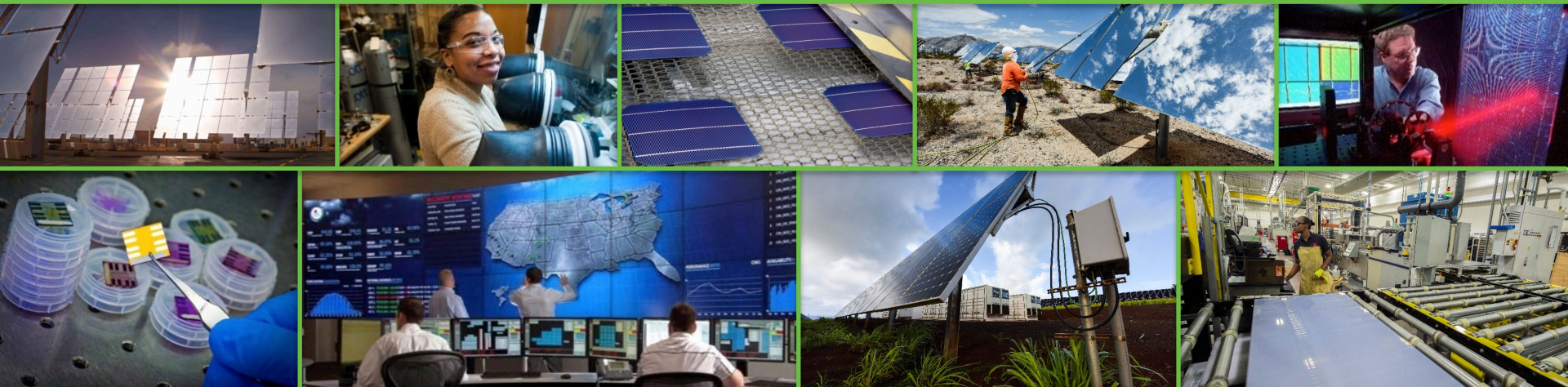


Recent Funding Efforts in Power Electronics Hardware and Control by the Solar Energy Technologies Office

Dr. John Seuss, Technology Manager

Solar Energy Technologies Office

john.seuss@ee.doe.gov



Solar Energy Technologies Office (SETO) Overview

MISSION

We accelerate the **advancement** and **deployment of solar technology** in support of an **equitable** transition to a **decarbonized economy no later than 2050**, starting with a decarbonized power sector by 2035.

WHAT WE DO

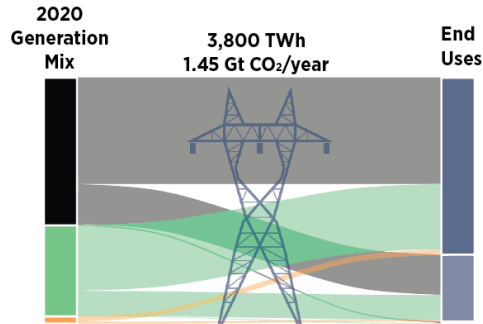
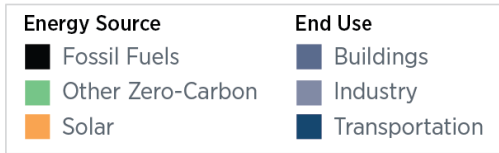
Drive innovation in technology and soft cost reduction to make solar **affordable** and **accessible** for all Americans

Enable solar to support the **reliability, resilience**, and **security** of the grid

Support **job growth**, **manufacturing**, and the **circular economy** in a wide range of applications

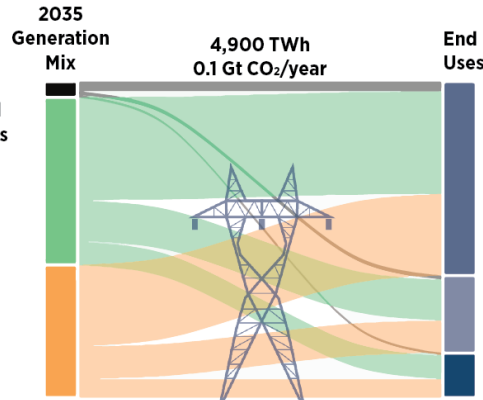


U.S. Energy Mix 2020-2050



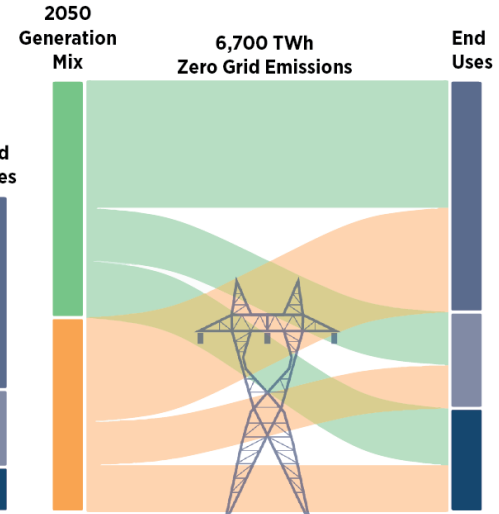
The U.S. Electric Grid in 2020

Solar: 3% of electricity demand, 80 gigawatts AC installed



95% Decarbonized Grid in 2035

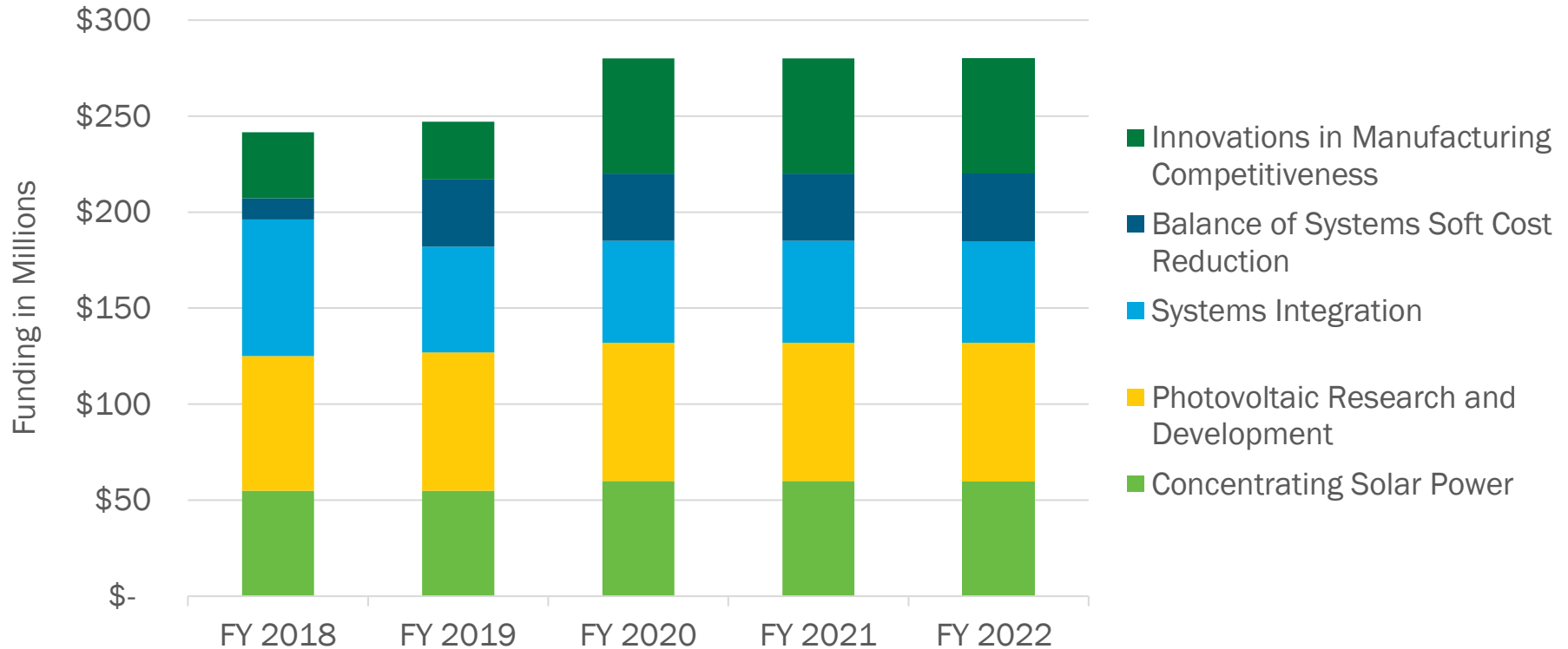
Solar: 40% of electricity demand, 1,000 gigawatts installed

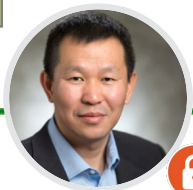


Decarbonized Grid in 2050

Solar: 45% of electricity demand, 1,600 gigawatts installed 3,000 GW in decarbonized energy system

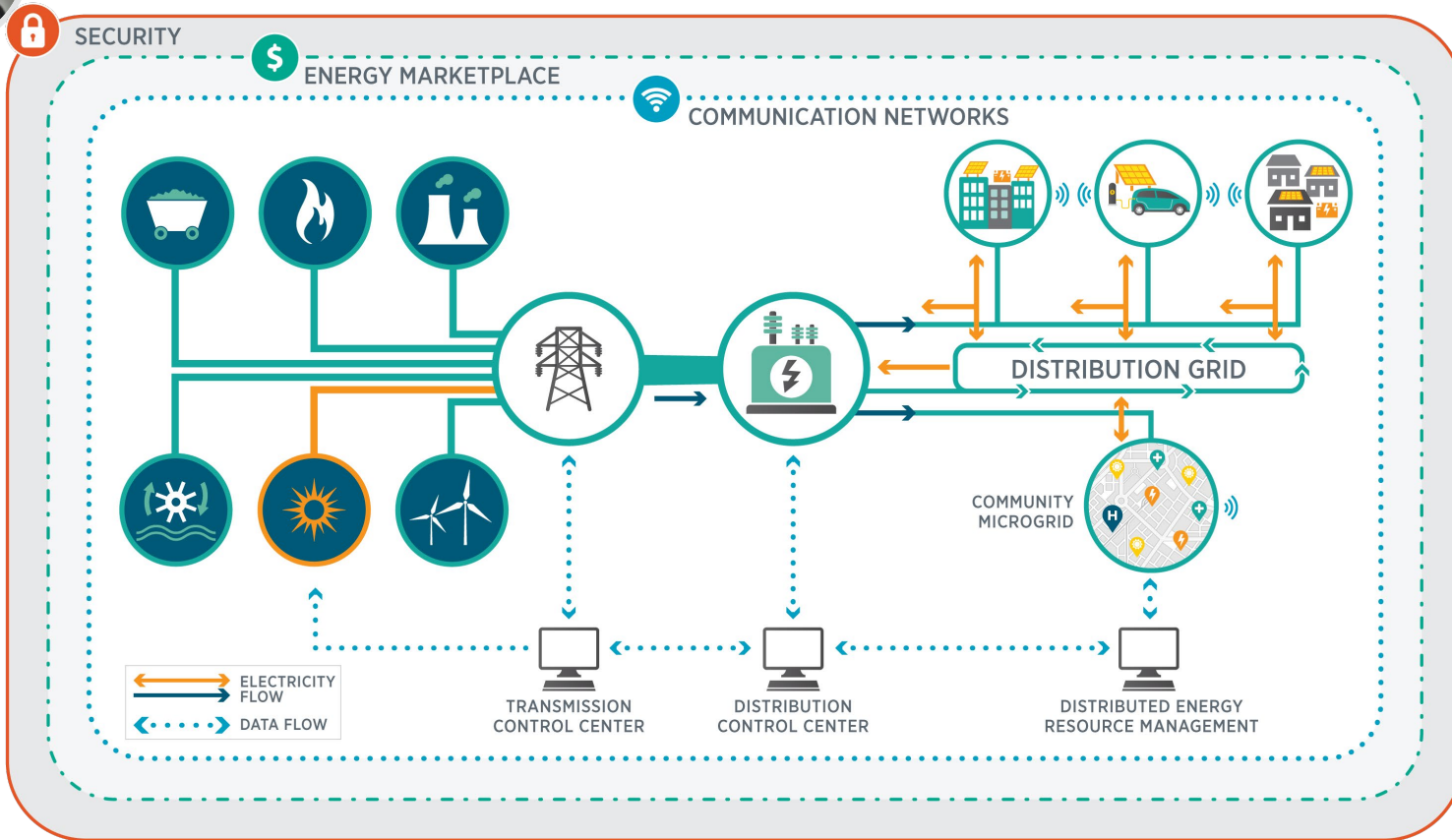
SETO Congressional Budget Overview





Systems Integration

Dr. Guohui Yuan, Program Manager



Research Areas: Systems Integration

The goal for SETO's system integration research is to achieve high-solar grid integration by supporting the reliability of the power system, enhancing resilience and security, and increasing system flexibility to reduce grid integration costs.

Where we are now:

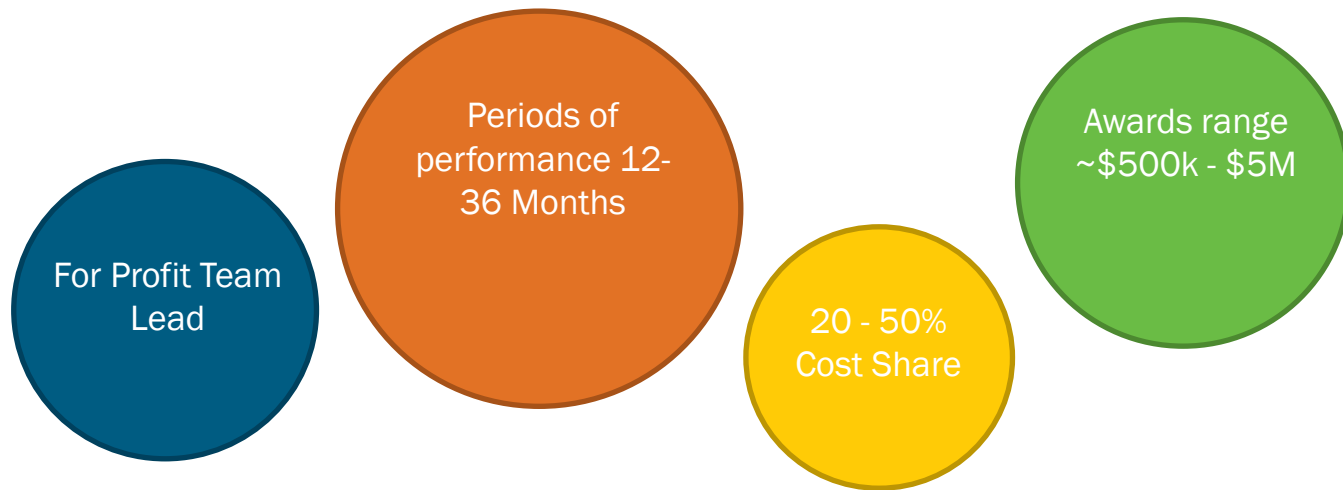
- Inverter-based solar and wind resources pose challenges to system reliability and stability
- Solar generation variability and uncertainties
- System operators have no visibility or control over most distributed solar

Priority R&D Topics:

- Develop long-term planning models and tools for solar integration
- **Develop advanced control capabilities for power electronics**
- **Enhance grid services to operate high-solar grid**
- Advance communications and sensing for situation awareness
- Improve solar forecasting
- **Integrate storage to add flexibility**
- Enhance resilience and security in system design
- **Accelerate grid codes and standards development**



Manufacturing & Competitiveness Funding Program Basics



Past Funding Programs

- Incubator
- SolarMat (Solar Manufacturing)
- SUNPATH (Manufacture Scaling)

OPEN to solutions addressing at least one of the following goals:

- Achieve the office cost targets
- Expand domestic solar manufacturing and supply chain
- Expand the domestic solar market
- Enable the integration of hundreds of GW of solar on the nation's grid



Small Business Innovation Research and Small Business Technology Transfer (SBIR/STTR)

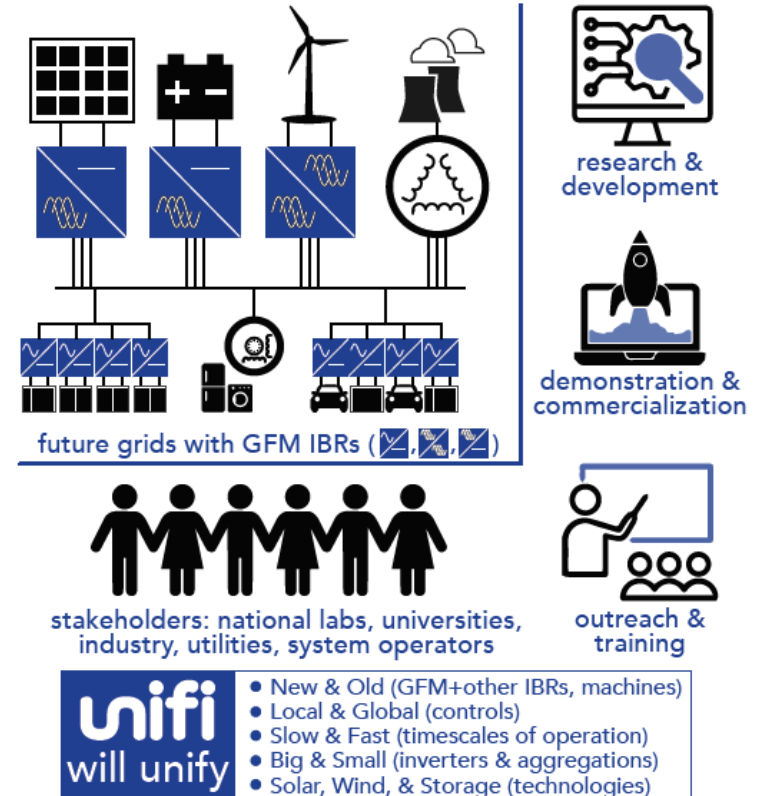


SBIR · STTR
America's Seed Fund

SUPPORTING
small business
SOLAR INNOVATIONS

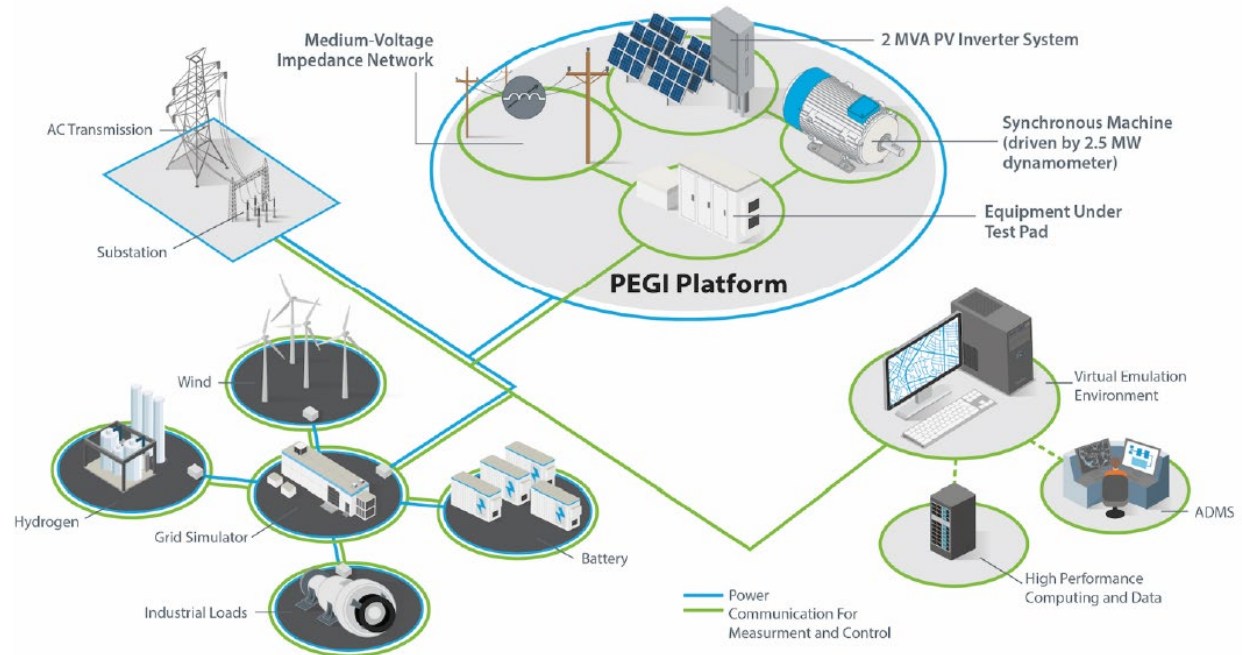
Grid-Forming Consortium: UNIFI at NREL

- \$25M over 5 years to establish a framework for **continued industry collaboration**
- Brings together industry and researchers to drive an **accelerated timeframe** for developing **grid-forming inverter standards**
- The **Fall 2022 UNIFI Seminar Series** is ongoing from 2pm-3pmMT every Monday.
- Register at the following link:
<https://sites.google.com/view/unifi-consortium/home>



ARIES Platform at NREL Flatirons and ESIF Campuses

- PEGI – Power Electronic Grid Interface testing platform
- Can test inverter controls on MW-scale grid with variable grid strength and equipment
- Public workshop describing platform and how to participate – early 2023



Advanced Power Electronics Design for Solar Applications

POWER ELECTRONICS:
Making the Pieces Fit Together

🔌 SMART INVERTERS

PV MODULE
INTEGRATION

GRID
INTEGRATION

🔌 ADVANCED
FUNCTIONS

Advanced Power Electronics Design for Solar Applications

- 2018 \$20M funding opportunity
- Two topic areas:
 - Lowering Cost and Improving Equipment Reliability
 - Georgia Institute of Technology  - MV converter designs
 - North Carolina State University  - Wide bandgap devices
 - University of Arkansas
 - University of Maryland: College Park
 - University of Washington
 - Virginia Polytechnic Institute and State University

Advanced Power Electronics Design for Solar Applications

- 2018 \$20M funding opportunity
- Two topic areas:
 - Enhanced Functionality for Grid Services
 - Flex Power Control, Inc.  - MV converter designs
 - Oak Ridge National Laboratory  - Wide bandgap devices
 - University of Texas at Austin

SETO Project 8348 – Univ. Texas – Austin (complete)

- Partnered with Toshiba International Corporation to develop 1 MVA 4.16 kV SiC-based, modular, multi-port converter
- Analysis by ANL/Temple showed reduced LCOE by 30%
- Initial tests show >98% PV-to-grid efficiency project continues in M&C commercialization
- Redundant modules could improve reliability and system life > 40 years

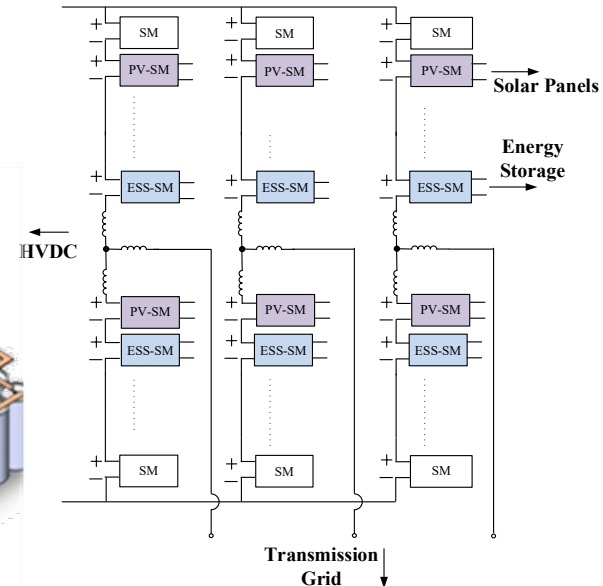
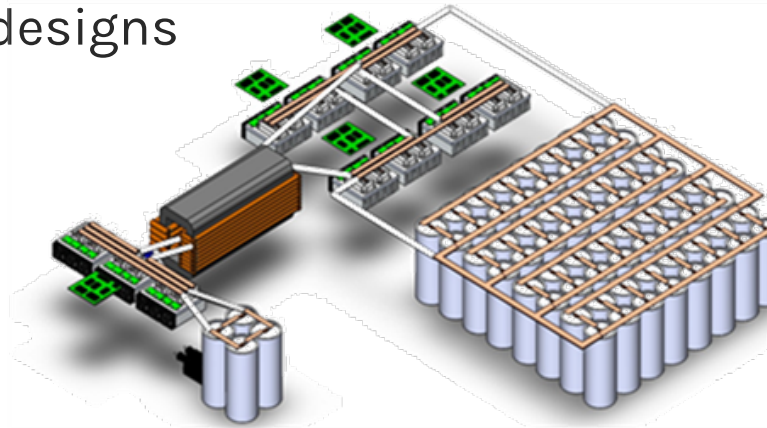
PI: Prof. Alex Huang,
w/ Toshiba, ANL,
Temple, Opal-RT,
ERCOT



SETO Project 34019 – Oak Ridge National Lab. (complete)

- Developed architecture for GW-scale, modular, multiport HVDC
- Includes embedded cybersecurity protection at controller-level
- Improved EMT simulations of switching elements by **orders of magnitude**, able to simulate 2400 PE modules in real-time HIL
- Projected LCOE reduced by 28%
- Improved freq. resp. >20%
- Novel HF xfmr designs

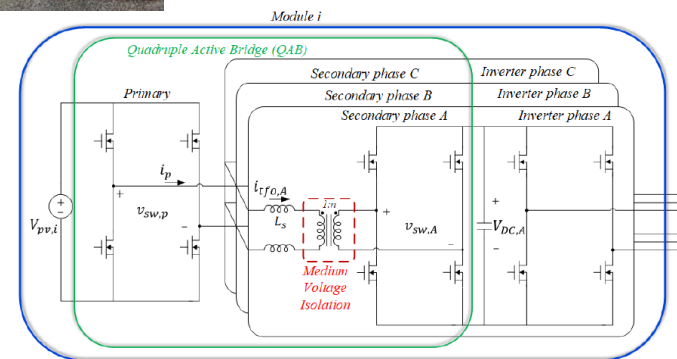
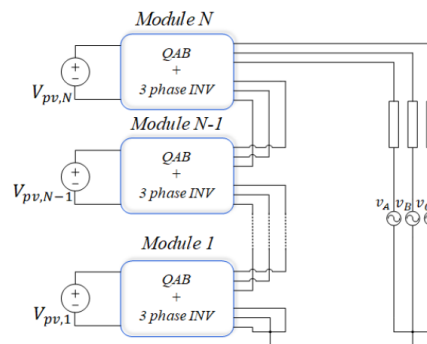
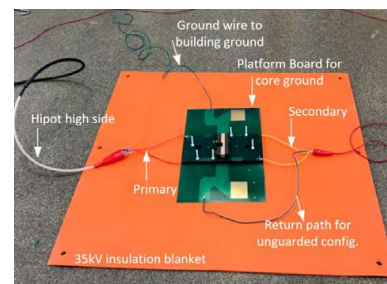
PI: Suman Debnath,
w/ Georgia Tech,
ABB/Hitachi, Opal-RT,
SCE



SETO Project 8346 – University of Washington (ongoing)

- Testing a prototype MV inverter in two stages – first at 7 kV and then at 13 kV with twice the series modules
- Project has led to new MV testing considerations at NREL
- Key design feature is the planar HF PCB isolation transformer
- Project team founding member of UNIFI

PI: Prof. Brian Johnson
 UC-Boulder: Dragan Maksimovic
 NREL: Gab-Su Seo





Potential Follow-on Power Electronics Research Areas for Solar

- **Deployment of PV plants with MV collector system directly tied to MV distribution**
 - Long-term pilot projects – holistic plant designs
 - Workforce, developer engagement
 - Evaluation of economics, efficiency after one year demo
- **High freq. isolation xfmr manufacturing and design**
- **Further design of modular converters**
 - Design of internal protection, hot-swapping
 - Field evaluation of maintenance, complexity
 - Accelerated end-of-life testing, more accurate LCOE

Future Research Areas of Interest

- **Grid-forming power electronics hardware**
 - Support for higher short-circuit ratios
- **Non-wire alternatives / Power flow routers**
 - Transmission and distribution applications
 - Dynamic congestion / resilience solutions
- **Power electronic circuit breakers**
 - Reduced critical clearing times
 - Minimize equipment damage / offset costs
- **Multi-terminal HVDC for PV**
 - Cost/benefit of PV along the way, local community benefits
 - Solving protection issues

Learn About Upcoming Funding Opportunities

EERE Funding Opportunity Updates

Promotes the Office of Energy Efficiency and Renewable Energy's funding programs.



SIGN UP NOW:

energy.gov/eere/funding/eere-funding-opportunities

SETO Newsletter

Highlights the key activities, events, funding opportunities, and publications that the solar program has funded.



SIGN UP NOW:

energy.gov/solar-newsletter

Email: john.seuss@ee.doe.gov