SOLAR ENERGY
TECHNOLOGIES OFFICE
U.S. Department Of Energy

PORTFOLIO REVIEW
2018

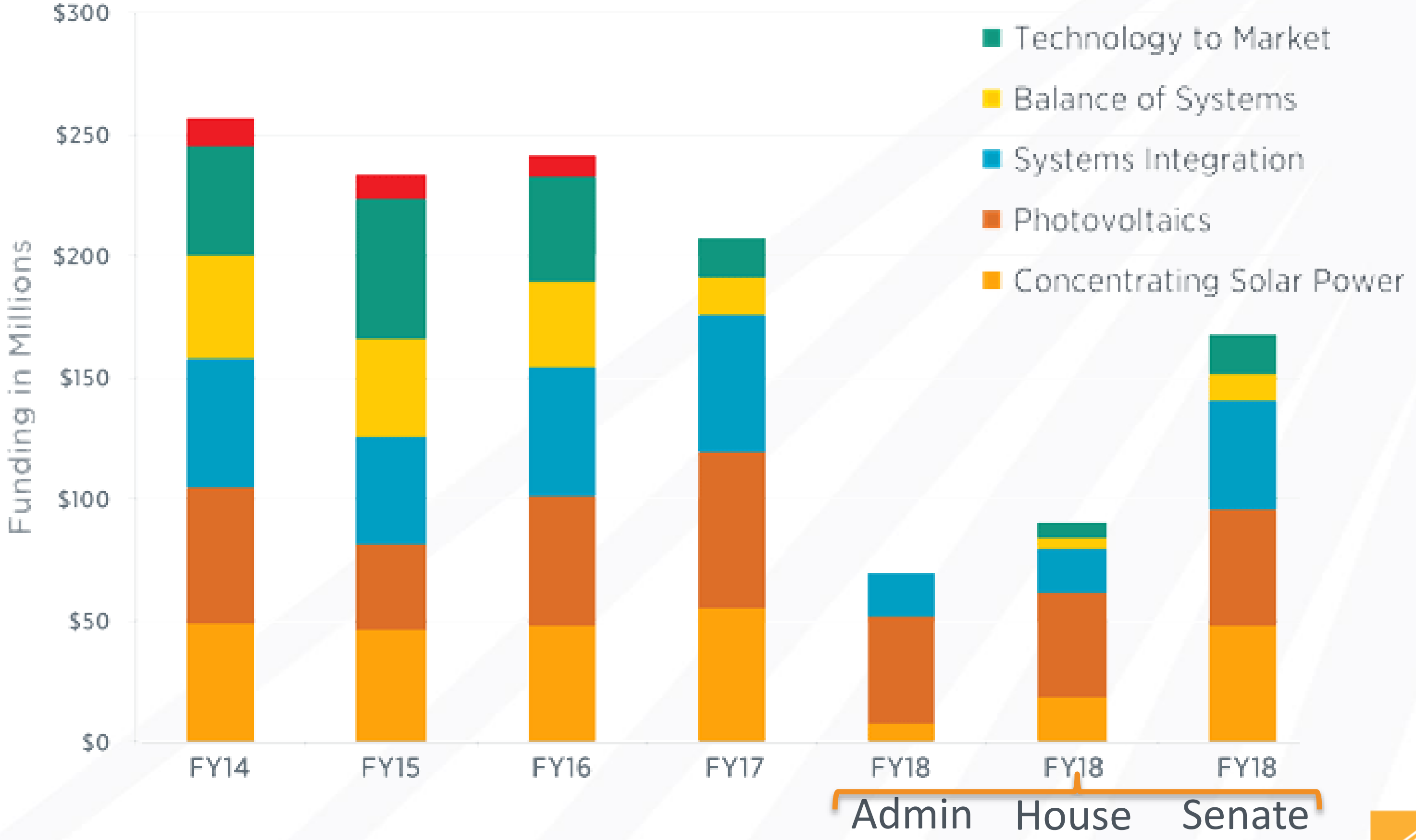
SOLAR ENERGY
TECHNOLOGIES OFFICE
U.S. Department Of Energy

2018 SETO Portfolio Review

2018 Solar Energy Technologies Office
Portfolio Review Day 2 Keynote

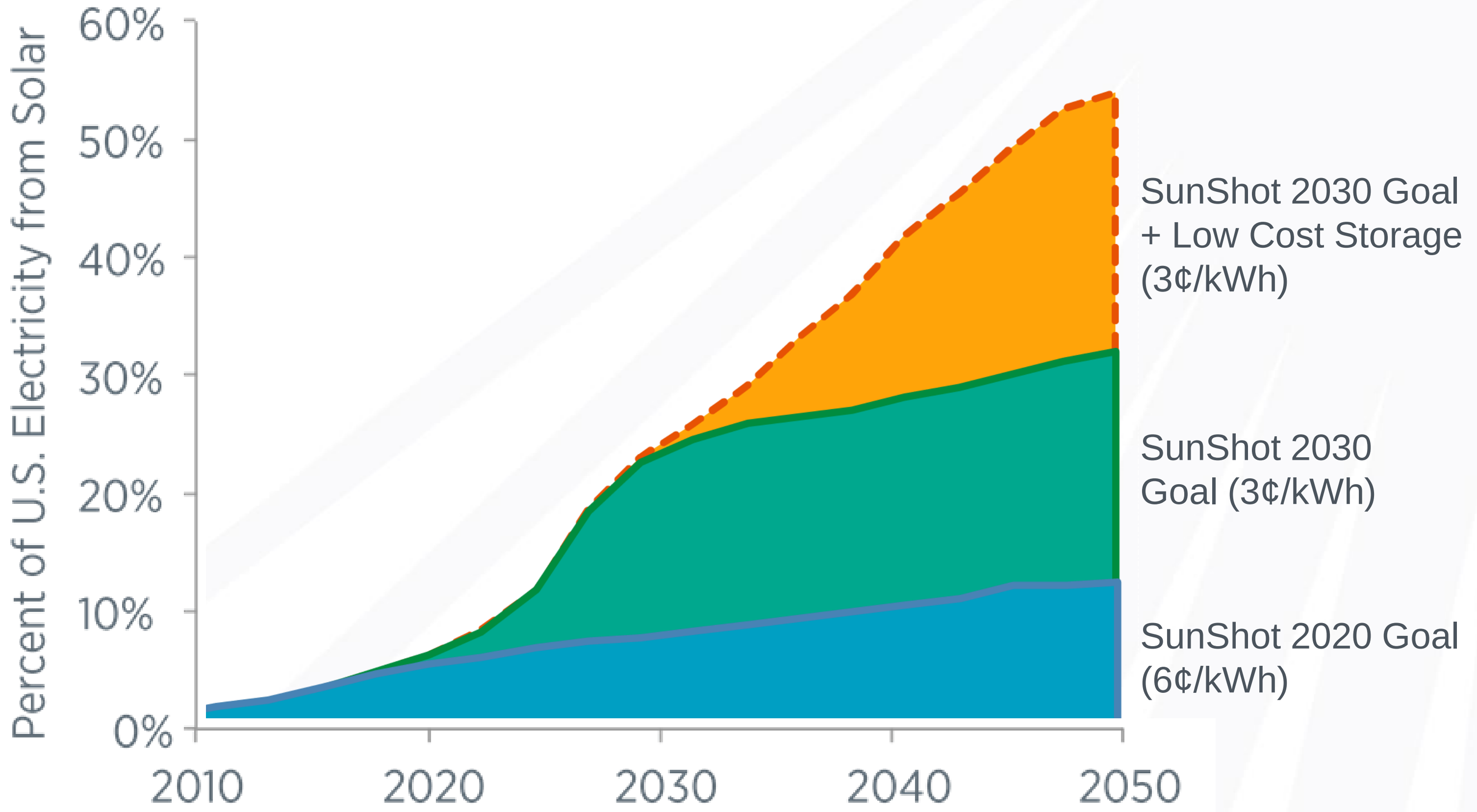
Dr. Charlie Gay
Director, Solar Energy Technologies Office

SETO Historical Funding and Range for FY 2018



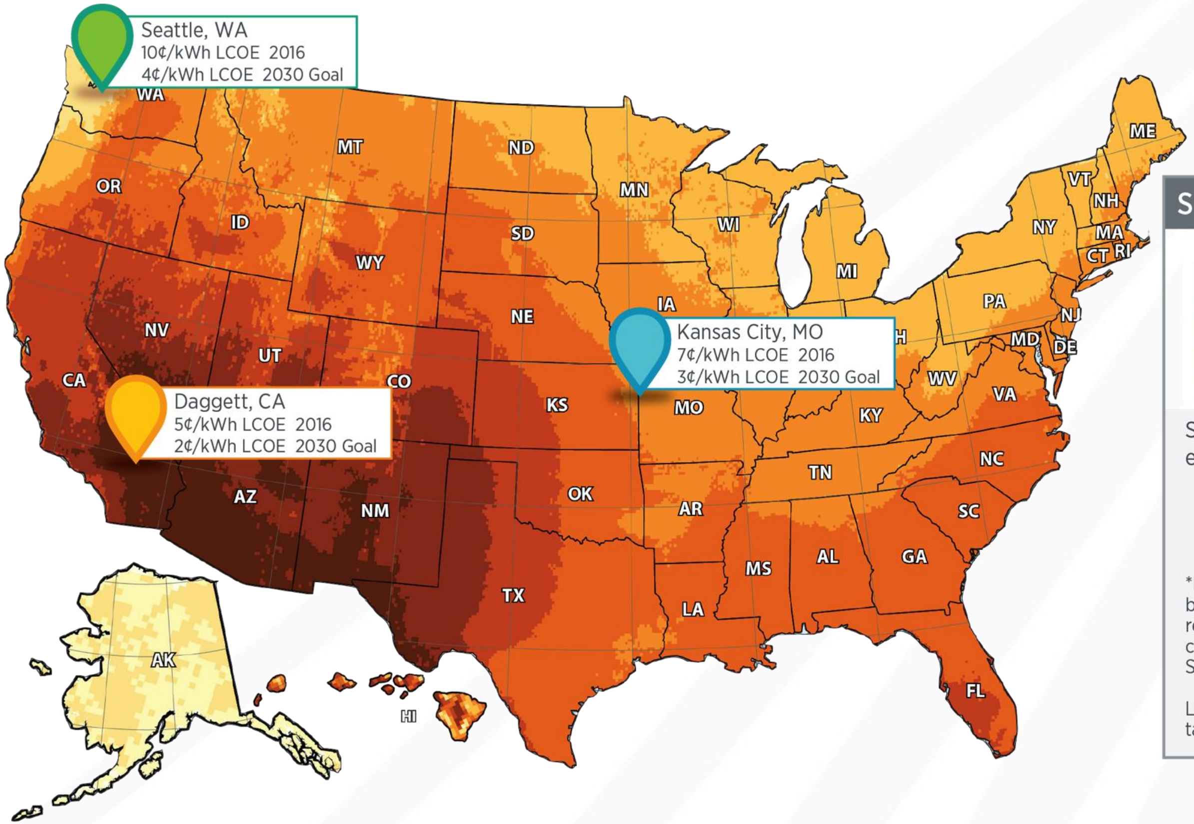
SOLAR ENERGY TECHNOLOGIES OFFICE
U.S. Department Of Energy

Half the Cost, More than Double the Solar



SOLAR ENERGY TECHNOLOGIES OFFICE
U.S. Department Of Energy

Moving Beyond Levelized Cost of Electricity



Solar Resource Across America

kWh/m²/Day

- > 6.5
- 6.0 to 6.5
- 5.5 to 6.0
- 5.0 to 5.5
- 4.5 to 5.0
- 4.0 to 4.5
- 3.5 to 4.0
- 3.0 to 3.5
- < 3.0

Daggett, CA - **High**
Kansas City, MO - **Average**
Seattle, WA - **Low**

SunShot determines "levelized cost of electricity" (LCOE) based on:
(Upfront Installation Price + Lifetime Operational Expenses ($)* / Net Present Value of the Power Produced (kWh)

*Lifetime operational expenses are calculated based on average solar resource locations, represented by Kansas City, MO, and also calculated for Daggett, CA (high resource) and Seattle, WA (low resource).

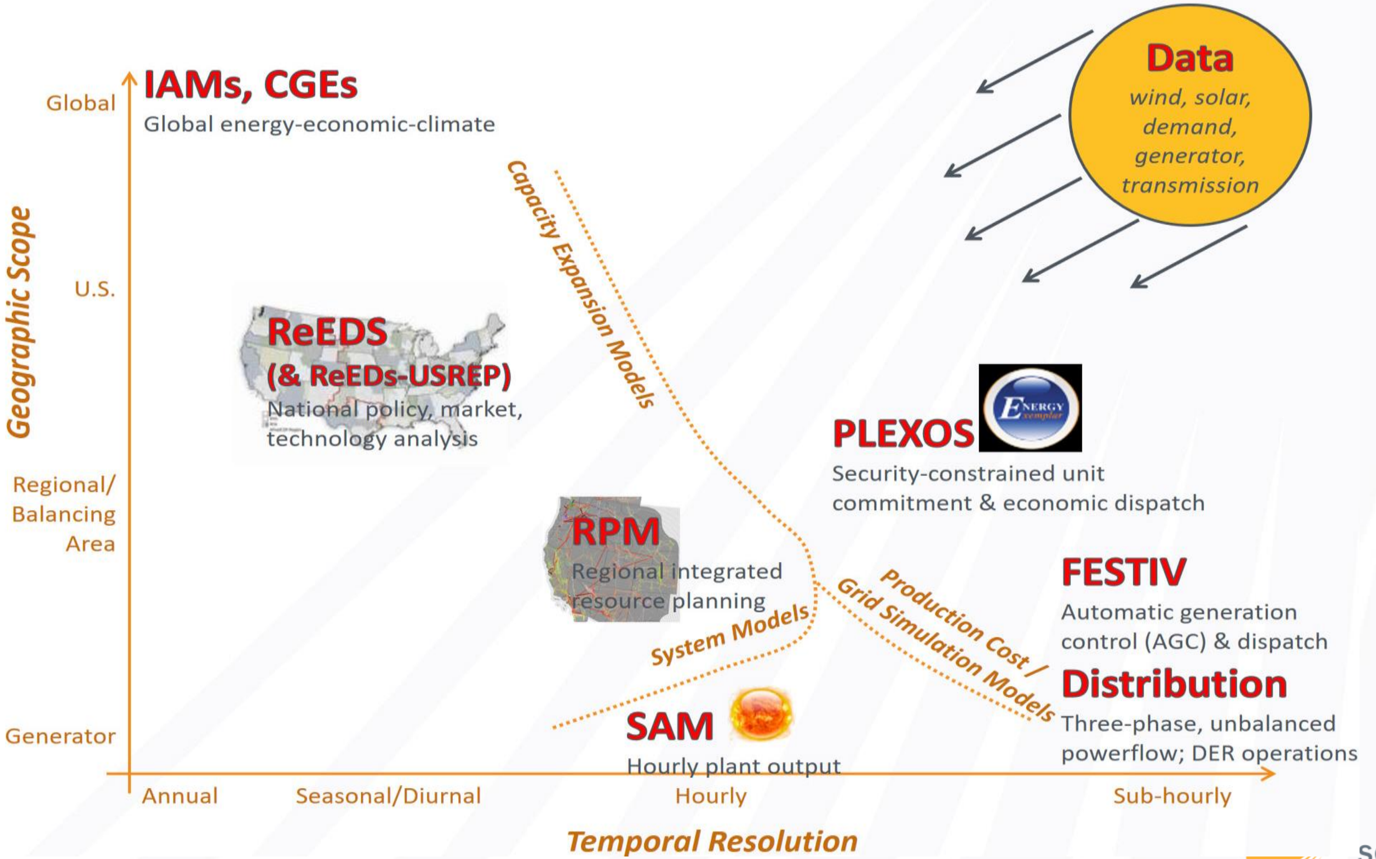
LCOE does not include the federal investment tax credit (ITC) or state or local incentives.

SOLAR ENERGY TECHNOLOGIES OFFICE
U.S. Department Of Energy

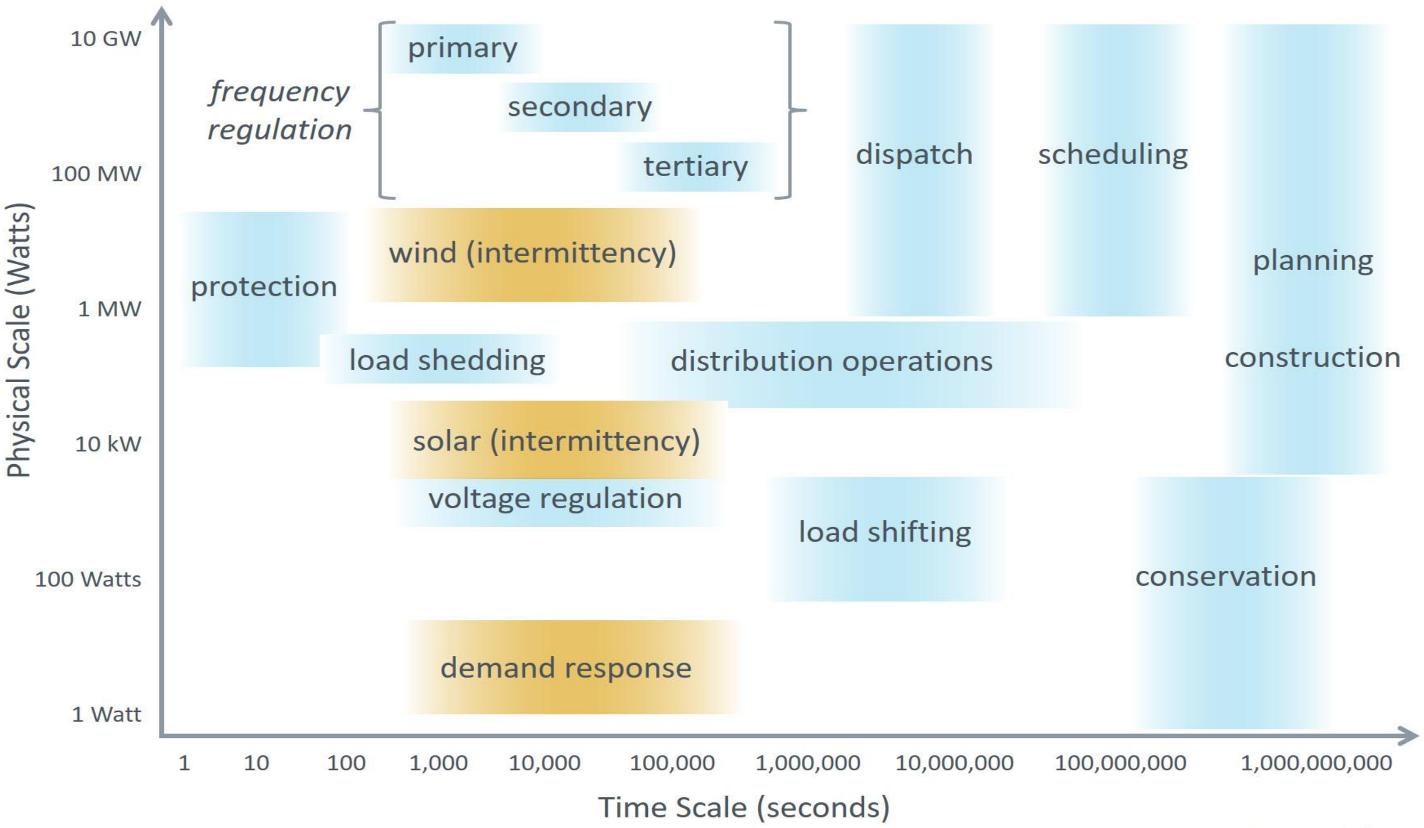
Emerging Issues

- LCOE as a metric requires clarification
  - Depends on location, time of day and financial assumptions
  - Depends on project scale even when hardware costs don’t
- Deployment is strongly dependent on policy
  - Focus on conservative policy scenarios (e.g. no ITC)
  - Standardization of installations, especially storage

Power Sector Models



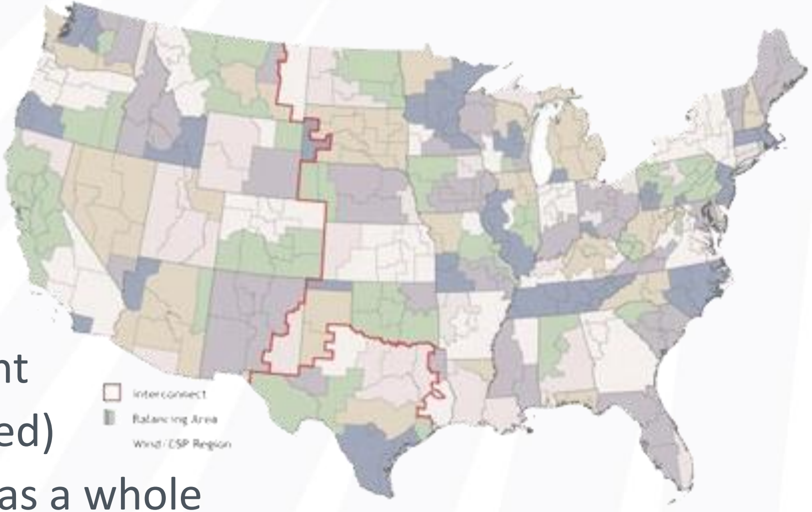
Multi-scale Grid Optimization



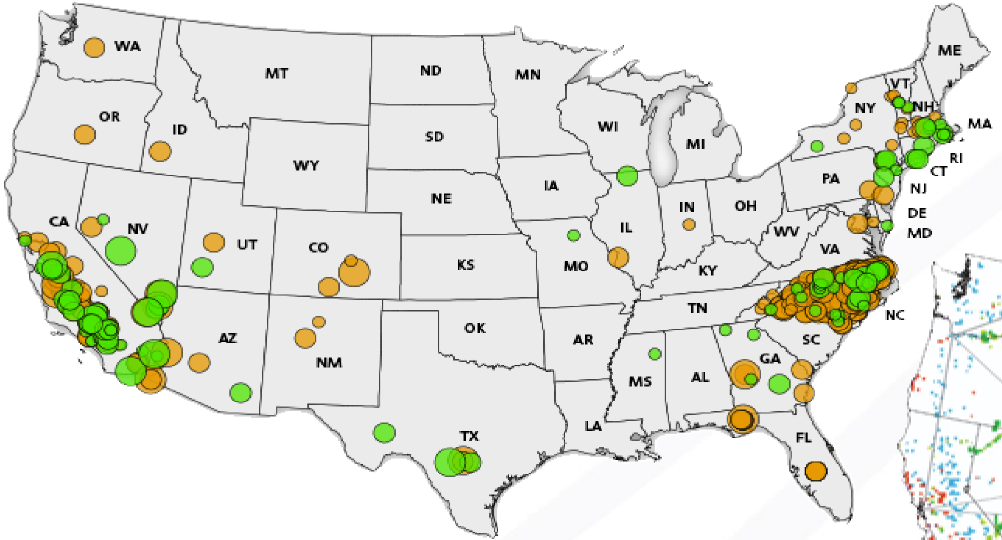
Demand: NREL's Regional Energy Deployment System

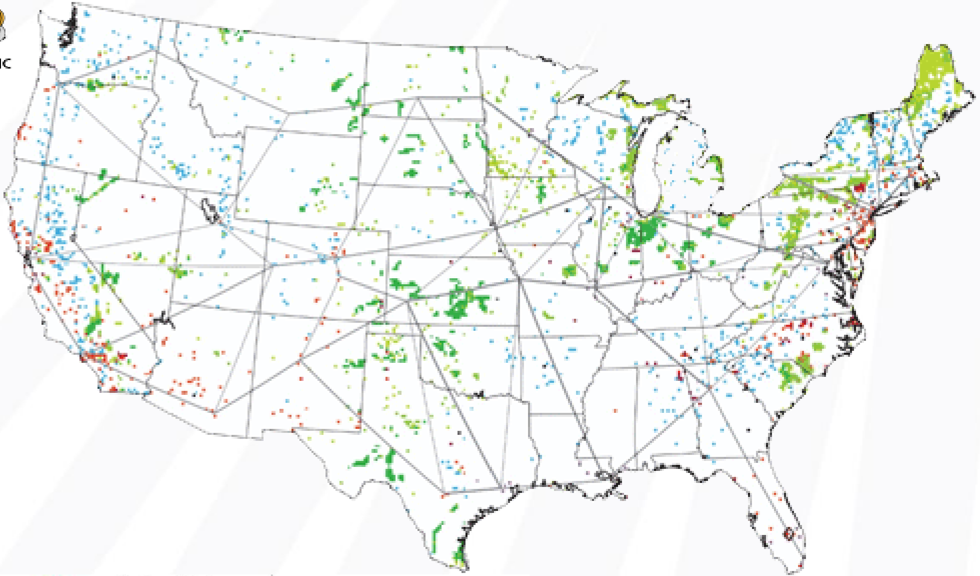
- ReEDS models the future deployment in the USA of:
  - Electric generation capacity (renewable and non-renewable)
  - Transmission capacity between 134 balancing areas
  - Distributed PV (dGen model)
  - Energy storage (UPV & DPV)

- Selections are made to:
  - Meet projected growth in demand
  - Replace power plants scheduled for retirement
  - Fulfill policy requirements (as currently enacted)
  - Minimize the total system cost for the nation as a whole

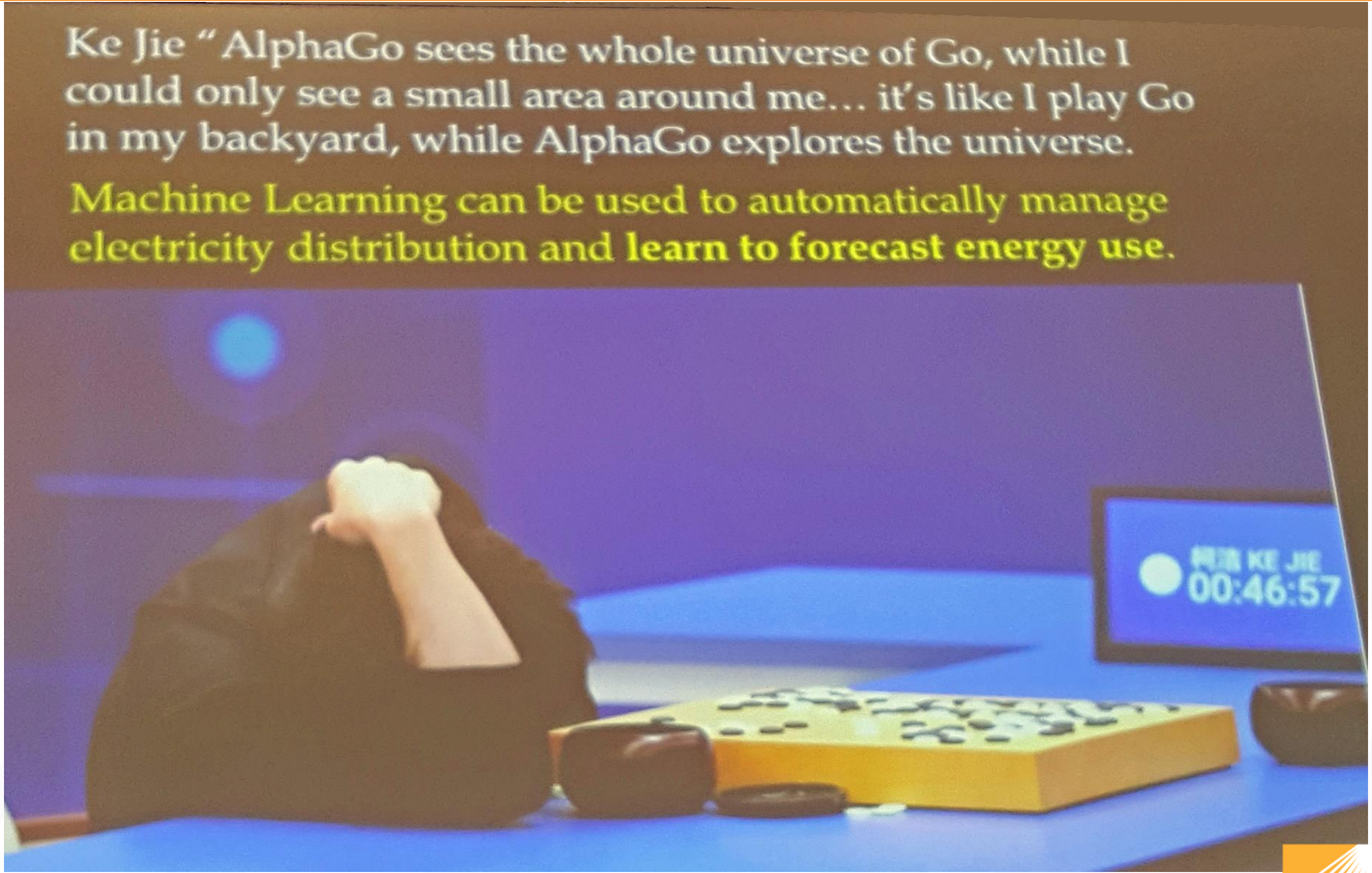


Current PV Power Plant Installations and Potential Grid Upgrades





Role of Artificial Intelligence



Solar Forecasting Gets a Boost from Watson, Accuracy Improved by 30%

- **Solar forecasting** can help utilities and grid operators **better predict solar generation levels** and make it easier to meet consumer electricity demands on a day-to-day basis.

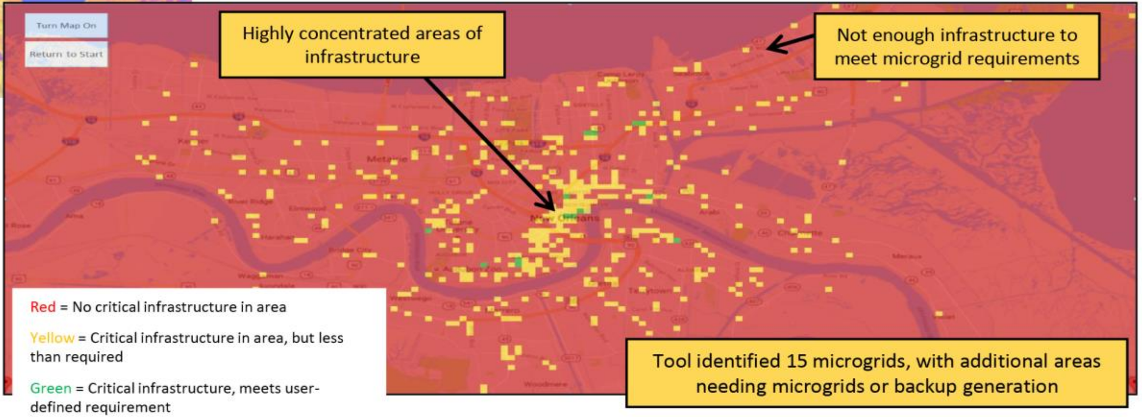
- Using **machine-learning**, the same technology behind the Jeopardy! playing robot Watson, IBM **improved solar forecasting accuracy by as much as 30%.**
- When utilities and grid operators better understand generation patterns, they're able to **maximize solar resources, operate more efficiently**, and **improve solar energy's economic competitiveness**.

Microgrid Resilience Case Example : New Orleans, LA

Leveraging the broad set of capabilities in DHS-sponsored *National Infrastructure Simulation and Analysis Center*

Results of Hurricane Inundation Modeling for New Orleans and surrounding regions

Area size of 1000 ft x 1000 ft | minimum of 4 buildings per microgrid

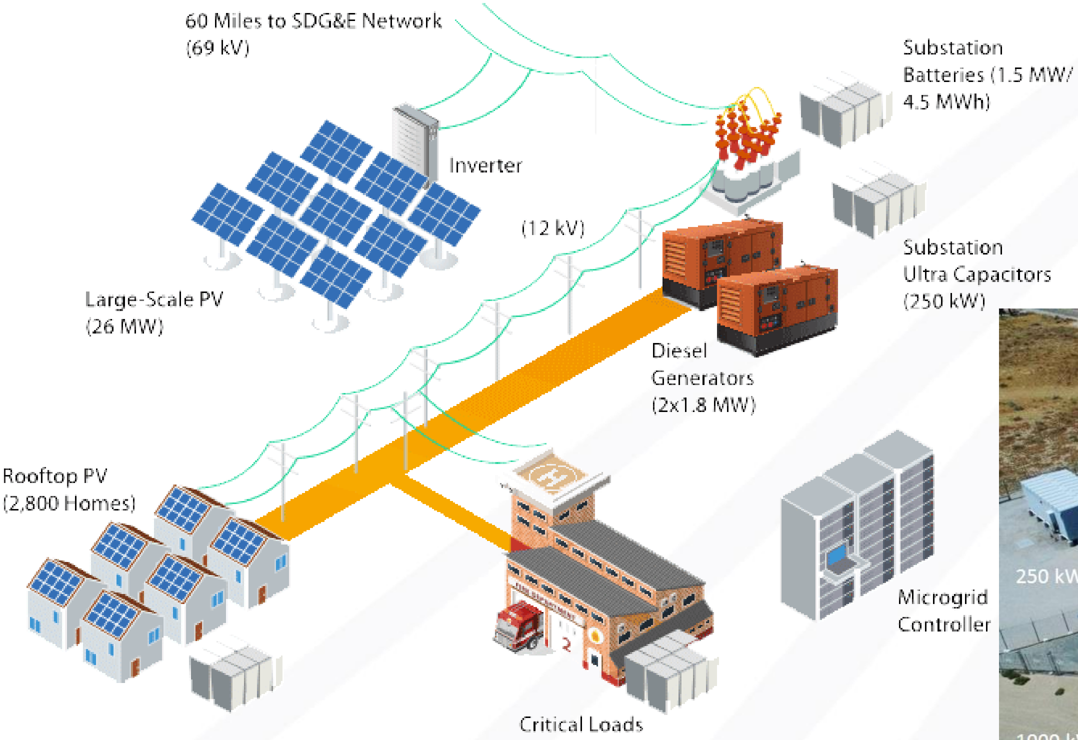


- Applying grid and infrastructure modeling to determine grid investments that will improve community resilience.
- **Resilience metric:** use microgrid designs to maximize the number of people with access to key services during flooding scenarios.

Rural Microgrid Example: Borrego Springs, CA

- 10 hour outage to entire community required to perform compliance-driven transmission maintenance and to replace 2 suspect transmission poles
- Utilized Borrego Springs Microgrid to keep all 2800 customers energized during transmission outage
- Base load was fed by the solar facility, using the batteries and distributed generation to "follow the load"
- Customers experienced a brief 10 minute planned outage to reconnect to the transmission grid

Rural Microgrid Example: Borrego Springs, CA



Technology Challenges

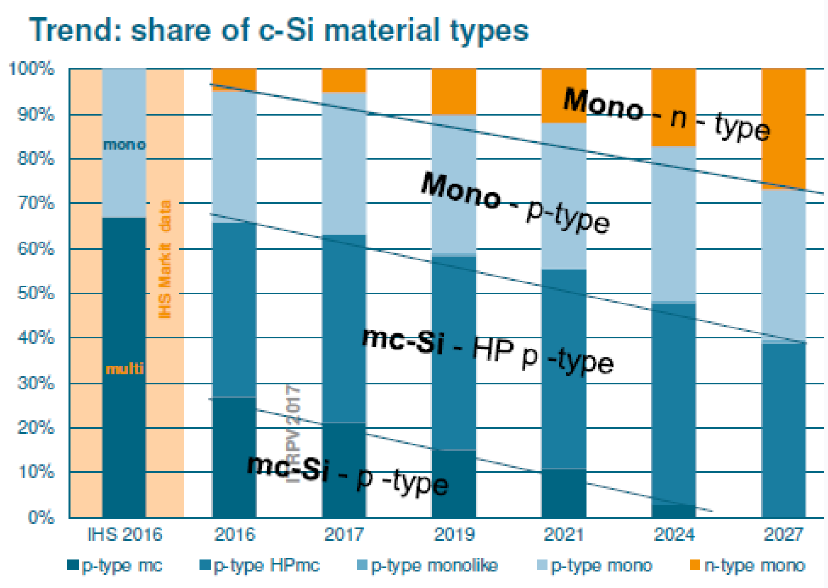
- Continue PV and Wind Cost Reduction (<$0.50/W Utility Scale)
- Increase Overall Energy Use Efficiency
    - Appliance Standards, LED conversion, …
- Demand Management – just-in-time demand control
    - Vehicle to Grid, Thermal Storage, Smart Homes, Smart Communities…
- Develop Firm Renewables
    - CSP with FE/NE via sCO_2, Biomass…
- Develop Flexible Base-load
    - Natural gas with CCS
    - Geothermal
- Strengthen Long Distance Transmission System
- Increase Grid and Generator Flexibility
- Peak Shift (4-8 hour) Storage (<$150/kWh, >85% efficiency)
- Seasonal Storage (2 to 4 months) (<$2/kWh, >40% efficiency)
    - Power to gas
    - Power to liquids

Source: R. Swanson

The market is changing – Our work is far from done

- The PV market is moving from a past driven by material cost reduction to a future driven by efficiency improvement
- Mono PERC from China is driving this transition faster than industry watchers recognize
- Likely to see in 2018 and beyond low eff. Poly-BSF product sold near marginal cost
- Global average pricing (outside US and China) currently in low 30c/Wp range

- To stay competitive, we MUST step up our game



Wide Bandgap Power Electronics Materials

Choices:

Silicon Carbide (SiC)
Gallium Nitride (GaN)
AlN (Aluminum Nitride)
Diamond

Only feasible options before 2030

Benefits:

High Operating Temperature
High Current Density
High Blocking Voltage
Lower Specific Resistance

Issues:

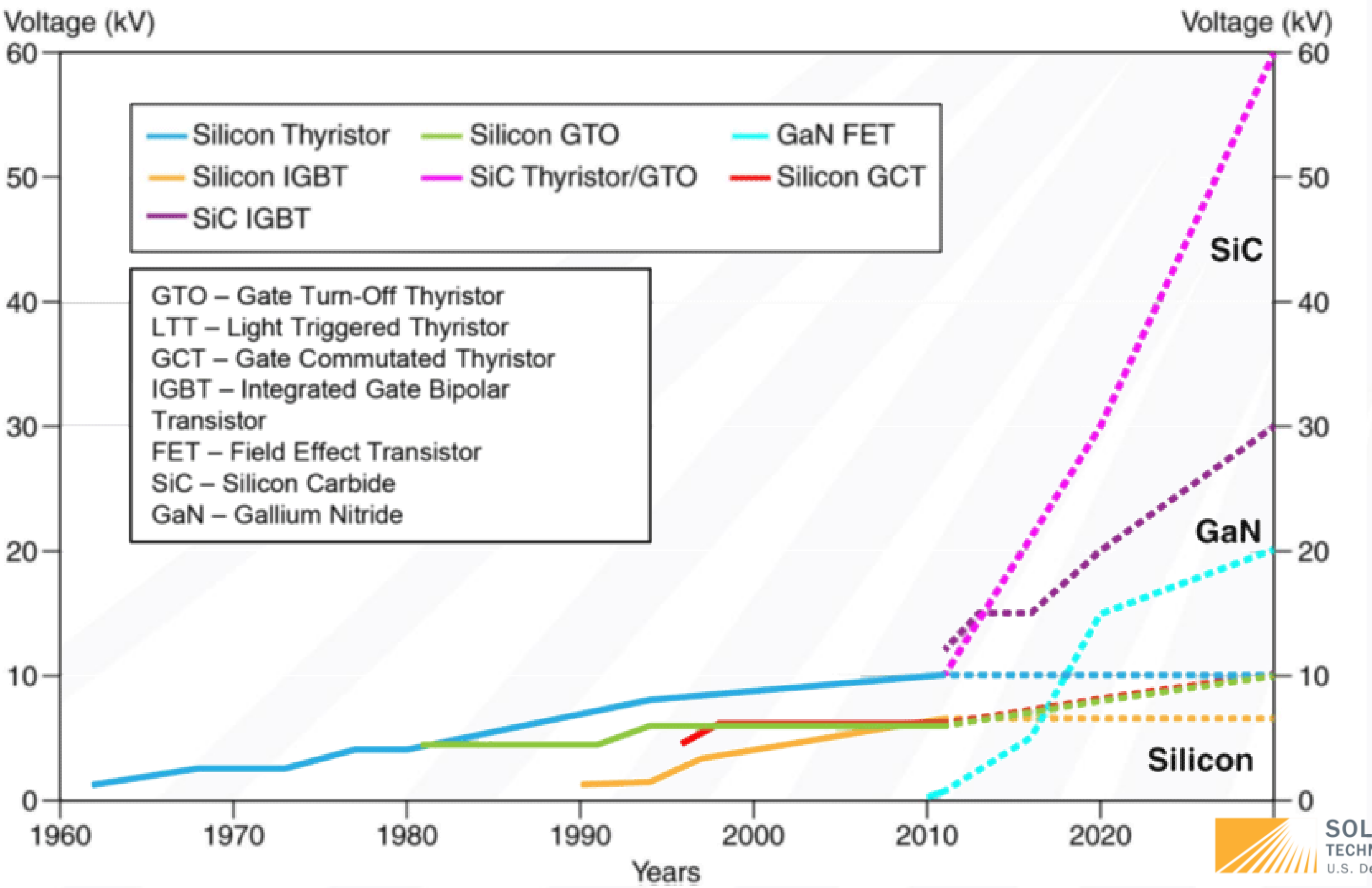
Defects in the material
Lower voltage and current levels
Less experience & Lower reliability
Higher Cost of material

Needed:

High Voltage & High Current (High Power) & Reliable Devices

Source: R. Swanson

Wide Bandgap Power Electronics Devices



SOLAR ENERGY TECHNOLOGIES OFFICE
U.S. Department Of Energy

Power to Gas and Fuels

P2G (elec to synthetic methane & back to elec):

electric energy → electrolyzer (gives H_2 + O_2)

→ Sabatier reactor ($4H_2 + CO_2 \rightarrow CH_4 + 2H_2O$)

→ back to electricity (and/or heat) via OCGT, CCGT, CHP

→ chain efficiency ~ from 25% (OCGT) to 50% (CHP)

P2H_2 (elec to hydrogen & back to elec):

electric energy → electrolyzer (gives H_2 + O_2)

→ back to electricity (and/or heat) via Fuel cells (FC) – PEM or SOFC

→ chain efficiency ~ from 30% (elec only and small) ... 70% (CHP)

Lousy efficiencies if valuable electricity as input; but interesting if cheap electric energy is available in the market

National Laboratory Role

Basic science

The foundation of technology innovation requires resources, depth, and specialized expertise that industry can’t maintain alone

Radical and disruptive concepts (high risk, high reward)

R&D beyond the limited time horizon of industry players

Independent validation to reduce perceived risk

Testing and evaluations

Well designed technical standards

R&D and Validation addressing system constraints to adoption

Projects showing that perceived integration risks can be addressed

Policy and Regulatory Opportunities

- Wholesale market reform to allow:
    - o Expand ISO service territories as much as practical
    - o Proper valuation of flexible base-load generators
    - o Proper valuation for renewable curtailment
    - o Maintain utility capability to operate and maintain T&D
- Utility regulatory reform:
    - o Outcome versus cost of service
    - o Innovative business models
    - o Properly incentivize transmission investment
    - o Streamline transmission approval process
- Business Model Reform:
    - o Regulated utilities become platform providers
    - o Improve process for IOU to municipal utility conversion

Source: R. Swanson

SETO's role

Early-Stage Research Investments

- PV, CSP, and grid integration R&D with a history of commercial impact
- Pre-competitive R&D, typically 10-20 years from the market, is beyond the private-sector horizon

Mid-Stage Development Investments

- Topics include reliability and open-access performance data not addressed by the private sector
- Public-private partnerships to support the next generation of innovative solar products

Energy System Planning

- In-depth technical studies and modeling solar's impact on the national grid
- Unique facilities for RD&D at the national laboratories (e.g.the Energy Systems Integration Facility)

Regional/National Scope Technical Analysis

- National labs provide tools and trusted, impartial information
- Leadership in data standardization and best practices

Expanding Consumer Choice

- Efforts to streamline solar deployment taking root with co-ops and utilities
- Programmatic efforts to expand household solar access to all Americans

SETO Team

Becca Jones-Albertus, Ph.D.
Deputy Director

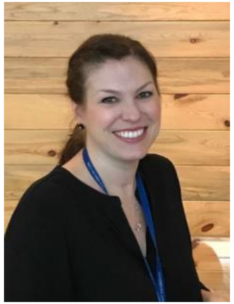
Elaine Ulrich, Ph.D.
Special Projects

Golden Field Office Staff

Diana Bobo, Contracting Officer

Sara Wilson
Supervisor

Pamela Brodie, Contracting Officer



Paige Smith
Grants Specialist

Clay Pfrangle
Grants Specialist

Eddie Campbell, Grants Specialist (not pictured)

Fania Barwick
Grants Specialist/TPO

Liz Parrish
Grants Specialist

SETO Operations Staff

Ebony Vauss,
Operations Supervisor

Meisha Baylor

Jamal Ferguson

Emily Marchetti

SETO Communications Staff

Susanna Murley,
Communications Lead

Jen Bristol

Greg O'Brien

Dawn Washelesky

SETO Faces Not in Yesterday’s Slides

Michele Boyd

Kemal Çelik

Tassos Golnas

Jeremiah Miller

Thomas Rueckert