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

SOLAR ENERGY TECHNOLOGIES OFFICE

2020 SETO PEER REVIEW

System Design, Yield Modeling, and Data Validation

A Virtuous Cycle

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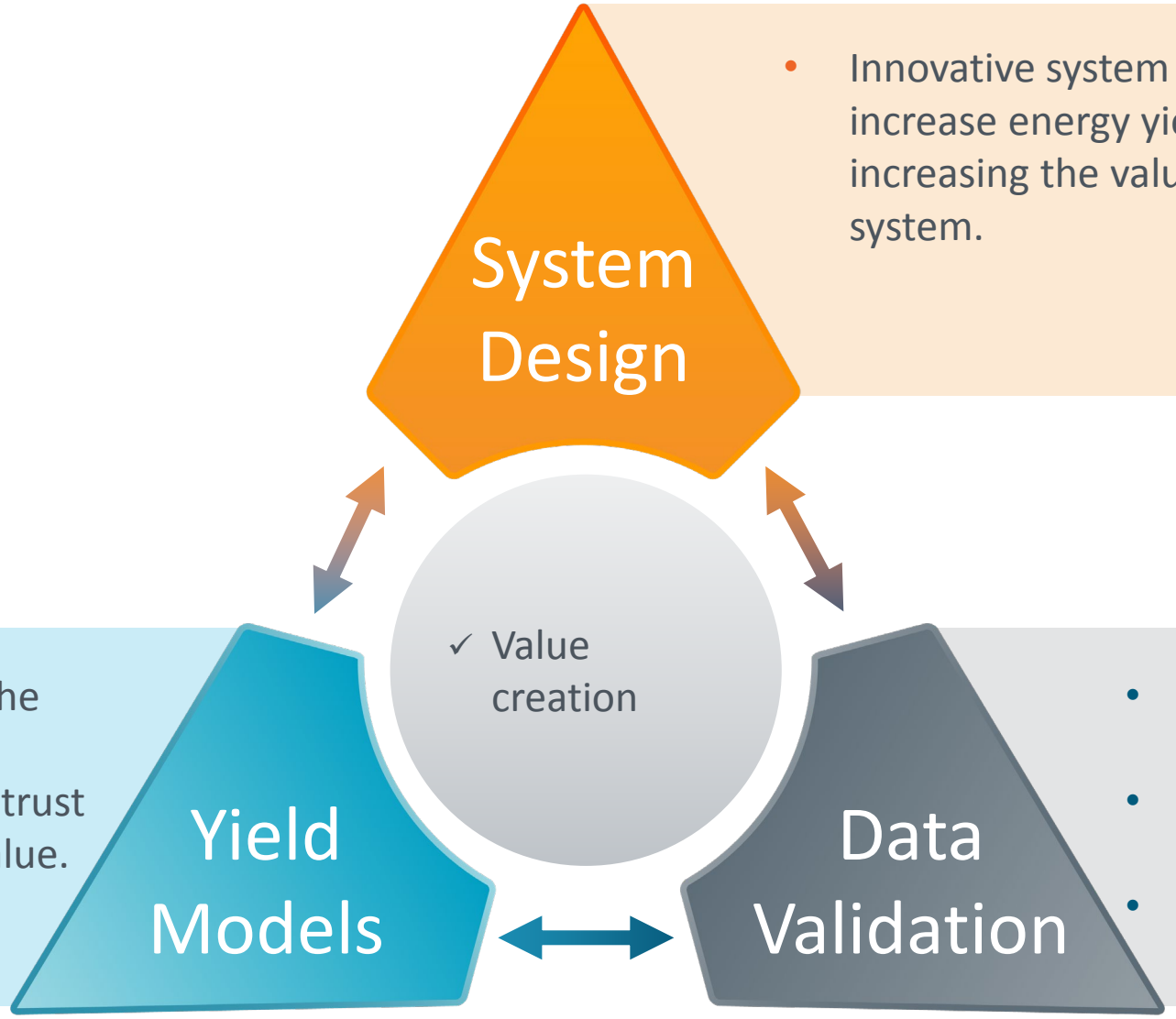
The Virtuous Cycle

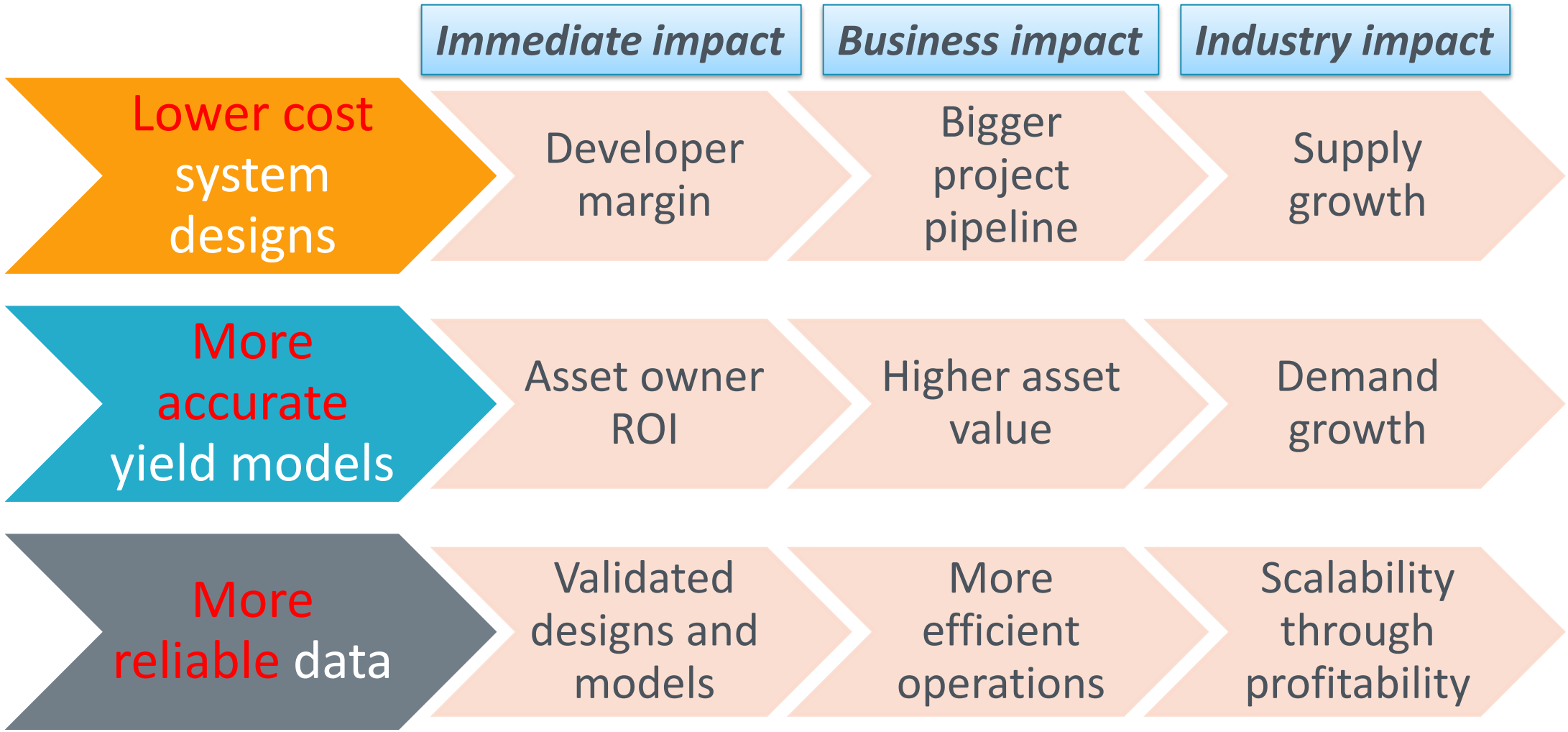


- Innovative system designs can increase energy yield, thereby increasing the value of the system.

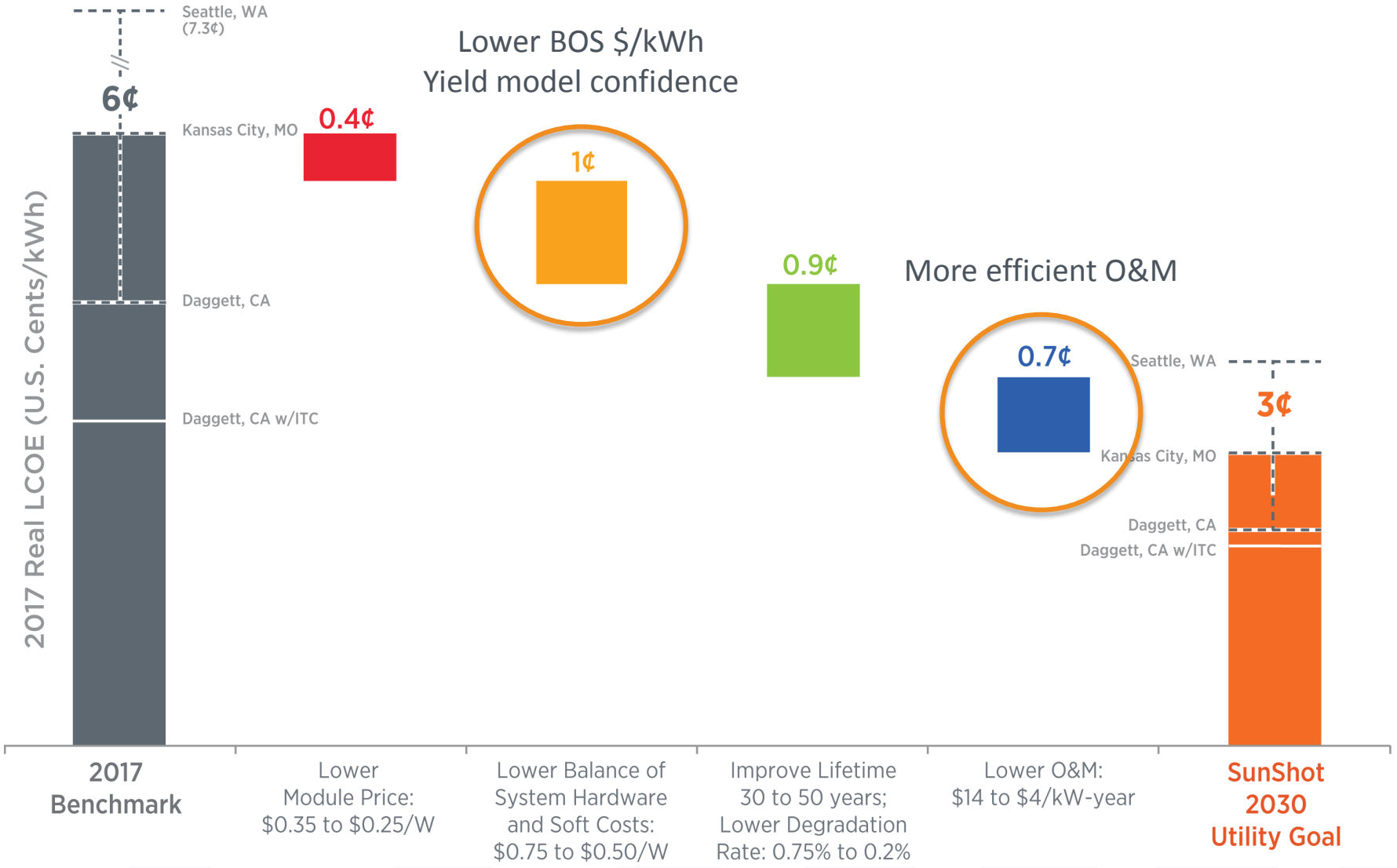
- Yield models are driving the valuation of PV systems.
- Developers and investors trust them to estimate asset value.

- Field data are necessary to validate yield models.
- Field data can inform system design.
- Field data can inform optimal O&M

Creating value across solar supply chain



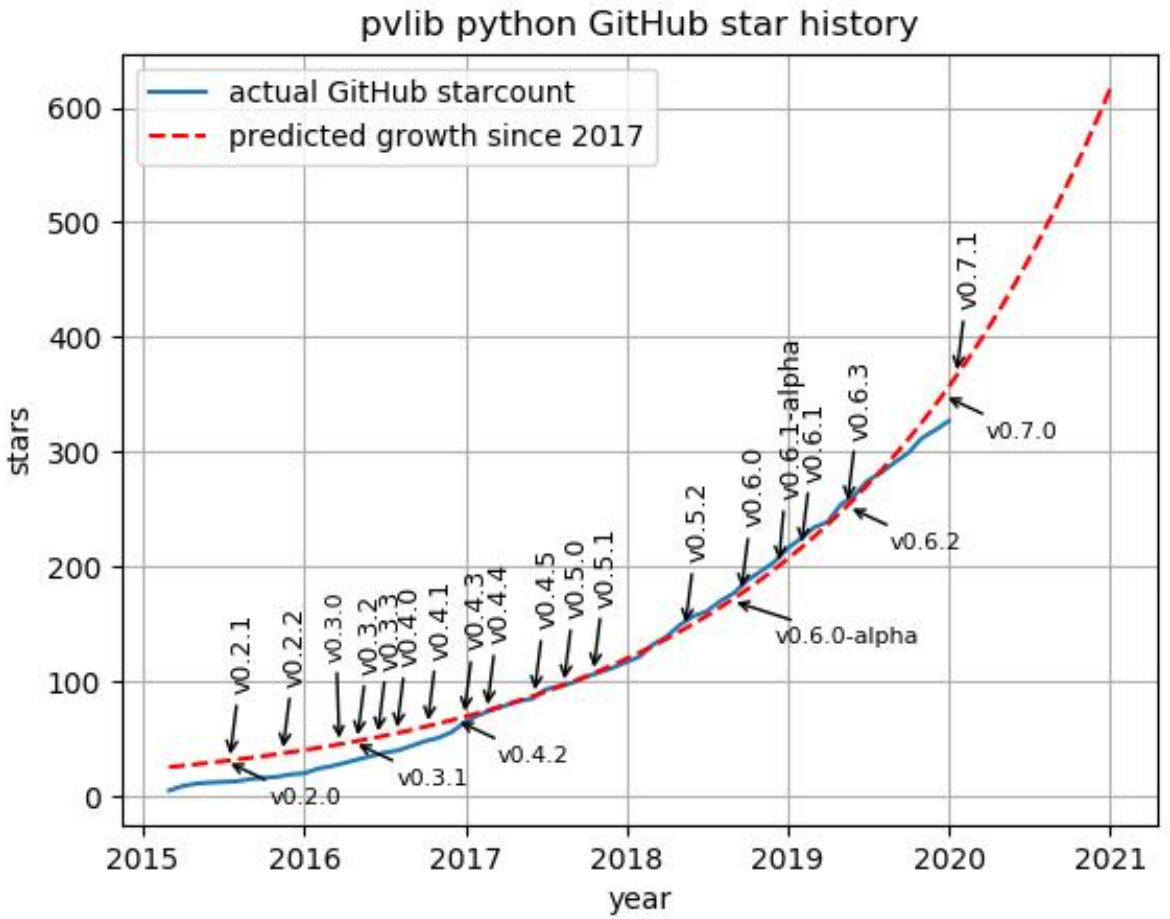
Impact on Solar Cost Roadmap



100 $MW_{(DC)}$ One-Axis Tracking Systems With 1,860 $kWh_{(AC)}/kW_{(DC)}$ First-Year Performance.
Includes 5 Year MACRS. Horizontal Lines Indicate Low, Median, and High U.S. Solar Resources.

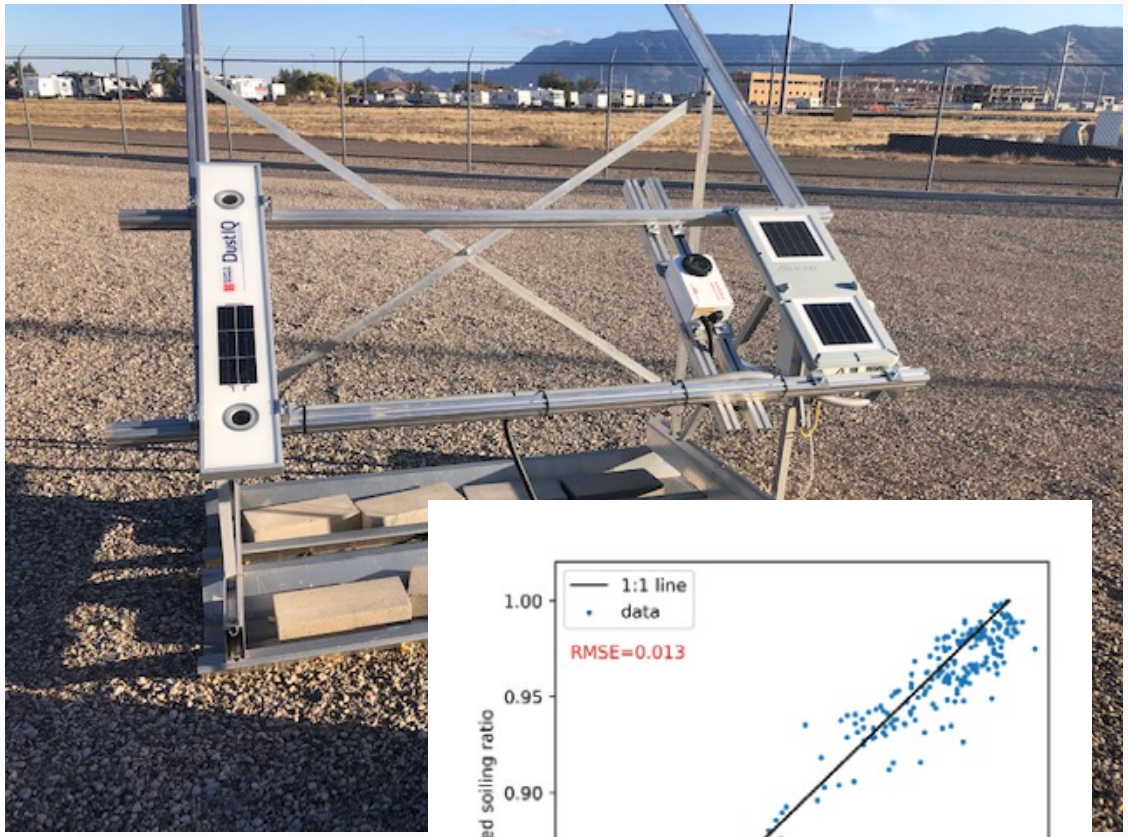
- Pvlib-python's mission is to provide
  - open,
  - reliable,
  - interoperable,
  - and benchmark

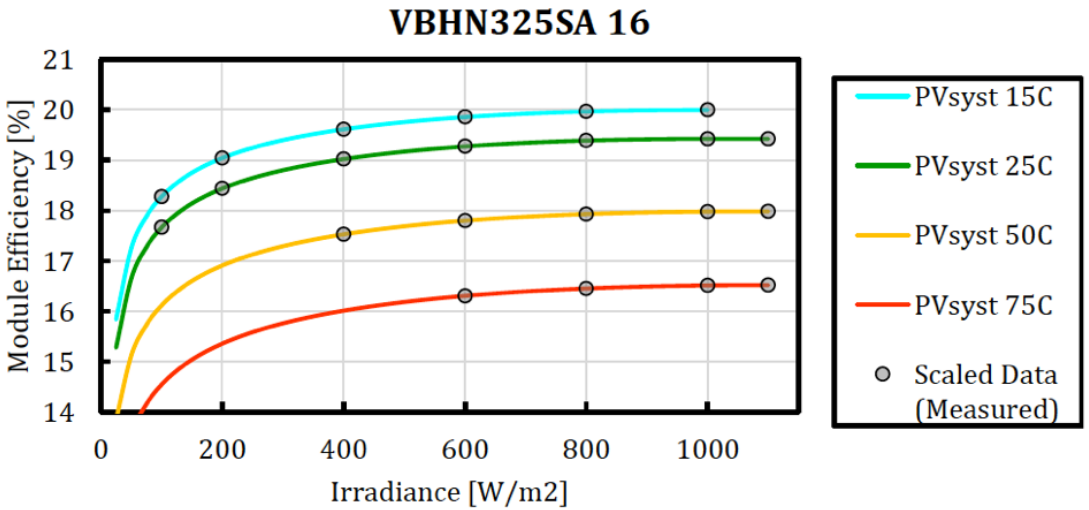
  implementations of PV system models
- Highly engaged community
  - 200k downloads
  - Used by 80 projects
  - https://pvlib-python.readthedocs.io/



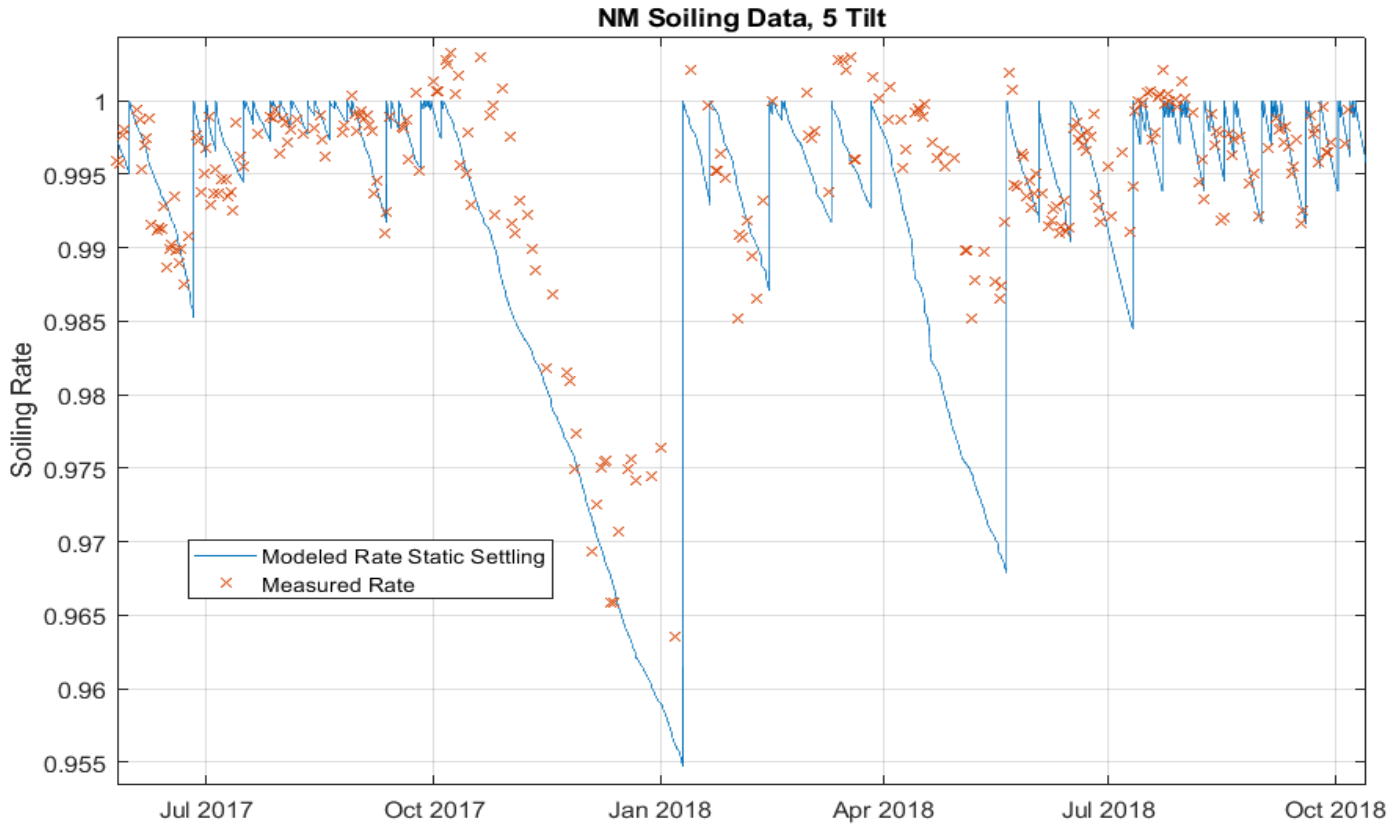
- Proving grounds (RTCs)
  - High-voltage, grid-connected systems, designed and installed by the project team
  - High-accuracy, high resolution performance and weather data
  - Installation of identical systems in multiple climates
  - Management of 50+ research systems/1100 modules
- Facility governance in transition

- Multiple soiling sensors
- 61853-1 Matrix Measurements
- Data to run and validate PV performance models will be made publicly available along with documentation on:
  - data collection,
  - instrument calibration.



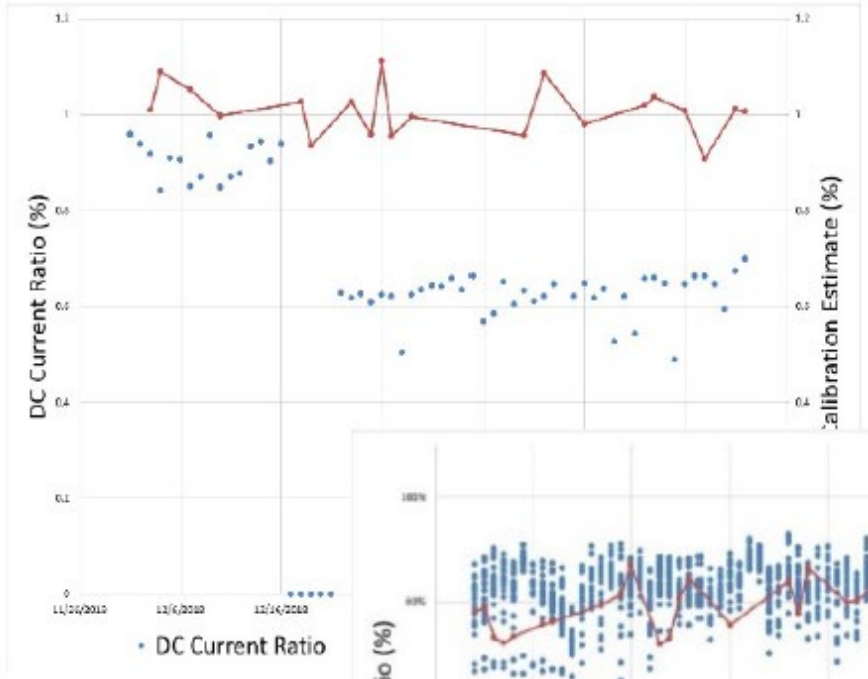


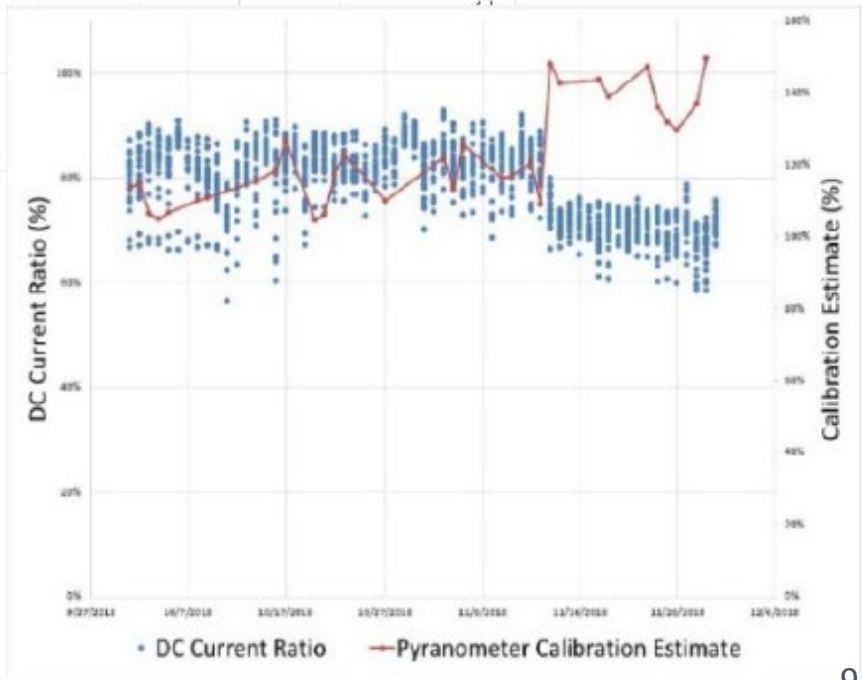
- Dynamic soiling and snow models (pvlib)
- Soiling models using $PM_{2.5}$ and PM_{10} data (Rdtools)

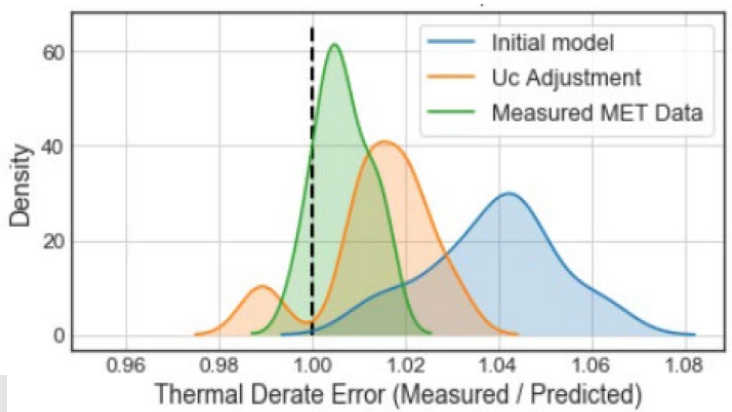


- Data capability is critical for
  - detailed performance assessment,
  - effective O&M, and
  - accurate modeling
- Event* detection is necessary for fine-tuned performance analysis

(*) issues with clear onset and resolution times

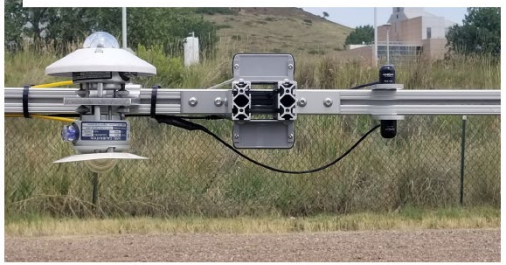


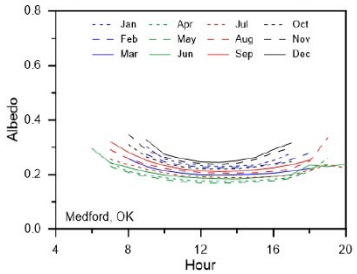




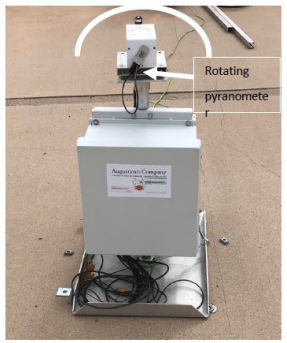
- Bifacial systems
  - **3 test sites and multiple commercial sites**
    - Bifacial systems showed 2-14% gains on a weekly basis
  - **Develop open-source models** (e.g., bifacial_radiance, electrical mismatch, etc.) to accurately simulate bifacial PV performance
  - **Adjustment of models using measured data**
    - Actual output exceeded original models by 1.5%
    - Upper module almost always receives more insolation
  - Leverage HPC to **optimize bifacial system designs**
  - Build project **investor confidence in bifacial energy model accuracy**

Albedo comparisons and database for 36+ locations

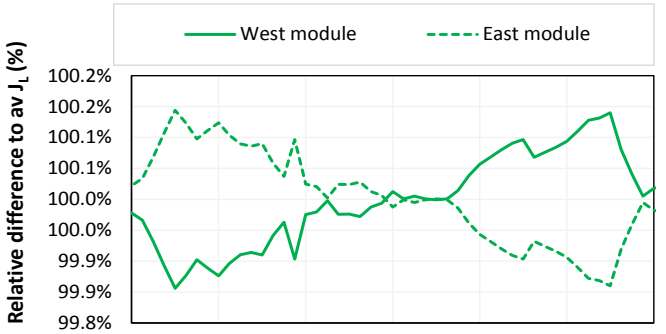




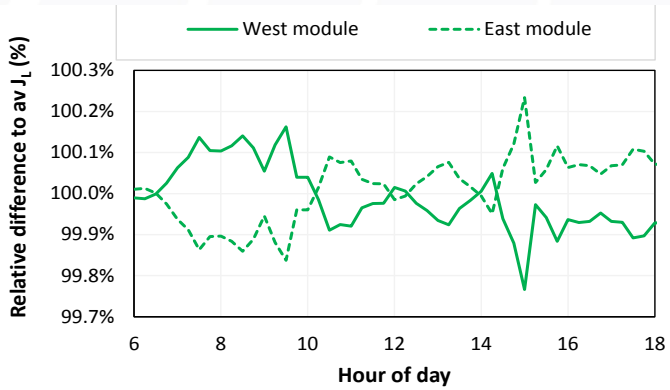
Miniaturized SAT testbed & rotating irradiance measurement to determine optimal tracking angle



Power Output, Sunny Summer Day

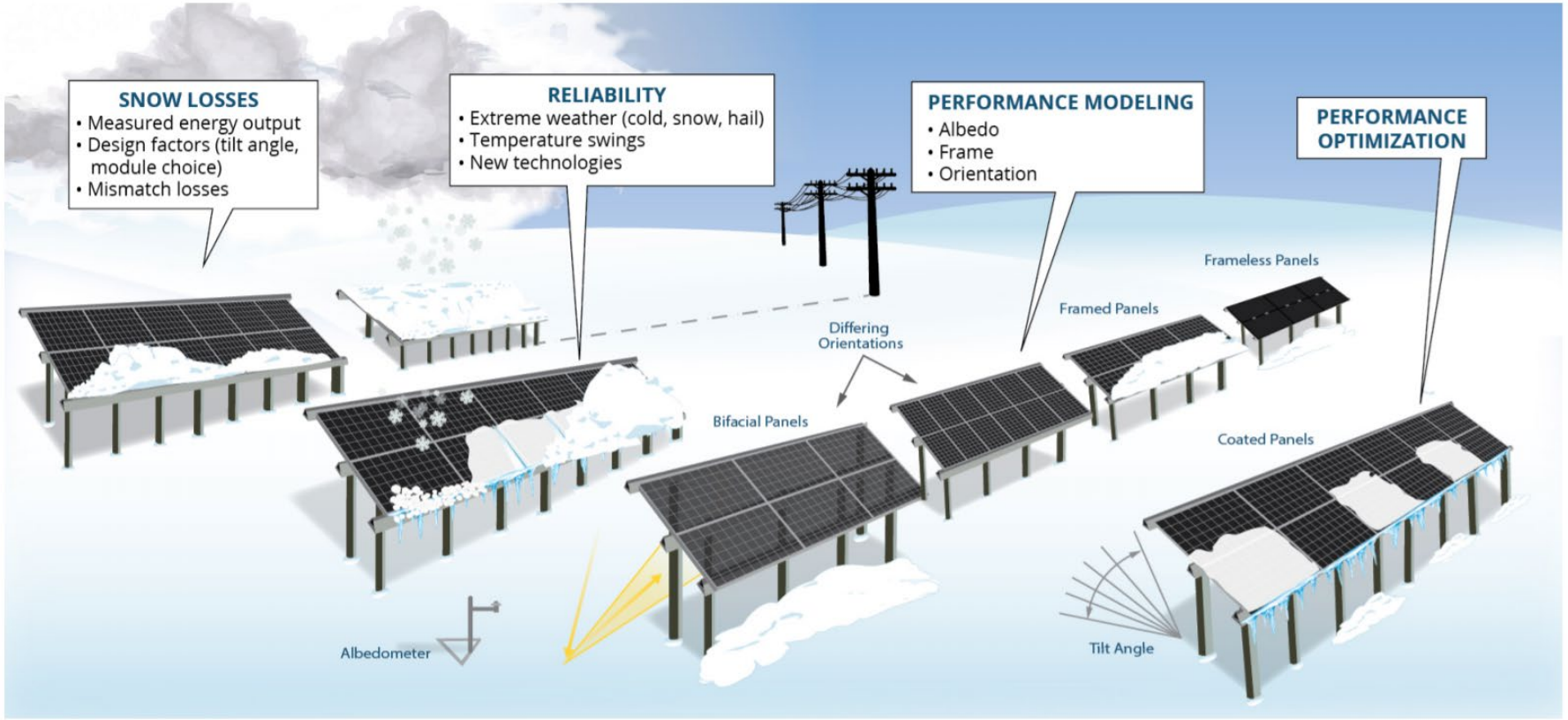


Without Edge Effects



With Edge Effects

- Snow loss modeling and optimal design parameters
  - Quantify and model the yield impact attributable to specific features (Frame, Bifaciality, Orientation)
  - Identify optically-transparent and anti-reflective coatings and demonstrate their snow-phobicity/efficacy
  - Construct expandable database to capture data, including images, from multiple PV plants across the northern US



List of Highlighted Projects

Award #	Project Title	Recipient Name	PI Name
34347	PV Proving Grounds - NREL	National Renewable Energy Laboratory	Chris Deline
34363	Snow Characteristics as a Factor in PV Performance and Reliability	Sandia National Laboratories	Laurie Burnham
34364	PV Proving Grounds - SNL	Sandia National Laboratories	Bruce King
34366	PV Performance Modeling	Sandia National Laboratories	Joshua Stein
34367	Optimized Bifacial Modules and Systems	Sandia National Laboratories	Joshua Stein
DE-EE0008157	Levelized Cost of Energy Reduction through Proactive Operations of Photovoltaic Systems	University of Central Florida	Joseph Walters
DE-EE0008158	Single Model Characterization	Power Factors	Steve Voss
DE-EE0008165	Non-Contact Simultaneous String-Modules I-V Tracer	Arizona State University	Govindasamy Tamizhmani
DE-EE0008169	Spread Spectrum Time Domain Reflectivity for String Monitoring in Photovoltaic Power Plants	University of Utah	Michael Scarpulla
DE-EE0008546	Bifacial PV Module Energy Modeling Validation Study	PVEL, LLC	Tara Doyle
DE-EE0008564	Capturing the full benefits of bifacial modules to approach an LCOE of 3c/kWh through a regional optimization of the electrical architecture	Cypress Creek Renewables, LLC	Jenya Meydbray