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

SOLAR ENERGY TECHNOLOGIES OFFICE

2020 SETO PEER REVIEW

Solar to the Max: Innovations in Distribution Grid Planning and Operations

Systems Integration

Data & Analytics Webinar Series

June 24 & 25

Agenda

EDT	Thursday, June 24	
12:00	Addressing challenges in power grid planning, operational planning and real-time operations *with high penetration of distributed solar generation*	DOE/SETO Systems Integration
12:30	Enhanced Control, Optimization and Integration of Distributed Energy Applications (Eco-Idea)	NREL
13:00	Voltage Regulation and Protection Assurance using DER Advanced Grid Functions	SNL
13:30	Integrated Distributed Energy Management System at RPU	UC Riverside
14:00	Keystone Solar Future Project : DERMS Implementation and Integration	PPL
14:30	Electric Access System Enhancement (EASE)	SCE
15:00	Q&A	
15:30	Adjourn	

EDT	Friday, June 25	
12:00	Grid Optimization with Solar (GO-Solar)	NREL
12:30	Scalable/Secure Cooperative Algorithms and Framework for Extremely-high Penetration Solar Integration (SolarExPert)	Uni of Central Florida
13:00	Robust Distributed State Estimator for Interconnected Transmission and Distribution Networks	Northeastern Uni
13:30	Robust and resilient coordination of feeders with uncertain distributed energy resources: from real-time control to long-term planning	Uni of Vermont
14:00	Phasor-Based Control Scalable Solar Photovoltaic Integration	UC Berkeley
14:30	Q&A	
15:00	Adjourn	

Solar Energy Technologies Office Overview

MISSION

We accelerate the **advancement** and **deployment of solar technology** in support of an **equitable** transition to a **decarbonized energy system by 2050**, starting with a decarbonized power sector by 2035

WHAT WE DO

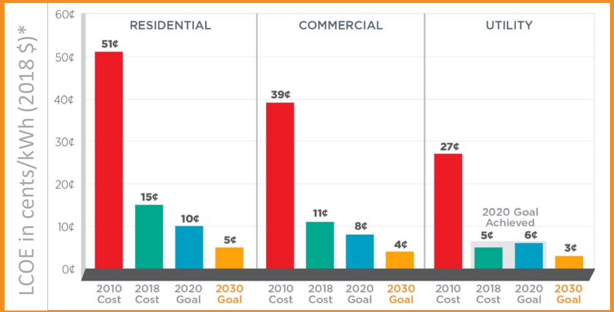
Drive innovation in technology and soft cost reduction to make solar **affordable** and **accessible** for all Americans

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

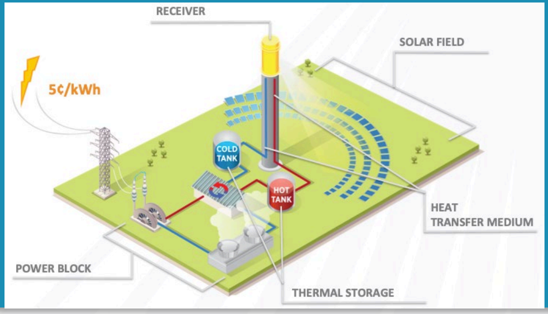
Support **job growth**, **manufacturing**, and the **circular economy** in a wide range of applications

SETO Programs

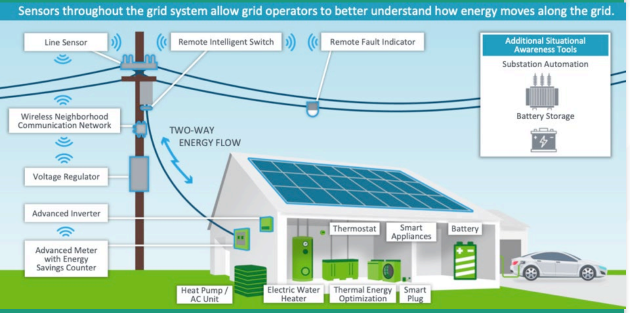
PHOTOVOLTAICS



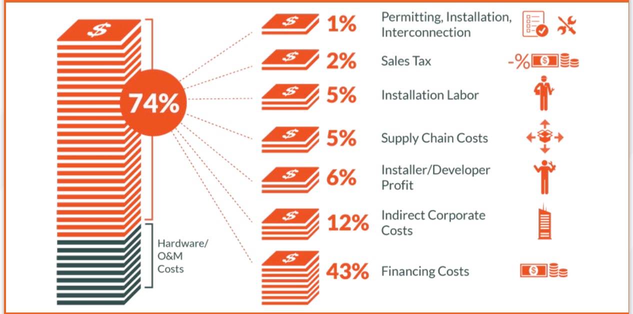
CONCENTRATING SOLAR POWER



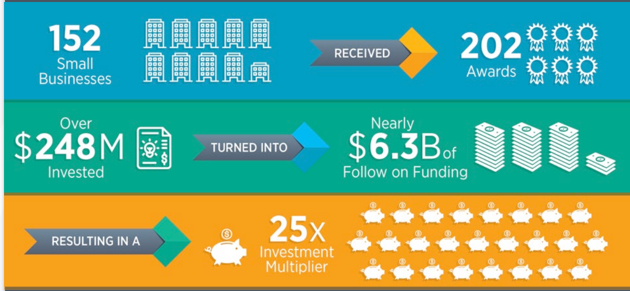
SYSTEMS INTEGRATION



BALANCE OF SYSTEMS SOFT COST REDUCTION

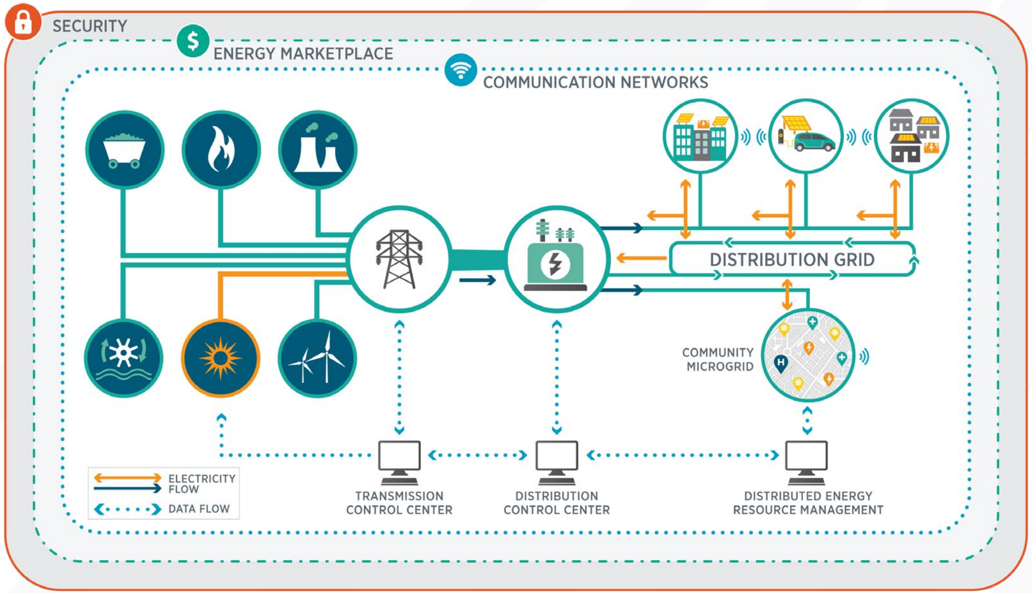


MANUFACTURING AND COMPETITIVENESS

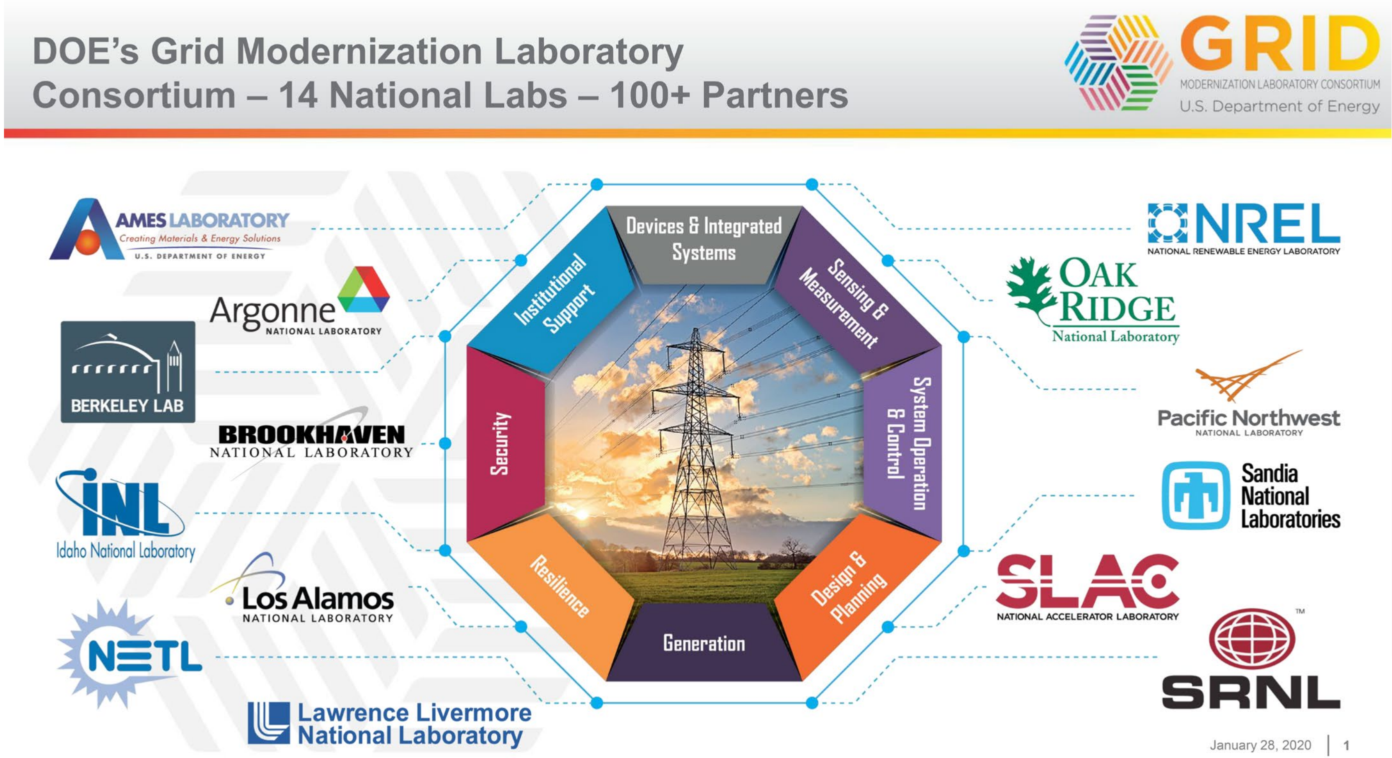


SETO Systems Integration (SI) Program

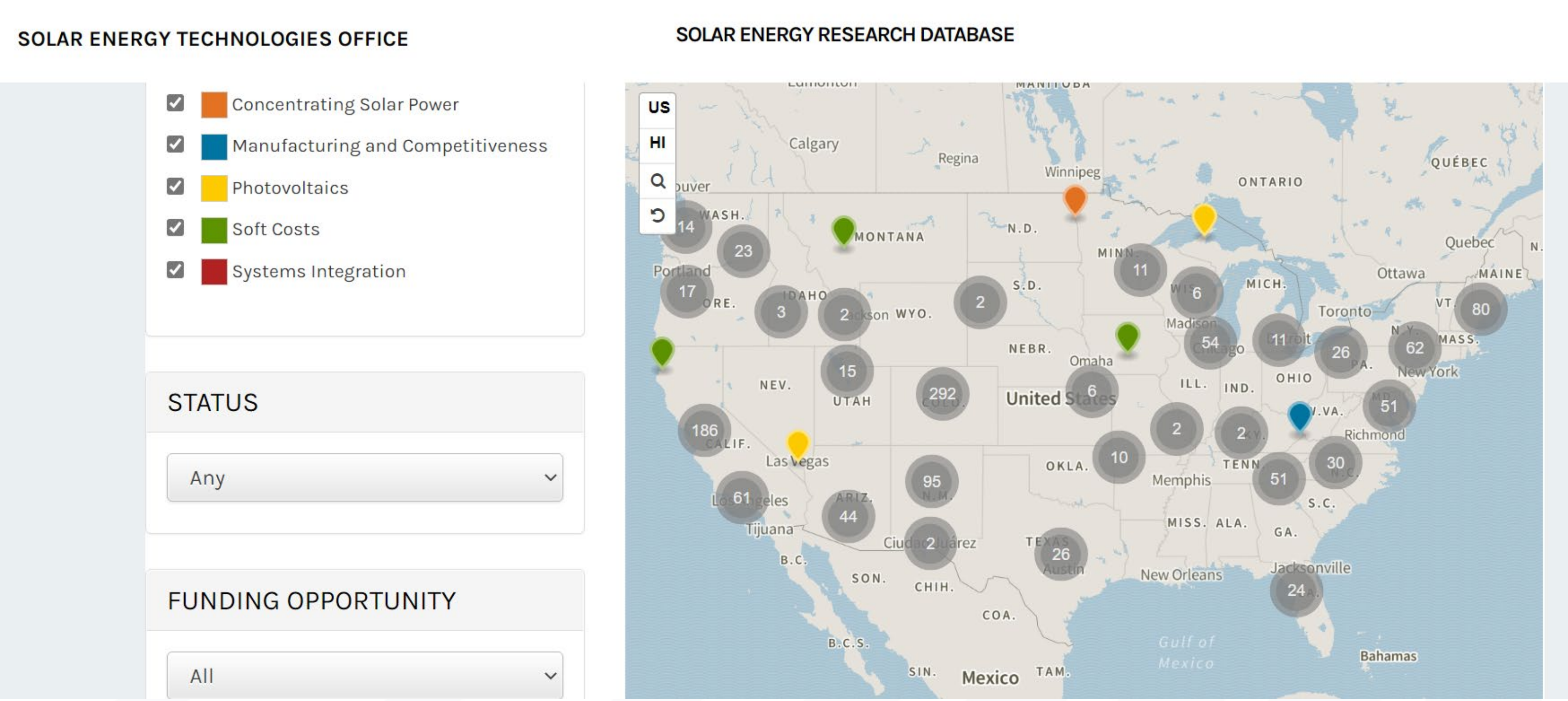
The Systems Integration (SI) subprogram supports early-stage research, development, and demonstration (RD&D) of technologies and solutions – focusing on technical pillars **data, analytics, control, and hardware** - that advance the **reliable, resilient, secure and affordable** integration of solar energy onto the U.S. electric grid.



GMI – DOE-Wide Collaboration



Solar Energy Research Database



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Solar Grid Integration Research Priorities

Solar generation has grown from less than 0.1 percent of the U.S. electricity supply 2010 to 3 percent per year in 2020 and rapidly expanding. In five states, solar electricity already represents more than 10 percent of total generation.

2010-2020 (low)

Solar maximize energy output to the grid

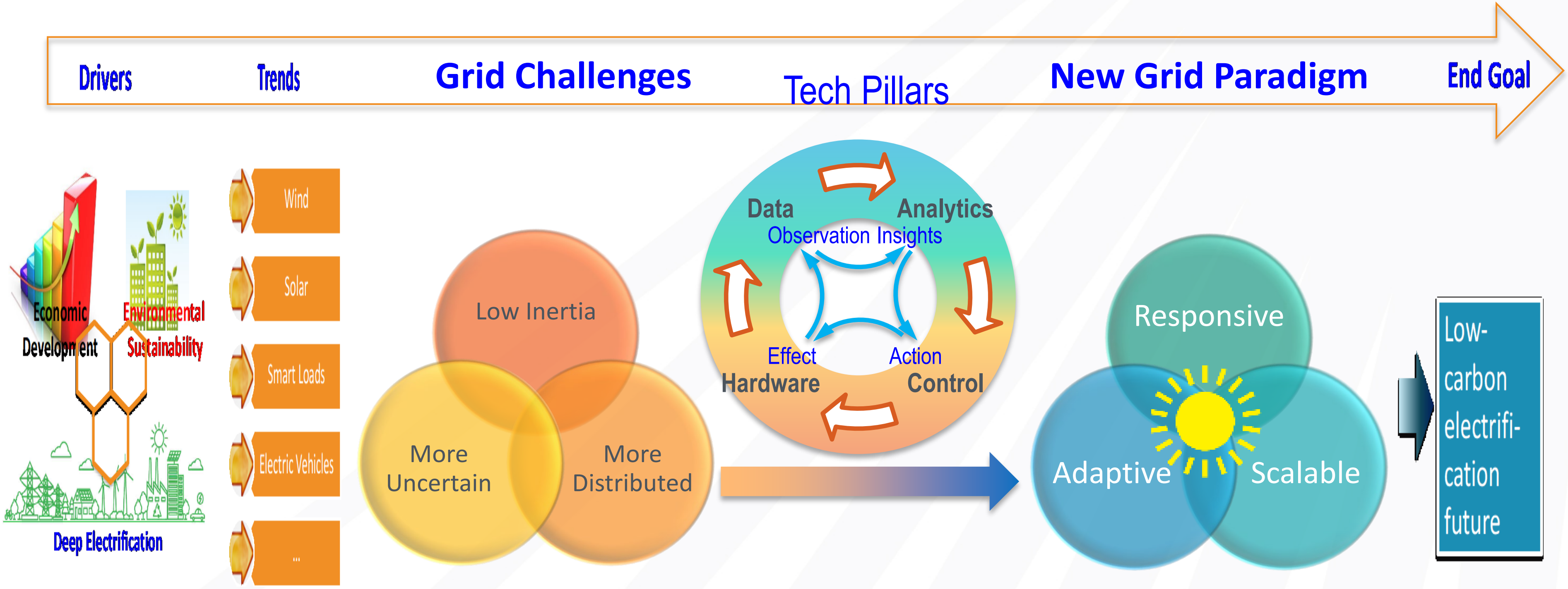
2020-2030 (medium)

Solar and storage contribute to essential reliability services

2030 – (high)

Solar, wind, storage, and other technologies fully support the reliable & resilient operation of 100% clean electricity grid

Grid evolution resulting in fundamental paradigm changes (grid challenges). Grid needs to move to a new paradigm. Solar can and should play a central role.

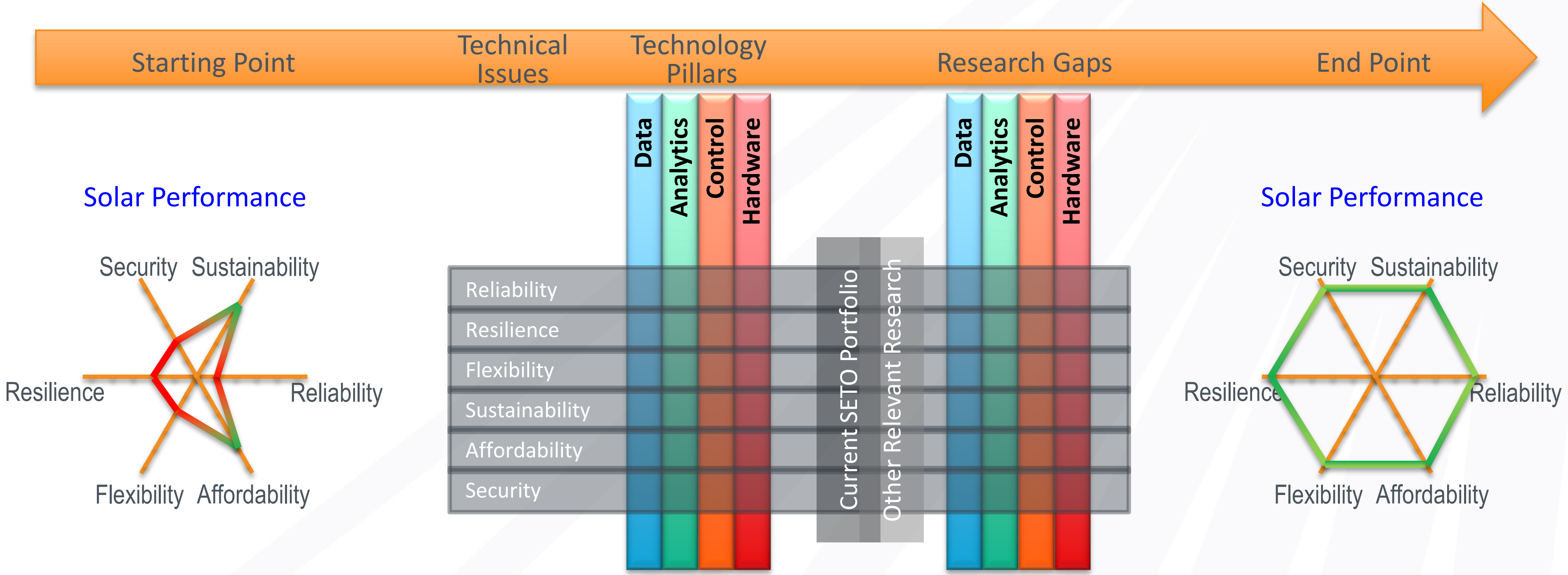


The shifting grid paradigm

- **Low Inertia:** Power electronics-connected generation and consumption reduce the mechanical inertia in the system.
- **More Uncertain:** Uncertainties increase due to variable generation, smart loads, electric vehicles, generation and network contingencies, weather and cyber events, and hidden failures.
- **More Distributed:** The grid trends to having many small active resources such as rooftop PVs, smart appliances, and electric vehicles.

- **Responsive:** The high-speed control capabilities of power electronics present new opportunities for achieving a more ***responsive*** power grid.
- **Adaptive:** The solutions can and should make the grid more ***adaptive*** – ramping requirements, network reconfiguration, AC/DC hybrid operation and islanding at various granularities.
- **Scalable:** Small resources are more ***scalable*** through various combinations as needed, e.g. against cyber or physical disturbances and during outage recovery.

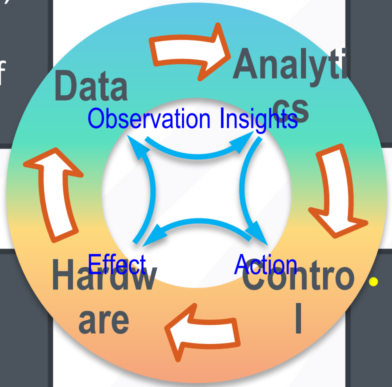
6-metric gap analysis framework for identifying R&D needs in the four technology pillars



Technical pillars for achieving the solar integration goals

- **Data** include the physical quantities such as analog and digital measurements and solar forecasts as well as the underlining infrastructure necessary for data acquisition, transfer, curation, imputation, and management. Data provides *observability* of solar generation and the power grid.

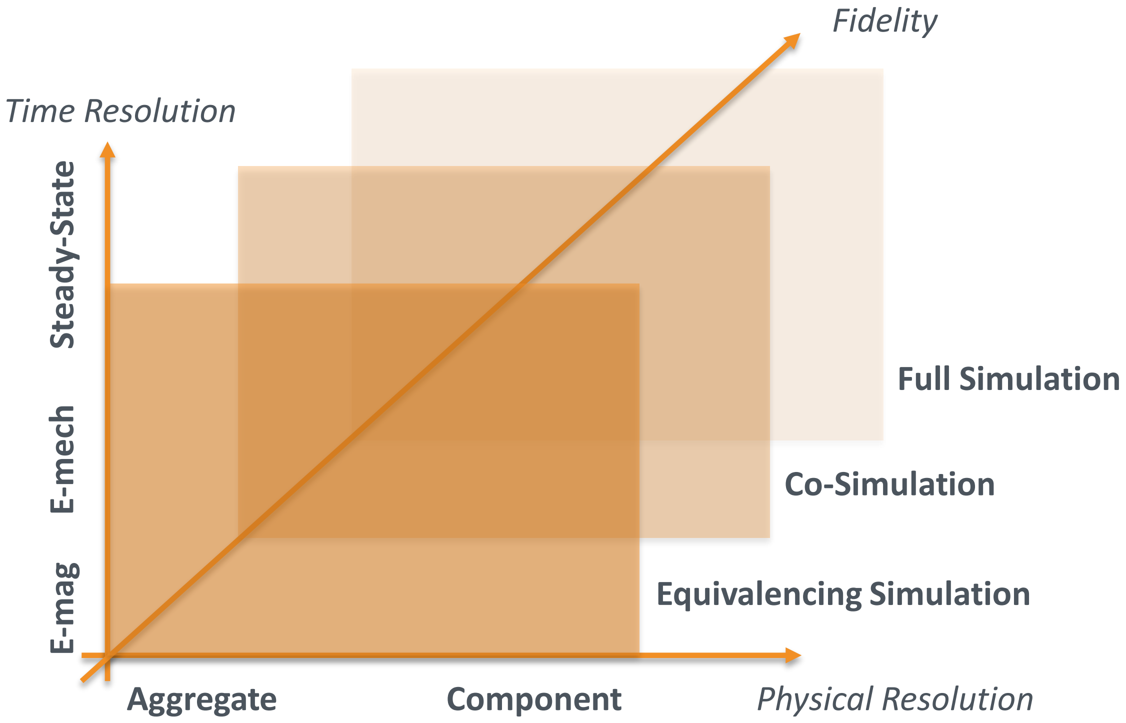
- **Analytics** includes modeling, simulation, computing, and data processing methods, including but not limited to, physics based numerical analysis, artificial intelligence and machine learning, which help to gain *insights* of solar generation in the context of integration with the grid.

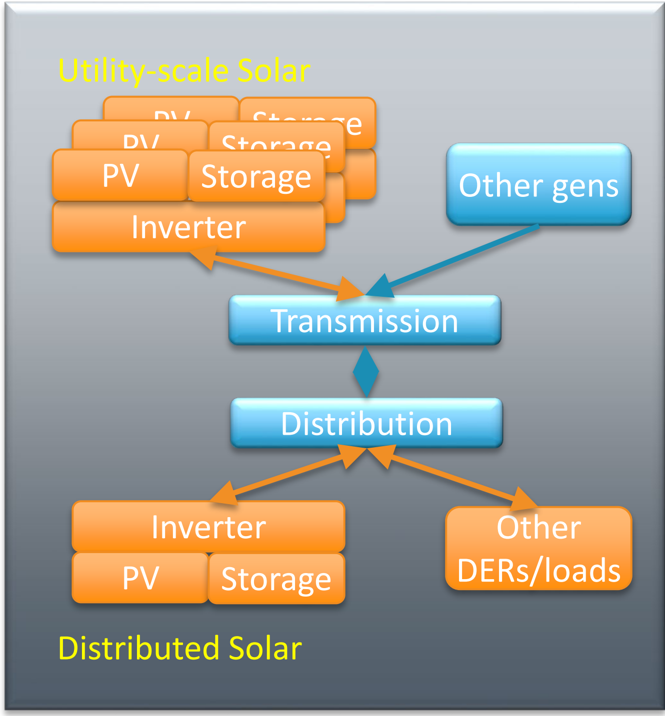


- **Hardware** is where the *effect* would take place. In the context of solar integration, it includes power electronics, inverters, transformers, energy storage systems, sensors, and their control implementations.

- **Control** refers to a broad category of *actions* over steady-state and transient conditions and many uncertainty scenarios, encompassing traditional control and also optimization, protection, operation decisions, policy decisions, and cyber defense methods.

Data, Modeling & Simulations Perspectives

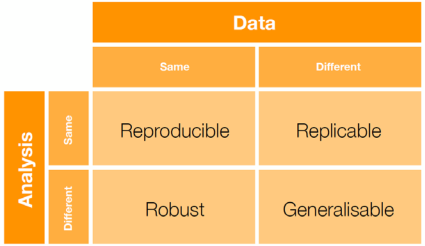




Solar Grid Data (National Lab Core Capability)

Problem Statement: Through OEDI as a gateway, provide access to data, data integration & mapping information/scripts for physics-(traditional) & data-(ML) based solar analytics. Enable reproducible, robust, replicable and generalizable R&D in simulation and emulation of solar system integration. Encourage/enforce dataset format/I/O standardization.

Inputs (Means for Achieving Outcomes)			Outcomes & Impact		
Program Partners & Resources	**DOE & Awardee Activities**	**Target Audience**	**Outputs** (Aggregate Awardee End of Project Goals)	**Short-term Outcomes**	**Long-term Impacts**

• Lab Call/Core
  • NREL
  • PNNL
  • ANL
  • ORNL
• Teaming with entities with experience and expertise in data acquisition, curation, management, sharing
• Entities with needed datasets and/or data/analytical tools
• Hosting capabilities of data repositories from other programs (ARPA-E Grid Data)
	DOE Activities
	• Review existing data repositories & dataset availability
	• Review existing programs
	• Prepare negotiations document
	• Enable continuity
	  • Mutually agree on use-cases
	  • Monthly meetings/Quarterly demos
	Awardee Activities
	• Project objectives around a specific dataset/technology
	• Generate & publish necessary datasets
	  • Develop/collect relevant data integration tools
	  • Provide a single gateway
		• Researchers in power systems simulations and emulations for solar integration
		• National Labs
		• Academia
		• PV/inverter Manufacturers
		• Software vendors
		• Utility planners and operators
		• Balancing authorities & ISOs
		• Regulators
		• PV/DER aggregators/owners
			• Generic and integrated datasets from four power systems operation technologies
			  • smart inverters/distributed energy resources management systems (DERMS)
			  • phasor measurement units (PMUs) and data concentrators (DCs)
			  • smart meters/advanced metering infrastructure (AMI)
			  • new sensor technologies
			• Benchmark analytics (physics and ML based algorithms)
			  • Distribution state estimation
			  • Optimization Functions
			
			Whitaker (2018) https://doi.org/10.6084/m9.figshare.7140050.v2
				(Large) field datasets & integrators for
				• Generation dispatch and flexibility reserve via utility-scale and behind-the-meter solar generation and other DERs
				• Designing blackstart capabilities via solar and other DERs
				• Reliable operation under uncertainty at multiple scales of solar-dominated systems
				• Characterizing system protection in inverter-heavy systems
				• Studying unexpected energization due to distributed PV and other DERs
				• Reconfigurable grid analysis with distributed PV
					• Reliable and Secure operation of a power system with more than 80% power penetration of inverter-based generation and energy storage, using advanced and responsive power electronics controls.
					• Flexible operation of a power system with capability to ramping up/down by 80%-100% of the peak load within the 2-3 shoulder hours, using more adaptive and affordable resource planning.
					• Resilient operation of a power system when facing cyber and physical disturbances, using the distributed and scalable solar generation and energy storage for rapid recovery of critical electricity services.

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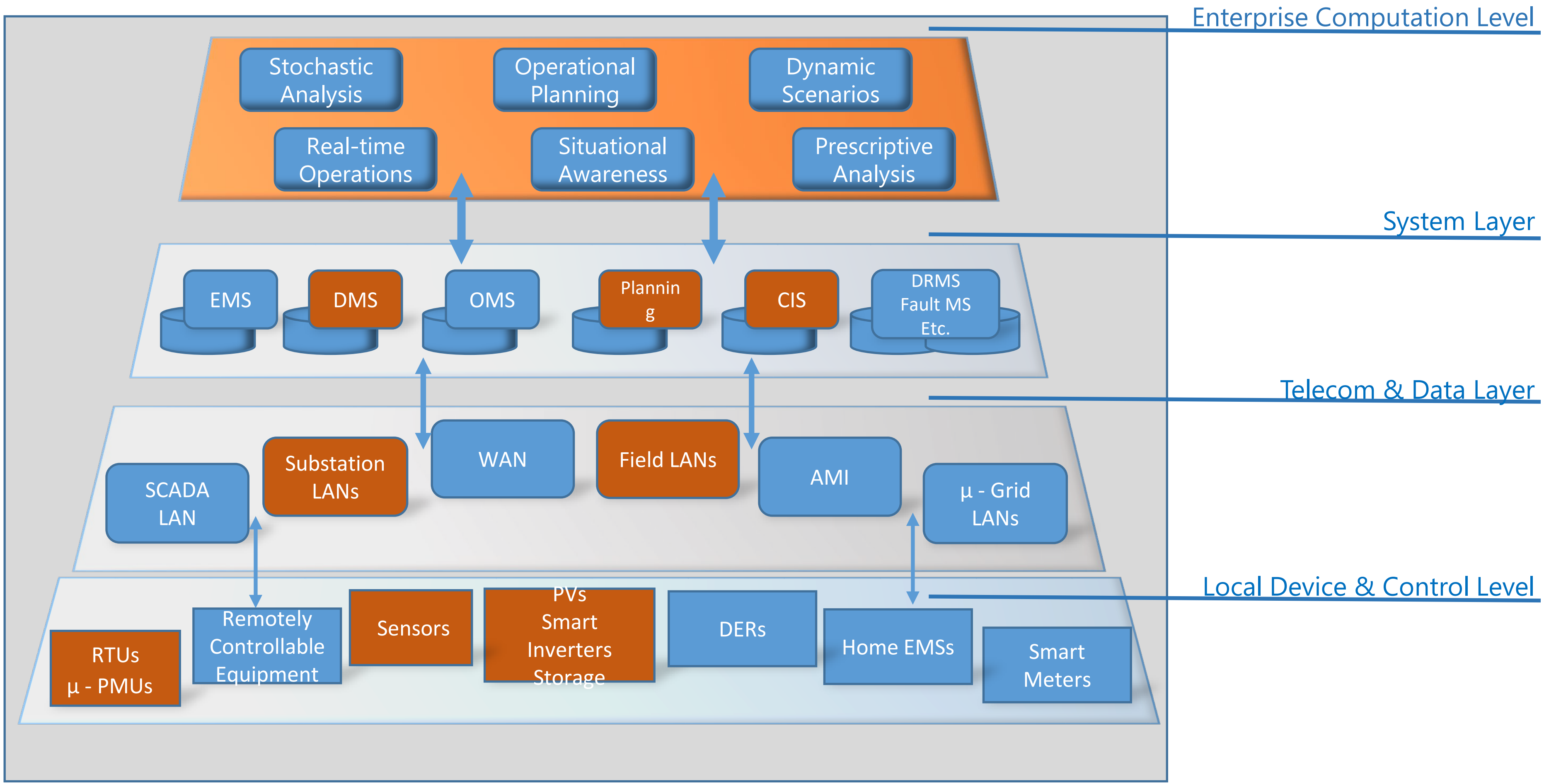
Data, Modeling & Simulation Time-lines

ENERGISE Challenges & Topics of Interest



ENERGISE FOA – Main Objectives

- The main objectives of this ENERGISE FOA were to:
  1. Topic Area 1: Seek near-term (2020), commercially-ready and highly scalable distribution system planning and real-time operation solutions that seamlessly interconnect and integrate high penetration (>50% of distribution peak load) solar generation in existing grid architecture (e.g. centralized generation, transmission, and distribution) in a cost-effective, secure, and reliable manner.
  2. Topic Area 2: Seek long-term (2030), transformative and highly scalable technologies that plug into distribution system planning and real-time operation solutions for advanced grid architectures (e.g. distributed generation, dynamic network topology, microgrid, and potentially distribution level energy market) to enable extremely high penetration (> 100% of distribution peak load) solar generation in a cost-effective, secure, and reliable manner.

ENERGISE Solutions Feature

- For the near-term (2020) topic area, the proposed planning and operation solutions should be able to
  - monitor and control in real time a distribution system (or subsystem) consisting of at least ten (10) distribution feeders and ten thousand (10,000) active nodes with 50% or more PV penetration relative to the peak load.
  - In addition, the solutions should be able to dynamically respond to simple feeder switching events under radial network topology to ensure that the system operates in a reliable manner.
- For the long-term (2030) topic area, the proposed planning and operation solutions should be able to
  - monitor and control a coupled sub-transmission and distribution system consisting of at least one thousand (1,000) distribution feeders and one million (1,000,000) active nodes with greater than 100% PV penetration relative to the peak load.
  - In addition, the solutions should be able to dynamically and adaptively respond to complex feeder switching events under radial, mesh, or hybrid network topologies to ensure that the system operates in a reliable manner.

Questions?