Sandia National Laboratories

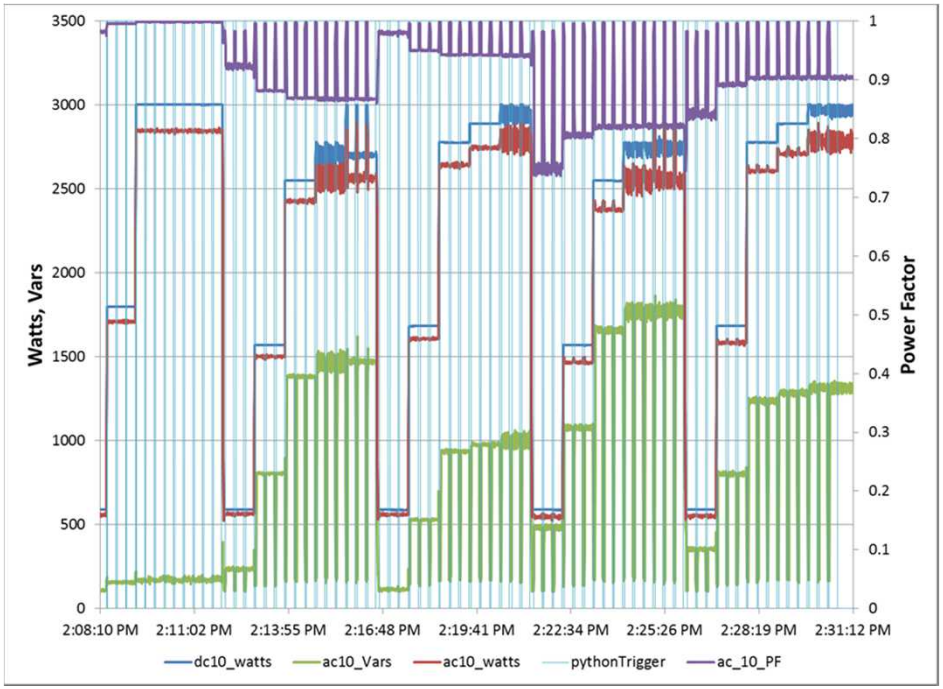
- Sandia Test Protocols
  (for IEC 61850-90-7 functions)
  - FW
  - INV1 (connect/disconnect)
  - INV2 (active power curtailment)
  - INV3 (fixed power factor)
  - VV
  - FRT (*nearly complete*)
  - VRT (*nearly complete*)
- SIRFN ESS Protocols
  - FW (draft)
  - VV (draft)
- UL 1741 SA
  - Normal Ramp Rate
  - Soft-Start Ramp Rate
  - Specified Power Factor
  - Volt/Var Mode
- SunSpec Utilities
  - Disable functions
  - Configure PV simulator
  - Configure AC (Grid) simulator
  - Record EUT-reported data

**Open source working directories: https://github.com/sunspec/svp_directories**

# Power of Testing Automation

- UL 1741 SA test permutations are large due to the number of settings in each advanced DER function:
  - 75 measurements for fixed power factor - takes about 25 minutes with the SVP
  - 375 measurements for volt/var - takes about 90 minutes with the SVP

**Proposed UL 1741 SA fixed power factor tests.**




**Proposed UL 1741 SA volt-var tests.**

More in: J. Johnson, B. Fox, "Automating the Sandia Advanced Interoperability Test Protocols," 40th IEEE PVSC, Denver, CO, 8-13 June, 2014.

# SIRFN Smart Grid Collaboration

Sandia National Laboratories

- IEA (International Energy Agency)
  - Clean Energy Ministerial (CEM)
    - International Smart Grid Action Network (ISGAN)
      - **Smart Grid International Research Facility Network (SIRFN)**
        - Smart Grid Distribution Automation
        - Advanced Laboratory Testing Methods
        - Power Systems Testing
        - Test Protocols for Advanced DER Functions

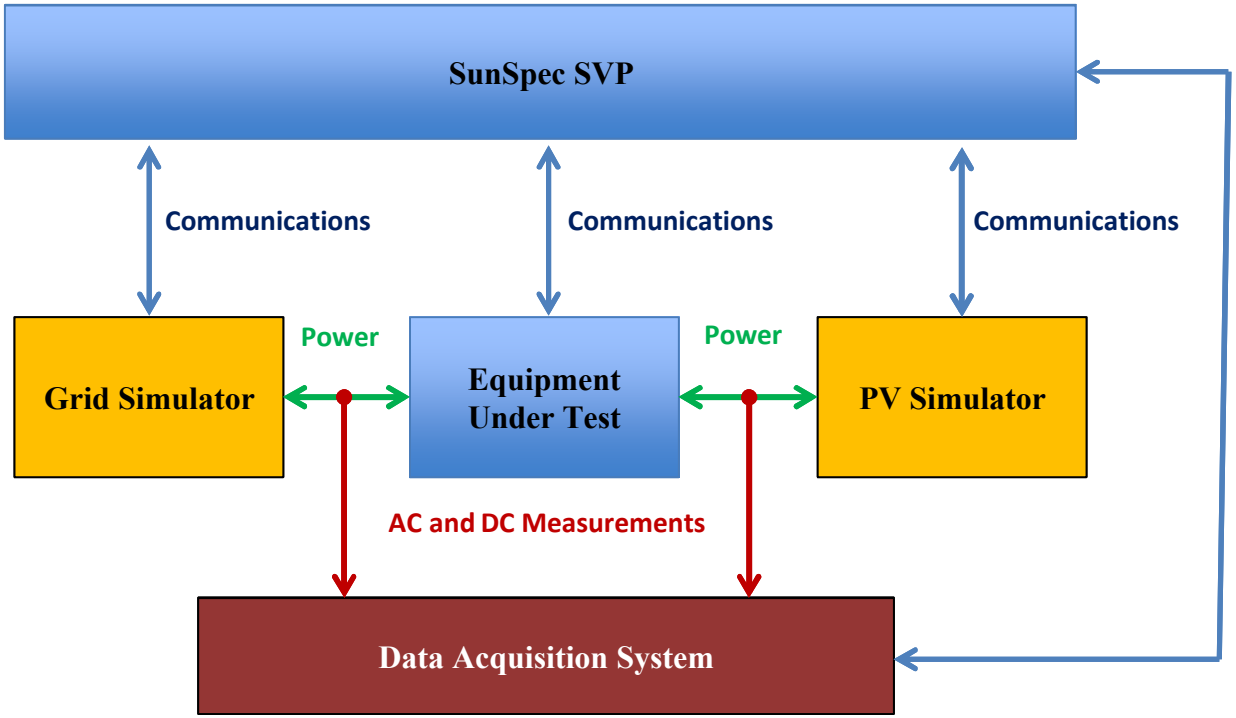
SIRFN - A coordinated network of smart grid research facilities from:

- **Primary goal**: Develop and demonstrate a consensus-based interoperability certification standard for advanced Distributed Energy Resources (DERs).
  - Design and compare advanced interoperability test-beds.
  - Perform round-robin testing of advanced DER.
  - Compare test results, communications methods, and automation procedures.
  - Gradually improve draft test procedures for advanced DER with the goal of becoming an internationally-accepted standard.

Some Experimental Results: J. Johnson, R. Bründlinger, C. Urrego, R. Alonso, "Collaborative Development Of Automated Advanced Interoperability Certification Test Protocols For PV Smart Grid Integration," EU PVSEC, Amsterdam, Netherlands, 22-26 Sept, 2014.

# SVP Architecture

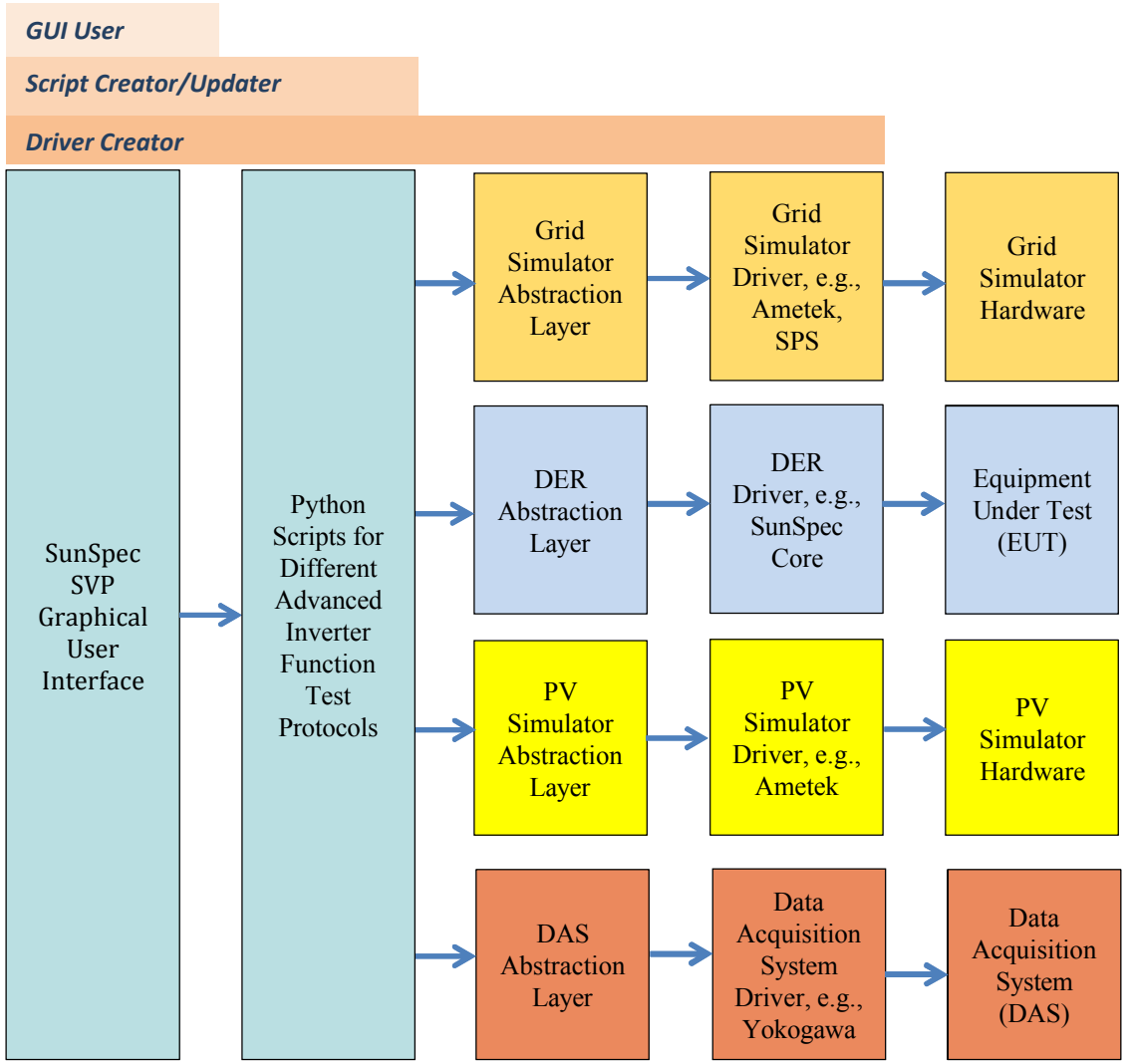
- Abstraction layers in python allow the same scripts to be executed for any PV simulator, grid simulator, DAQ, and EUT with the associated communication driver.



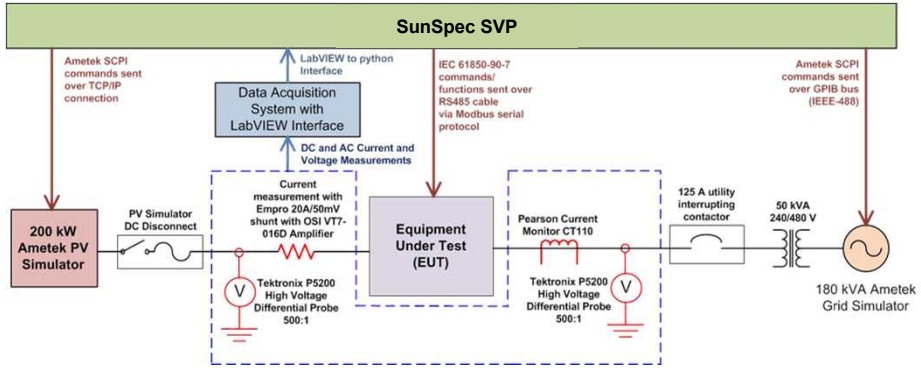



More in: J. Johnson, B. Fox, "Automating the Sandia Advanced Interoperability Test Protocols," 40th IEEE PVSC, Denver, CO, 8-13 June, 2014.

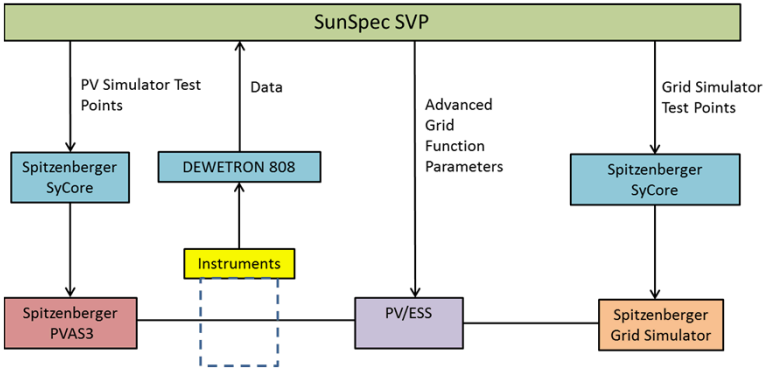
# SVP User Domains



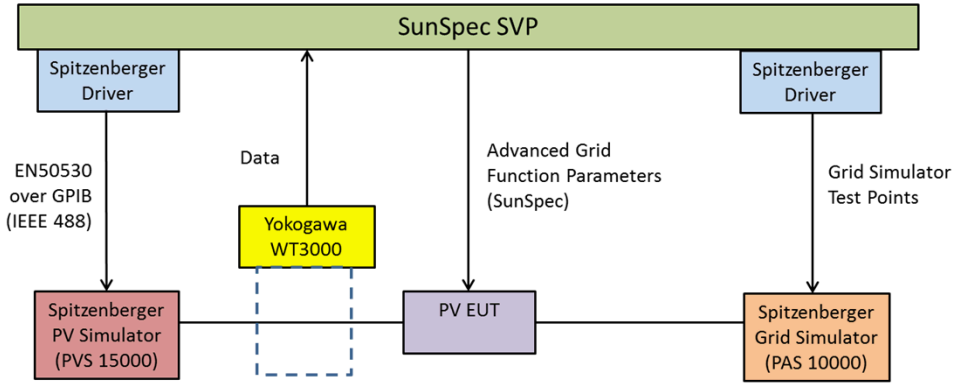
# SVP Deployment at SIRFN Labs and other Facilities



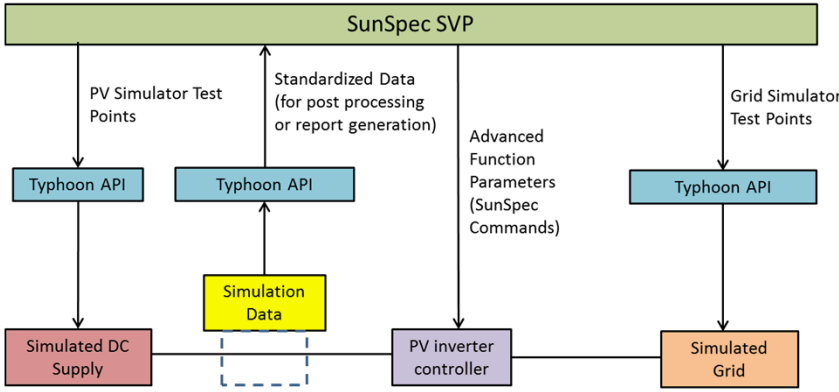

**Sandia National Labs**




**Austrian Institute of Technology**




**Ricerca sul Sistema Energetico (Italy)**




**Sandia National Labs and AIT**
**(Control Hardware-in-the-Loop Configuration)**

Other labs using the SVP:

- Fukushima Renewable Energy Institute, AIST
- Underwriters Laboratories
- University of California - San Diego

# SIRFN Next Steps

Sandia National Laboratories

1. **Complete/refine test scripts** and parameters for each of the test protocols, including the UL 1741 SA

2. **Execute SVP test scripts** at each of the laboratories
   a. **Compare results** for accuracy of the SVP operations, equipment variations, DAQ accuracies (esp. w.r.t. pass/fail criteria), etc.
   b. **Improve SVP scripts** with error checking, faster execution, etc. through crowd sourcing and the github repository

3. Provide **working directories to NRTLs** and other testing facilities.

4. **Suggest improvements to the codes/standards** based on results
   a. Many of the protocols have not been vetted with experimental tests by the SDO - clarifications and corrections are likely

# Conclusions

- Advanced **DER functions help support the electricity grid**.
- In the US, **UL 1741 SA is nearly finalized** and there will be many manufacturers rushing to complete certification tests.
  - Need for automation to complete tests with minimal cost and time requirements.
  - SunSpec SVP offers one solution.

- **Sandia, SIRFN, and SunSpec** are also **improving certification protocols and test capabilities** by:
  - Building test-beds for advanced inverter testing (electrical performance and interoperability).
  - Comparing advanced DER test results and improving draft certification protocols.
  - Recommending improvements to national and international codes and standards.

- **Standardized test methods for** verifying **interoperability** are **critical** also.
  - **Communications certification not defined**; cybersecurity a big concern.

# Questions?

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