U.S. DEPARTMENT OF ENERGY | Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

SOLAR ENERGY TECHNOLOGIES OFFICE

Systems Integration Program Overview

Challenges, Opportunities, Research Activities

Guohui Yuan, Program Manager
Systems Integration

Solar Energy Technologies Office

WHAT WE DO

The Solar Energy Technologies Office (SETO) funds early-stage research and development in three technology areas: photovoltaics (PV), concentrating solar-thermal power (CSP), and systems integration with the goal of improving the **affordability**, **performance**, and **value** of solar technologies on the grid.

HOW WE DO IT

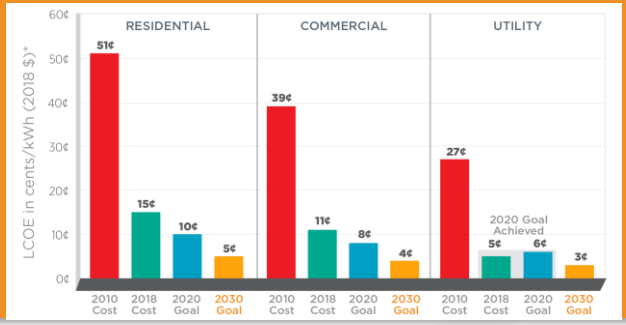
Advance solar technology to drive U.S. leadership in innovation and reductions in solar electricity costs.

Enable solar to **support grid reliability** and pair with storage to provide new options for **community resilience.**

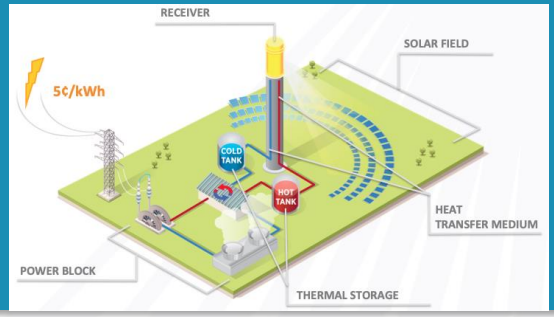
Provide **relevant and objective technical information** on solar technologies to stakeholders and decision-makers.

SETO Teams

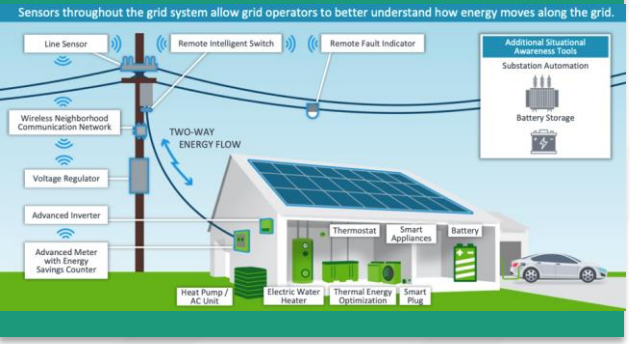
PHOTOVOLTAICS



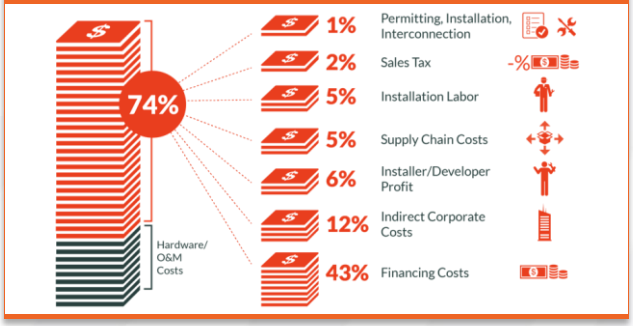
CONCENTRATING SOLAR POWER



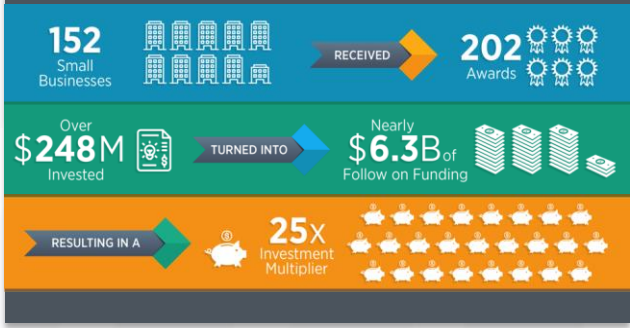
SYSTEMS INTEGRATION



STRATEGIC ANALYSIS AND INSTITUTIONAL SUPPORT

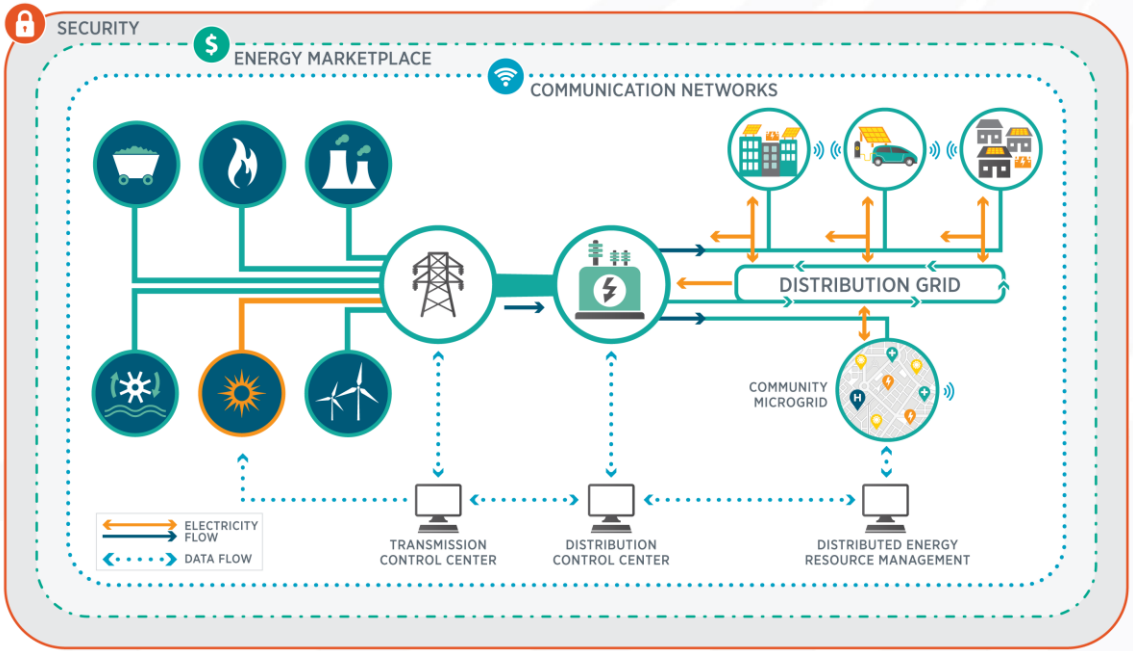


MANUFACTURING AND COMPETITIVENESS



SETO Systems Integration (SI) Program

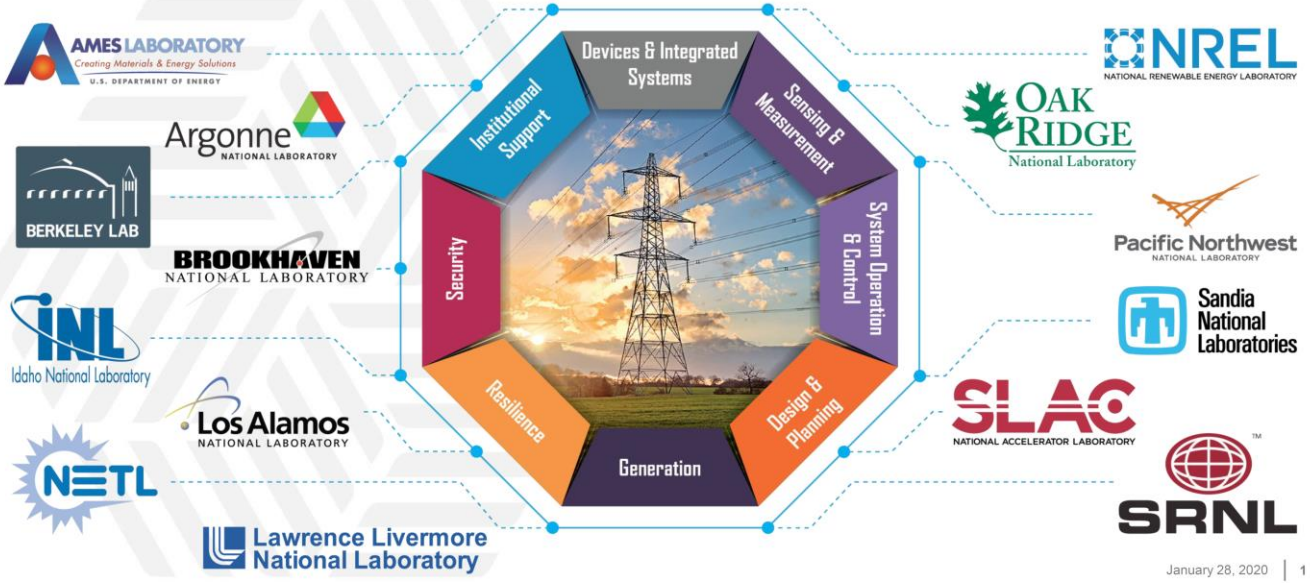
The Systems Integration (SI) subprogram supports early-stage research, development, and demonstration for technologies and solutions that advance the reliable, resilient, secure and affordable integration of solar energy onto the U.S. electric grid.



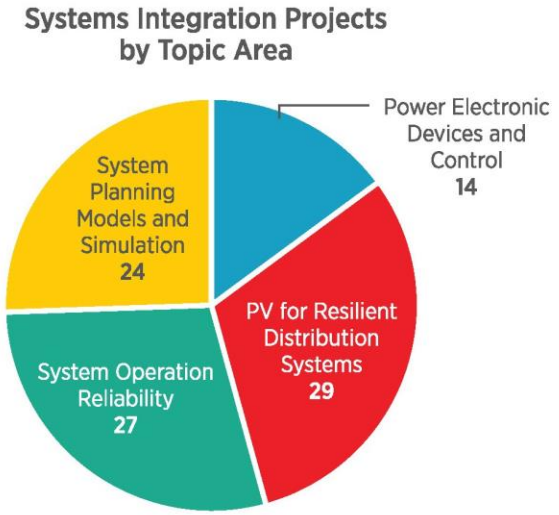
GMI – DOE-Wide Collaboration

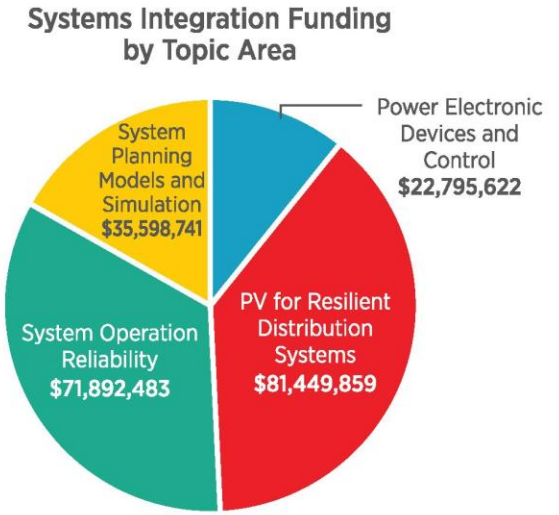
DOE's Grid Modernization Laboratory Consortium – 14 National Labs – 100+ Partners

GRID MODERNIZATION LABORATORY CONSORTIUM
U.S. Department of Energy



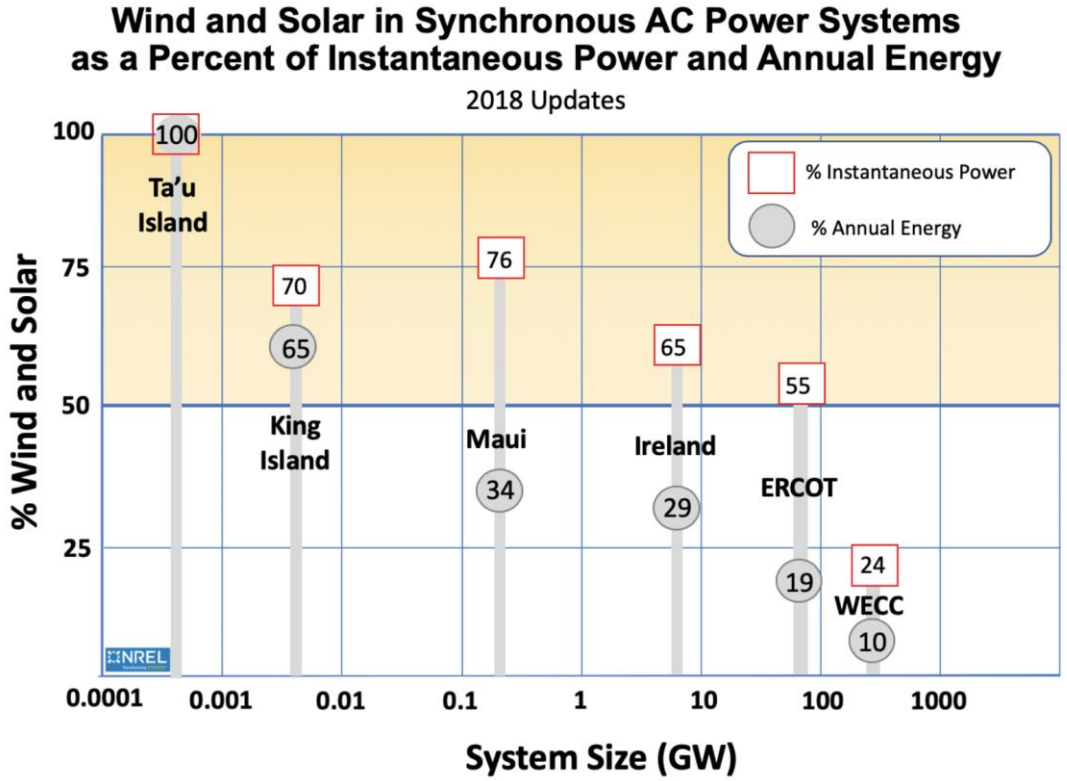
SI Track Breakdown – 95 Projects and $213M Funding





- Projects include GMLC, and relevant projects under M&C, and SA programs
- Awardees represent national labs, universities, utility companies, and industry solution providers

Many Technical Challenges Ahead for Solar Grid Integration



Source: Ben Kroposki / NREL

- Weak grid and Low inertia
- Fast dynamics of IBR
- Variability and uncertainty
- Protection
- Situation awareness
- DER control
- T&D interdependence
- Cybersecurity
- Resilience

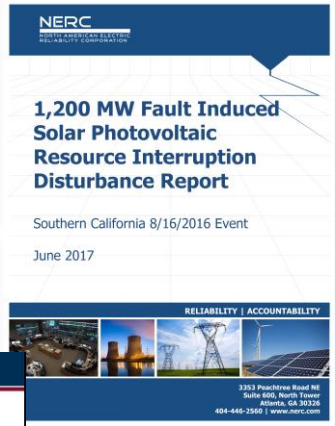
- Cost/benefit
- Institutional challenges

Renewable Integration and Grid Stability

Major Events

- 9/28/2016, South Australian Blackout
  - Extreme weather (high wind, high temperature)
  - 456 MW wind generation reduction
  - 850,000 customers lost power for hours
- 8/16/2016, Southern CA Blue Cut fire
  - transmission fault
  - 1200 MW of solar PV resources lost; PV inverters trip off due to frequency during transients
- 10/09/2017, Southern CA Canyon 2 Fire
  - transmission fault;
  - 900 MW of solar PV resources lost; PV inverters trip off due to momentary cessation in response to voltage transients
- 8/09/2019, UK Blackout
  - lightening strike
  - 150MW of small embedded generation disconnected
  - 737MW offshore windfarm output reduction
  - further 350MW of embedded generation disconnected
  - 45 minute outage for 1.1 million customers

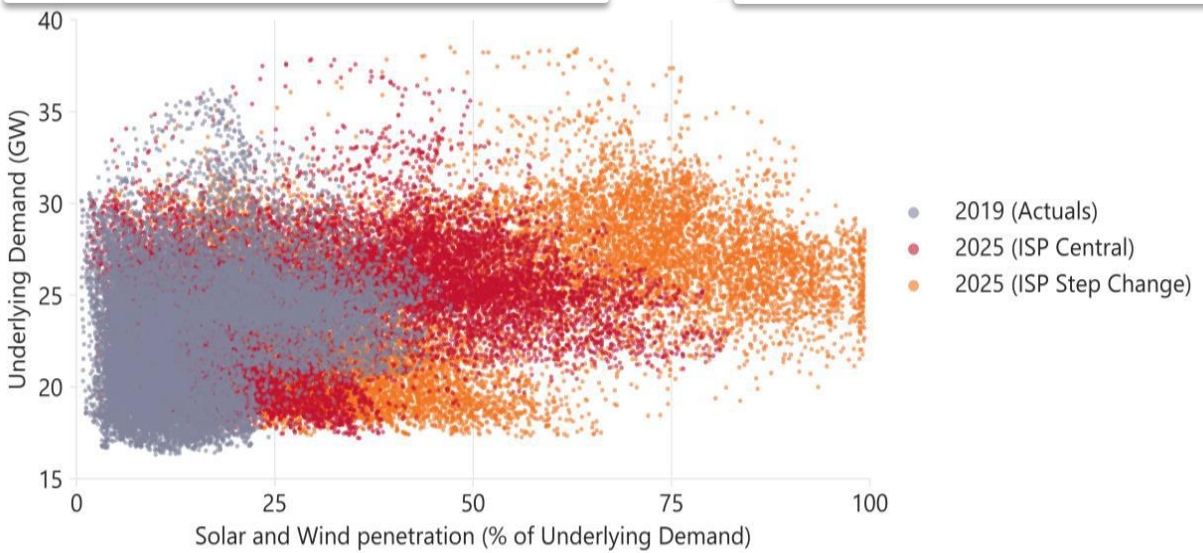
NERC/DOE/Industry Response

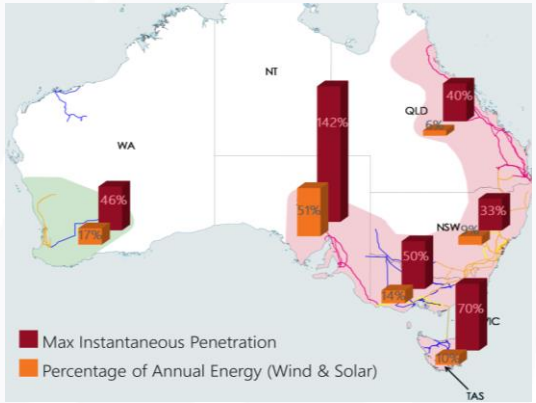


AEMO Renewable Integration Study (RIS) Findings

If the recommended actions are taken to address the regional and NEM-wide challenges identified, the NEM could be operated securely with up to 75% instantaneous penetration of wind and solar2.

- Managing distributed solar PV
- Managing frequency
- Maintaining system strength
- Managing variability and uncertainty

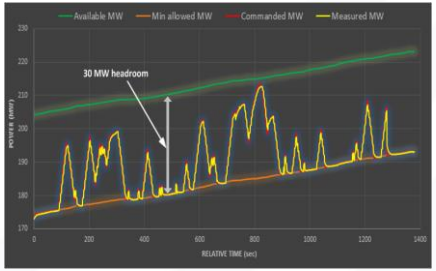


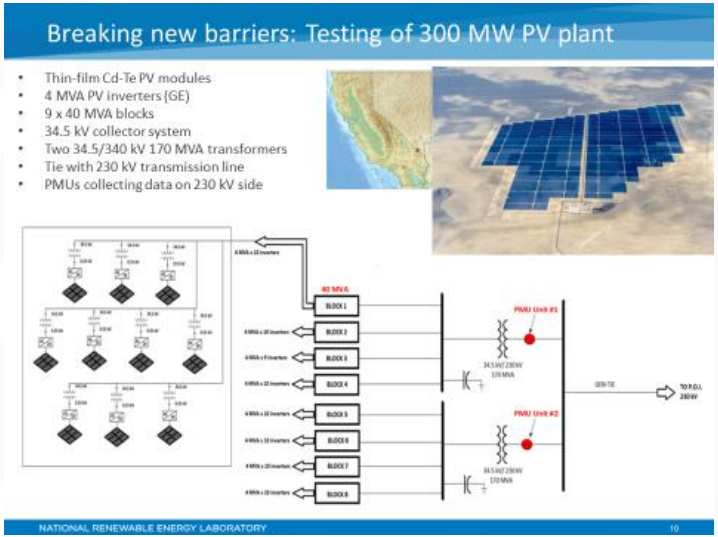


Demonstration of Essential Reliability Services from Solar PV

- NREL/CAISO/First Solar partnering in the 300-MW PV System Commissioning Test
- Winner of NARUC Innovation Award in 2017

- 4-sec AGC signal provided to PPC
- 30 MW headroom
- Tests were conducted for 30 minutes at:
  - Sunrise
  - Middle of the day
  - Sunset
- 1-sec data collected by plant PPC





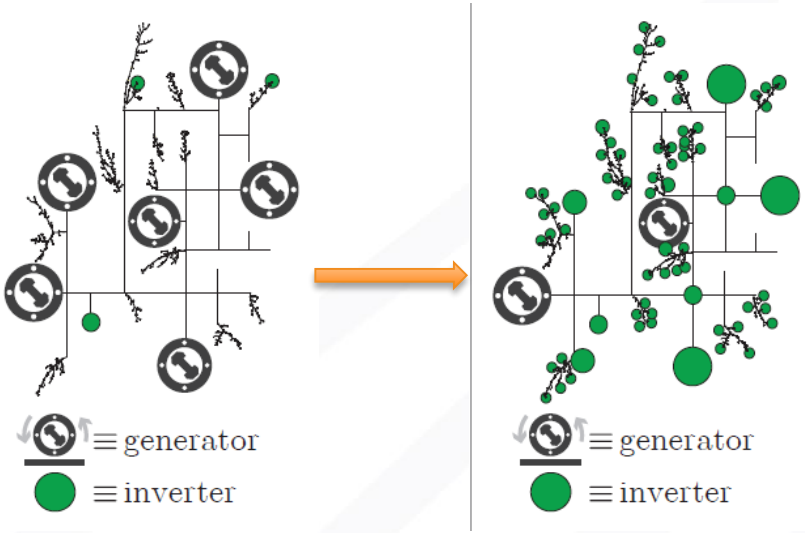
Courtesy: NREL, Vahan Gevorgian
http://www.nrel.gov/docs/fy17osti/67799.pdf

"These data showed how the development of advanced power controls can enable PV to become a provider of a wide range of grid services, including spinning reserves, load following, voltage support, ramping, frequency response, variability smoothing, and frequency regulation to power quality."

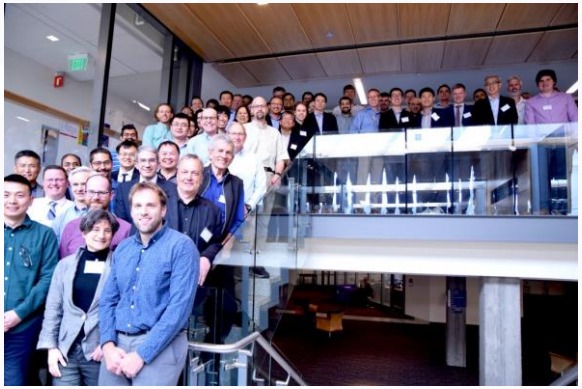
A Paradigm Shift – Power Electronics-based Electric Grid

Grid-Forming Inverters and Controls
In addition to grid-following, wind and solar need to have cooperative, grid-forming capabilities

DOE-funded NREL Grid-Forming Inverter project (2015-)
https://www.energy.gov/eere/solar/



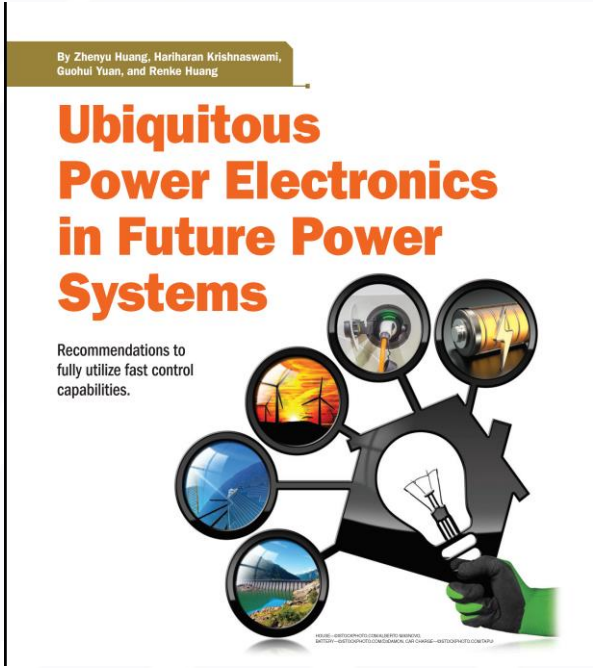
University of Washington Grid-forming Inverters Workshop (April, 2019)



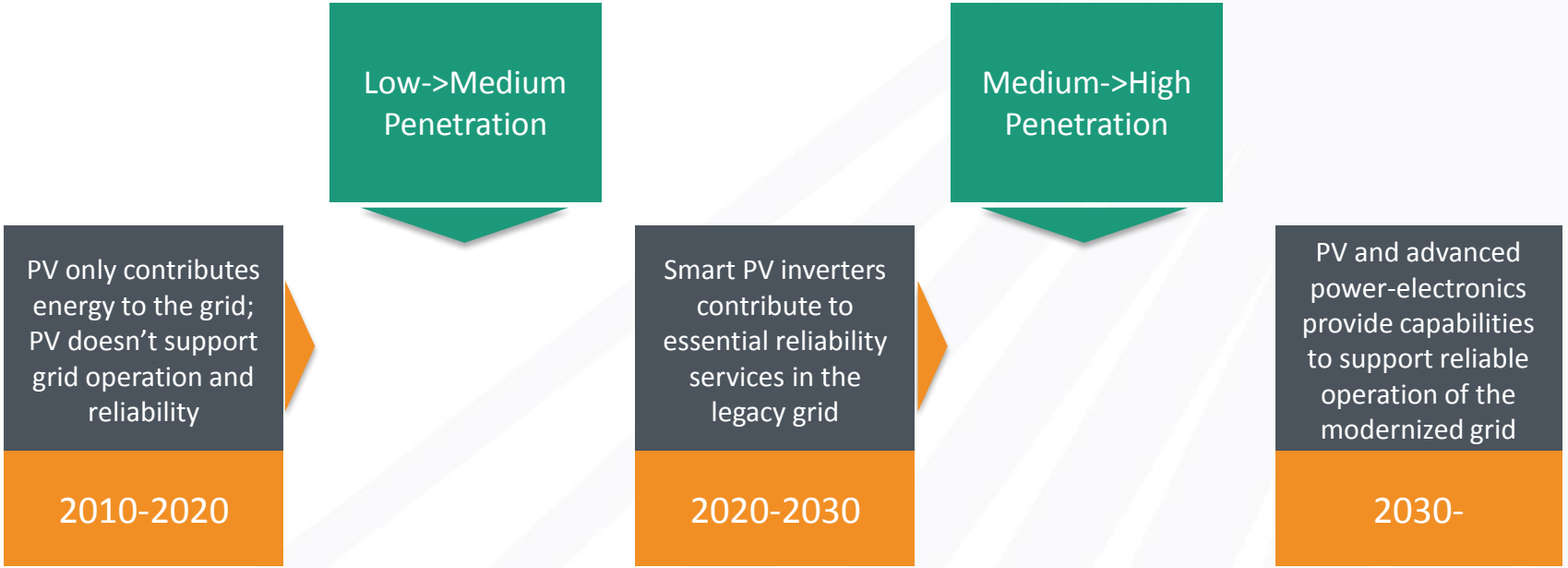
To be published

Power Electronic Grid Integration Testbed

- Research platform
  - Solar grid integration at very high penetration levels
  - Integration of multiple technologies (wind, ES) at scale
  - Interdependency of bulk power and DERs
  - Real world testing environment
- Industry partnerships
  - Joint technology development
  - Testing and validation of vendor product functionalities
  - Collaboration with utilities to address practical issues
  - Engagement with broader stakeholders



Solar Grid Integration Research Priorities



Solar generation has grown from less than 0.1 percent of the U.S. electricity supply to 2.7 percent per year and rapidly expanding. In five states, solar electricity already represents more than 10 percent of total generation.

For Questions:

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