SOLAR ENERGY
TECHNOLOGIES OFFICE
U.S. Department Of Energy

Solar Forecasting II

The Solar Energy Technologies Office

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Director
12 July 2018

Solar Energy Technologies Office Staff

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Systems Integration
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Concentrating Solar Power
Dr. Avi Shultz,
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Photovoltaics
Dr. Lenny Tinker,
Program Manager

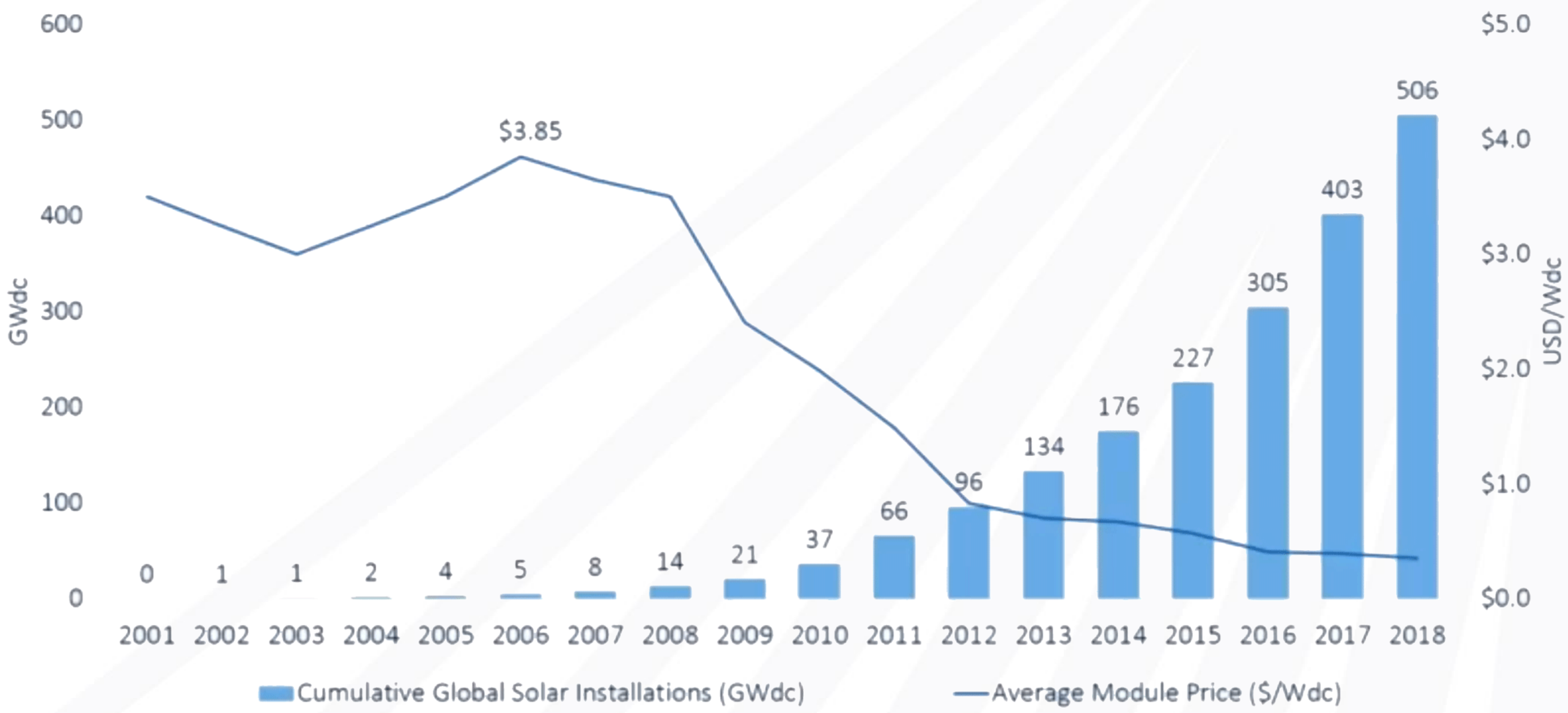
Technology to Market
Garrett Nilsen, Program Manager

Balance of Systems (Analytics /Soft Costs)
Garrett Nilsen, Program Manager (Acting)

Budget Details

EERE Funding Table by Subprogram (FY 2018 Structure)		
($ Thousands)	FY 2017	FY 2018
Solar Energy Technologies	**207,600**	**241,600**
Photovoltaic Research and Development	64,000	70,000
Balance of Systems Soft Cost Reduction	15,000	11,000
Concentrating Solar Power	55,000	55,000
Systems Integration	57,000	71,200
Innovations in Manufacturing Competitiveness	16,600	34,400

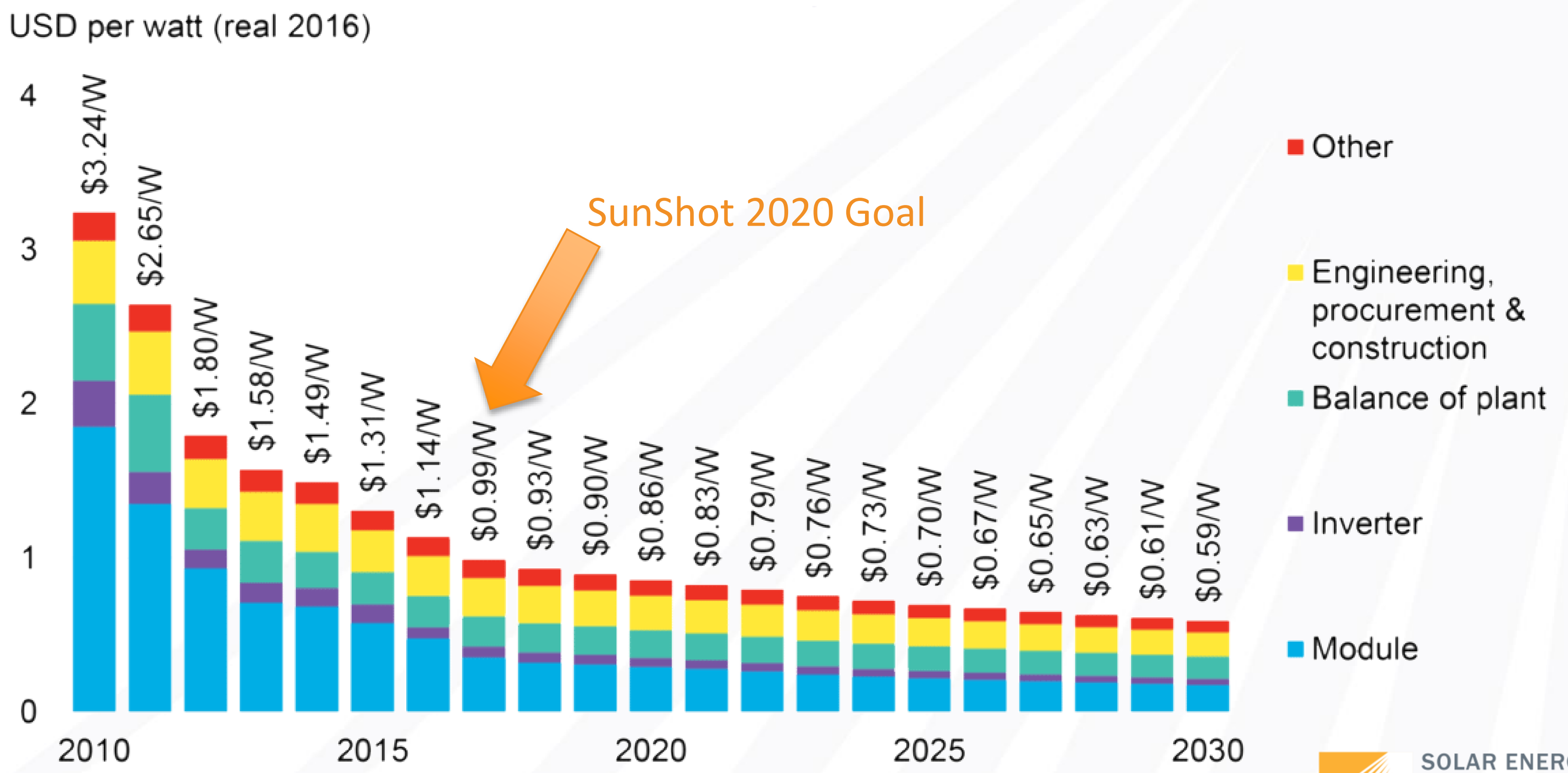
Cumulative Global PV Installations (GW) and Average Module Price ($/W)



Source: GTM

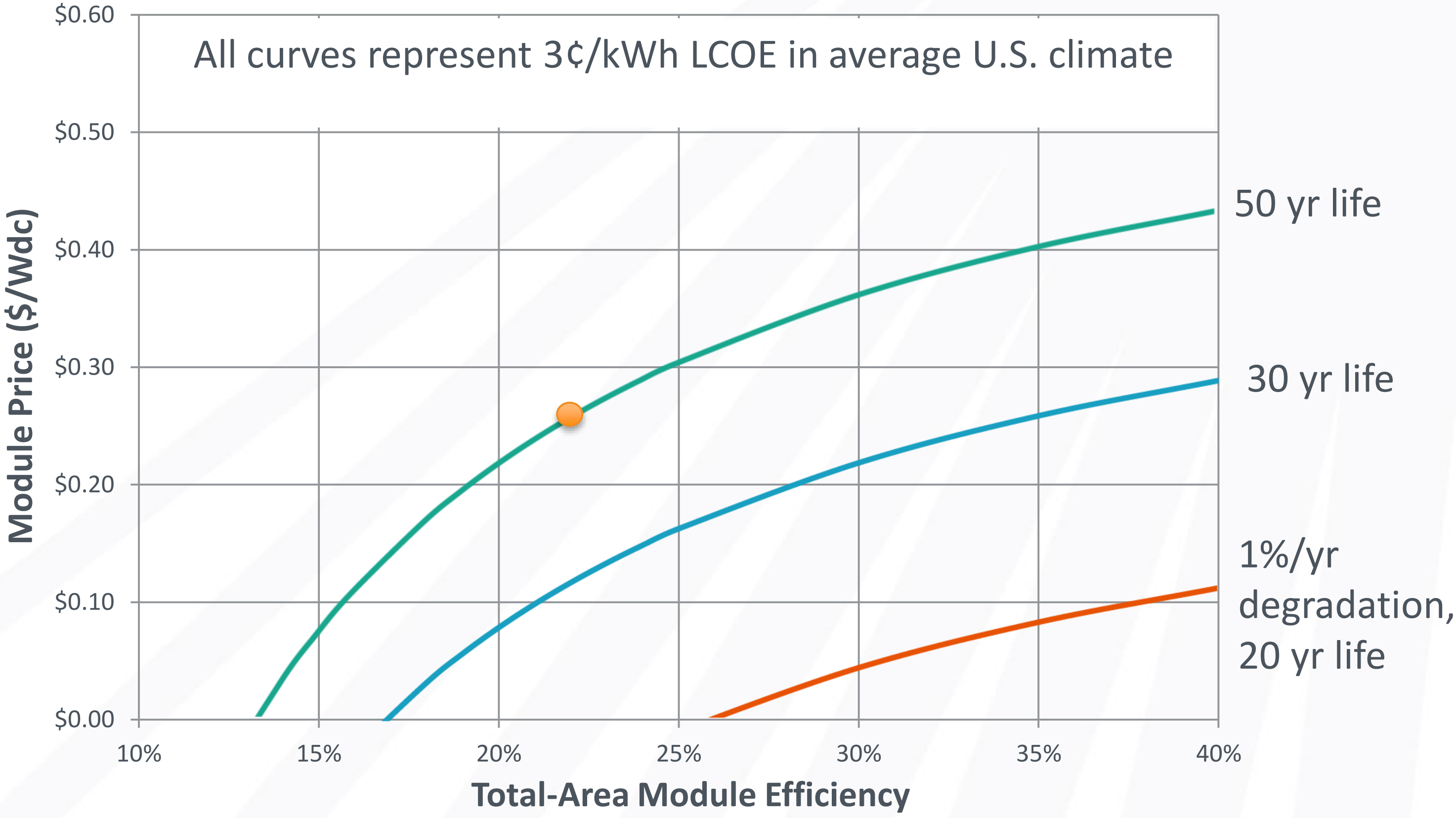
World’s Largest Thin Film PV Plant
550 MW
Riverside County, CA

Global price benchmark for fixed-axis PV power plants



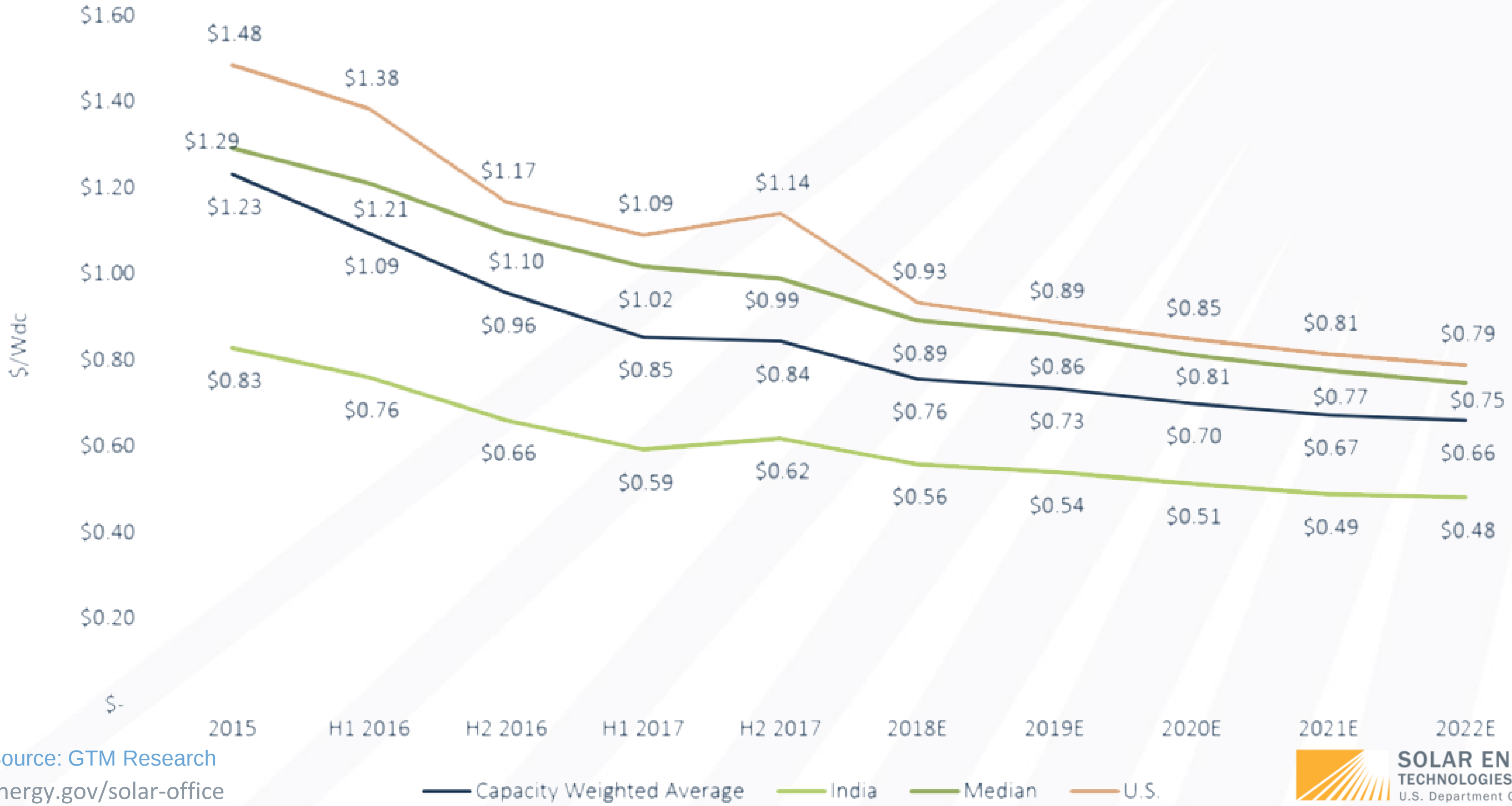
There are Many Technology Pathways to $0.03/kWh

- Cost and performance tradeoffs open up numerous pathways.
- All pathways require sustained, multifaceted innovation.



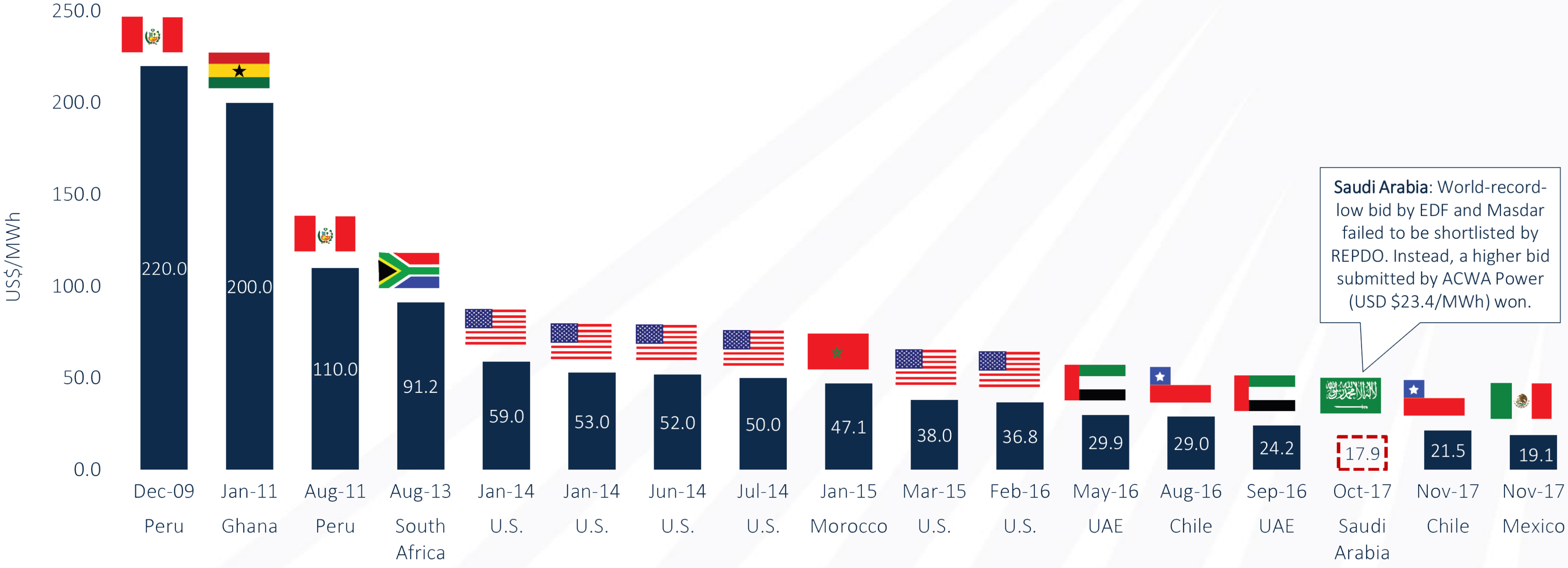
Scenarios assume: 7% WACC, 2.5% inflation, $4/kW-yr O&M, 21% capacity factor

Utility Scale Global Capacity Weighted Average, Global Median, U.S. & India, 2015-2022E



Source: GTM Research

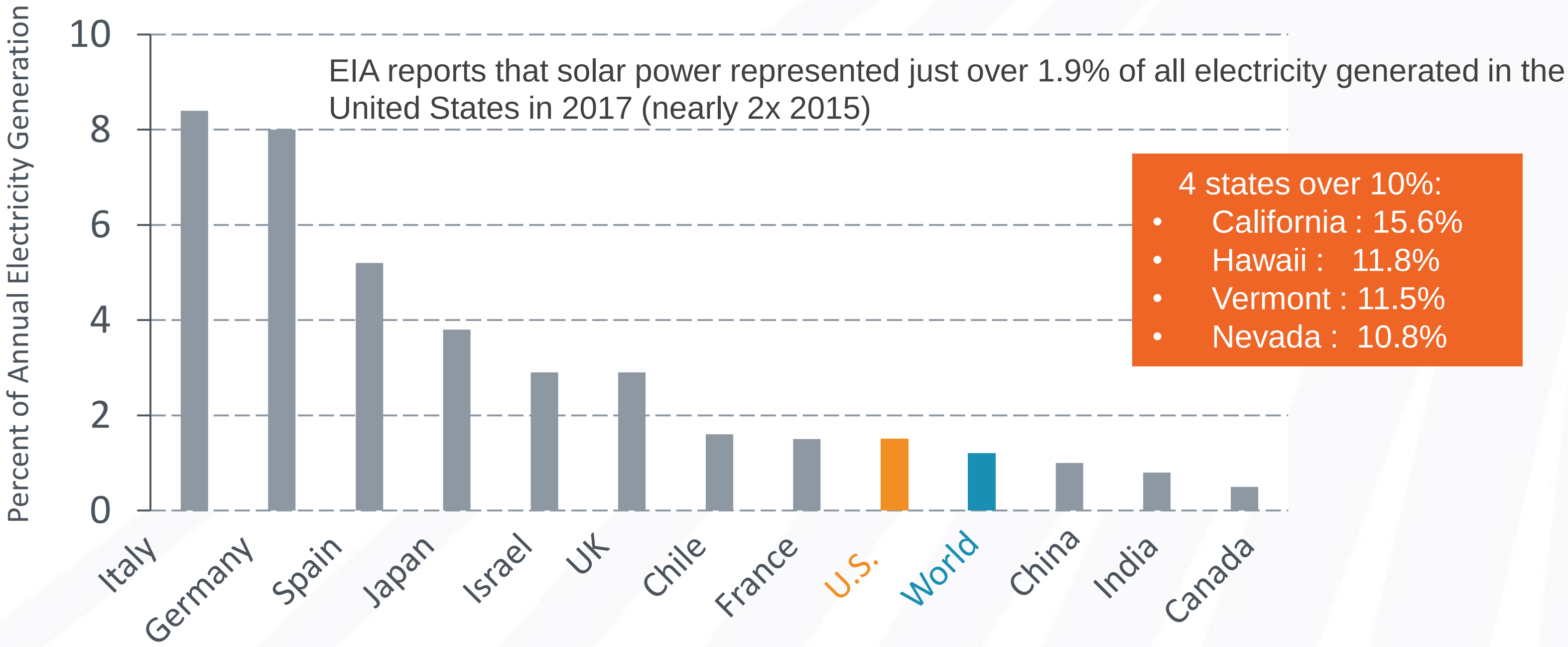
Record-Low PPA Prices for Utility-Scale Solar



Source: GTM

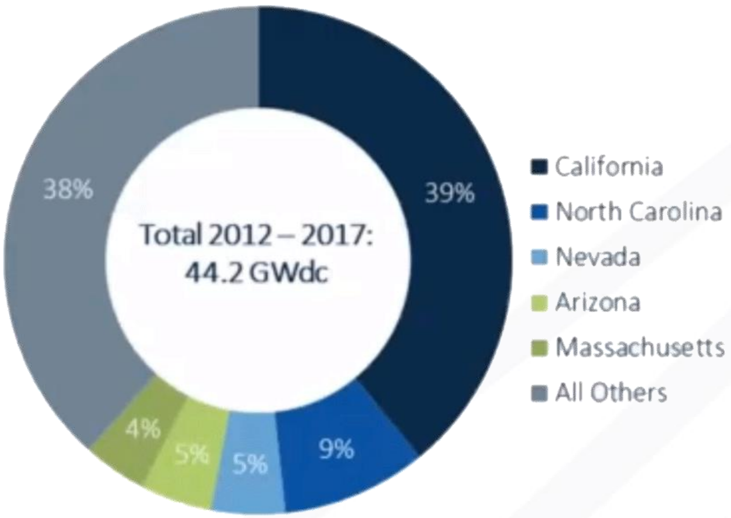
Solar Supplies Nearly 2% of U.S. Electricity

Further progress must be made to expand this domestic energy resource and to globally compete.

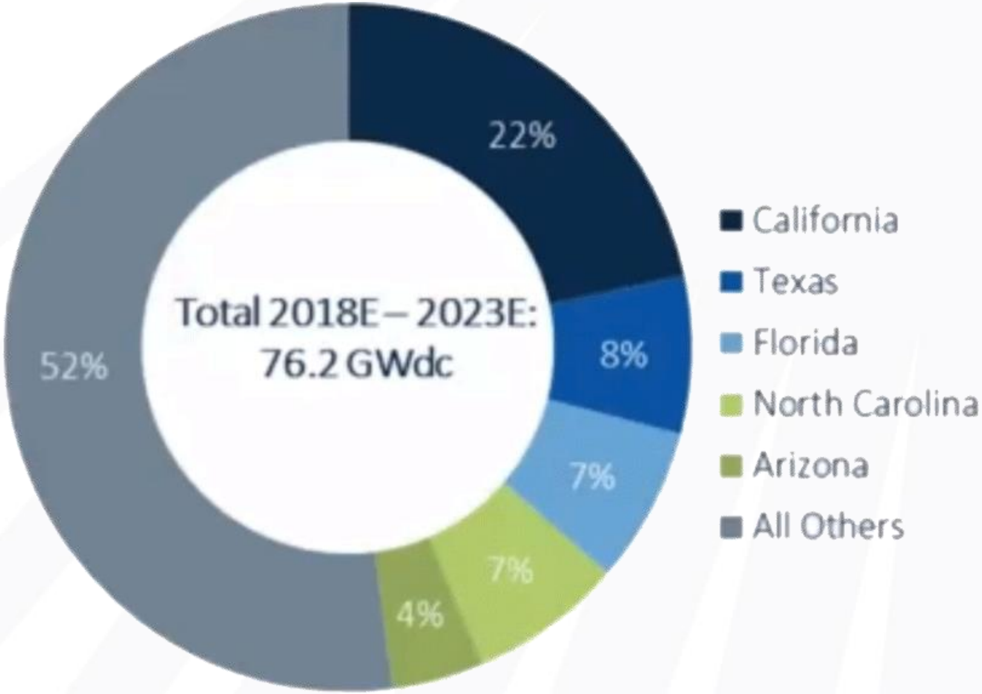


Sources: International Energy Agency, “2015 Snapshot of Global Photovoltaic Markets”; “Solar Thermal Electricity Global Outlook 2016”; National Renewable Energy Laboratory, “U.S. Solar Photovoltaic System Cost Benchmark: Q1 2017”.

The U.S. Market is Moving Beyond California



Past

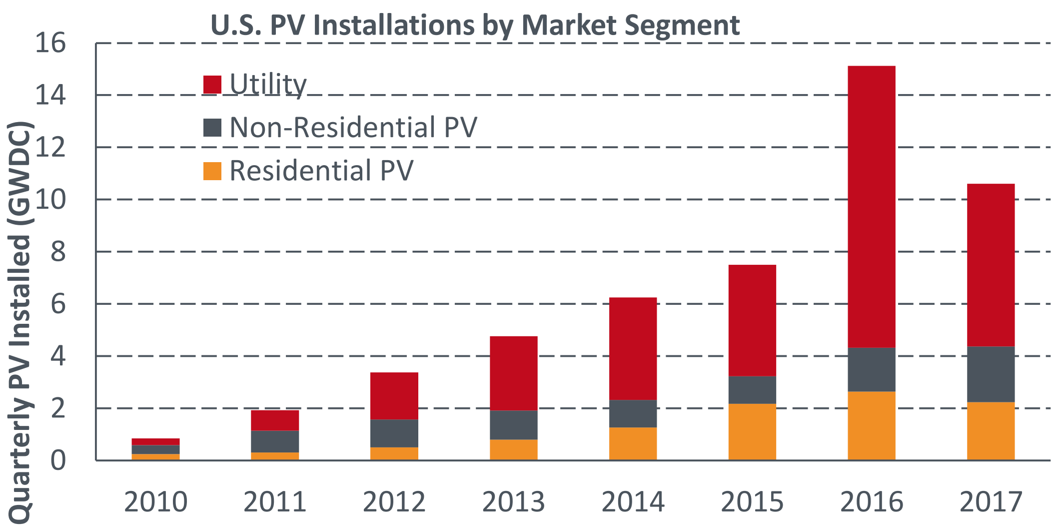


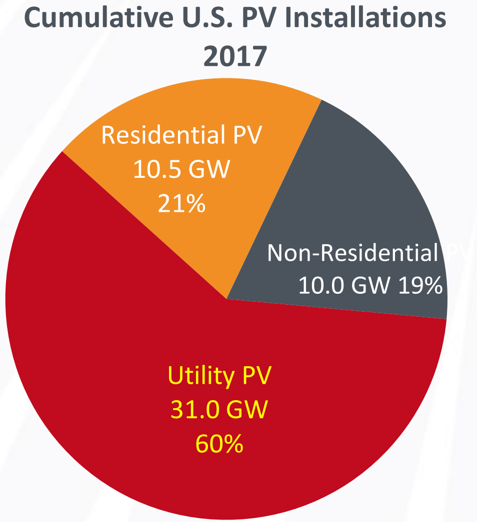
Projected

Source: SEIA/GTM

U.S. Installation Breakdown

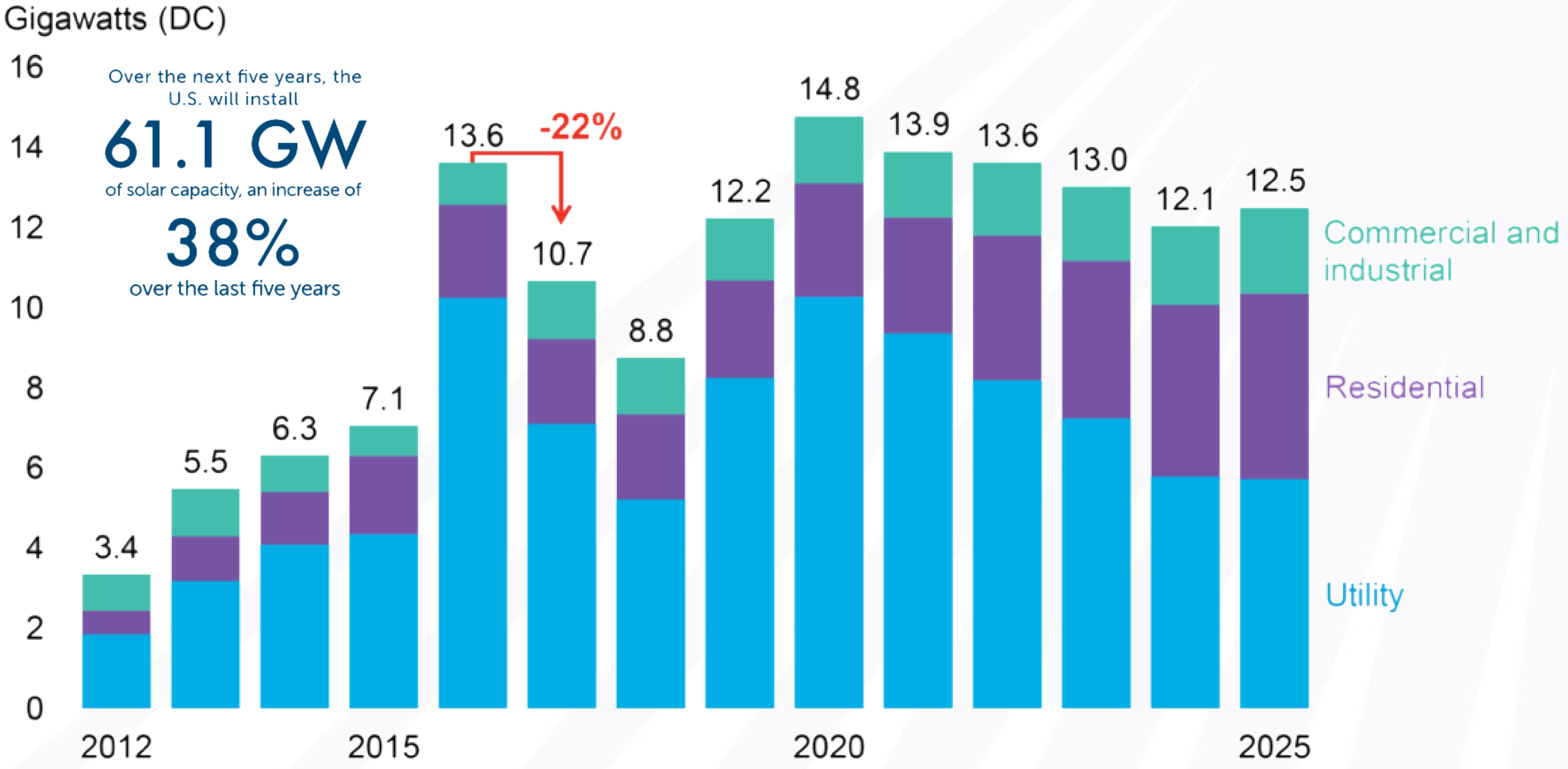
- At the end of 2017 the U.S. had installed approximately 53 GW of PV installations, 60% of which were utility-scale.





Sources: GTM Research/SEIA: U.S. Solar Market Insight Q4 2017.

U.S. Market by Segment

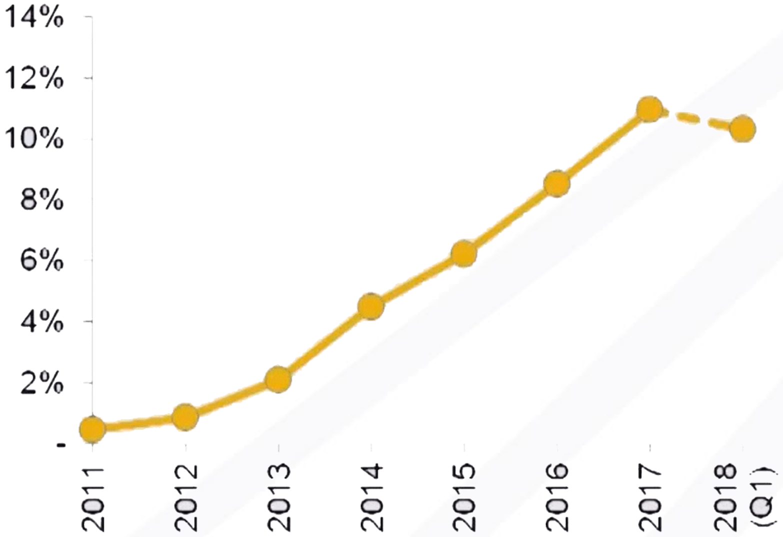


Source: Bloomberg New Energy Finance (2H 2017 U.S. Renewable Energy Market Outlook)

Challenges : Curtailment

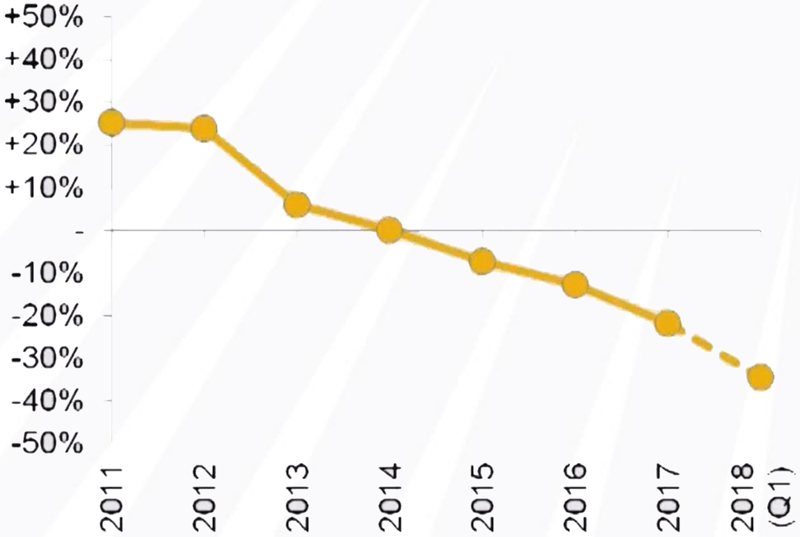
California Independent System Operator Data

Solar penetration (% of generation)



Includes utility-scale solar only. Does not include behind-the-meter.

Realized price scalar (% of ATC)



Measured against Day-Ahead, SP15 power prices.

Grid Operational Challenges

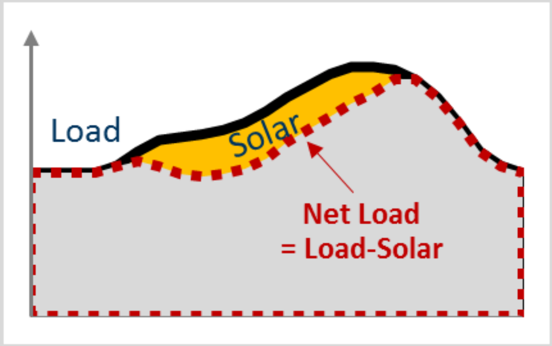
Distributed Energy Resources
Net Energy Metering
Renewable Portfolio Standards
Variable and Uncertain Generation
Fast Ramping Requirements
Distributed Storage
Community Solar
Community Choice Aggregators
Need for Flexibility
Autonomous Microgrids
Grid Defection
Self-Generation

Stagnant or Declining Demand
Aging Infrastructure
Negative ISO Clearing Prices
Physical and Cyber Threats
Transmission Right-of-Way Access
Confusion among Regulators
Confusion among Investors
Electric Vehicle Loads
Carbon Tax ?
Retail Choice
Virtual Power Plants
Reduced Grid Inertia

Flexible & Dispatchable Solar … Key to Market Expansion & Value Retention

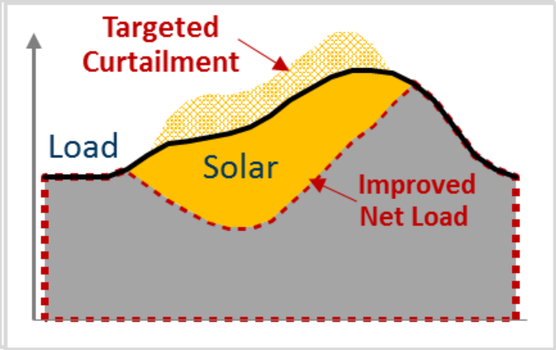
Solar 1.0: Traditional

- Solar is part of mid-day load offsets peak or near-peak demand
- **Energy-Only Value**



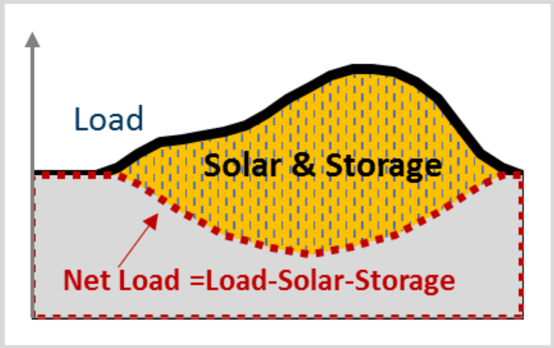
Solar 2.0: Dispatchable

- Solar mitigates value erosion through plant controls
- Adds **Grid Reliability Services & Flexibility** Value



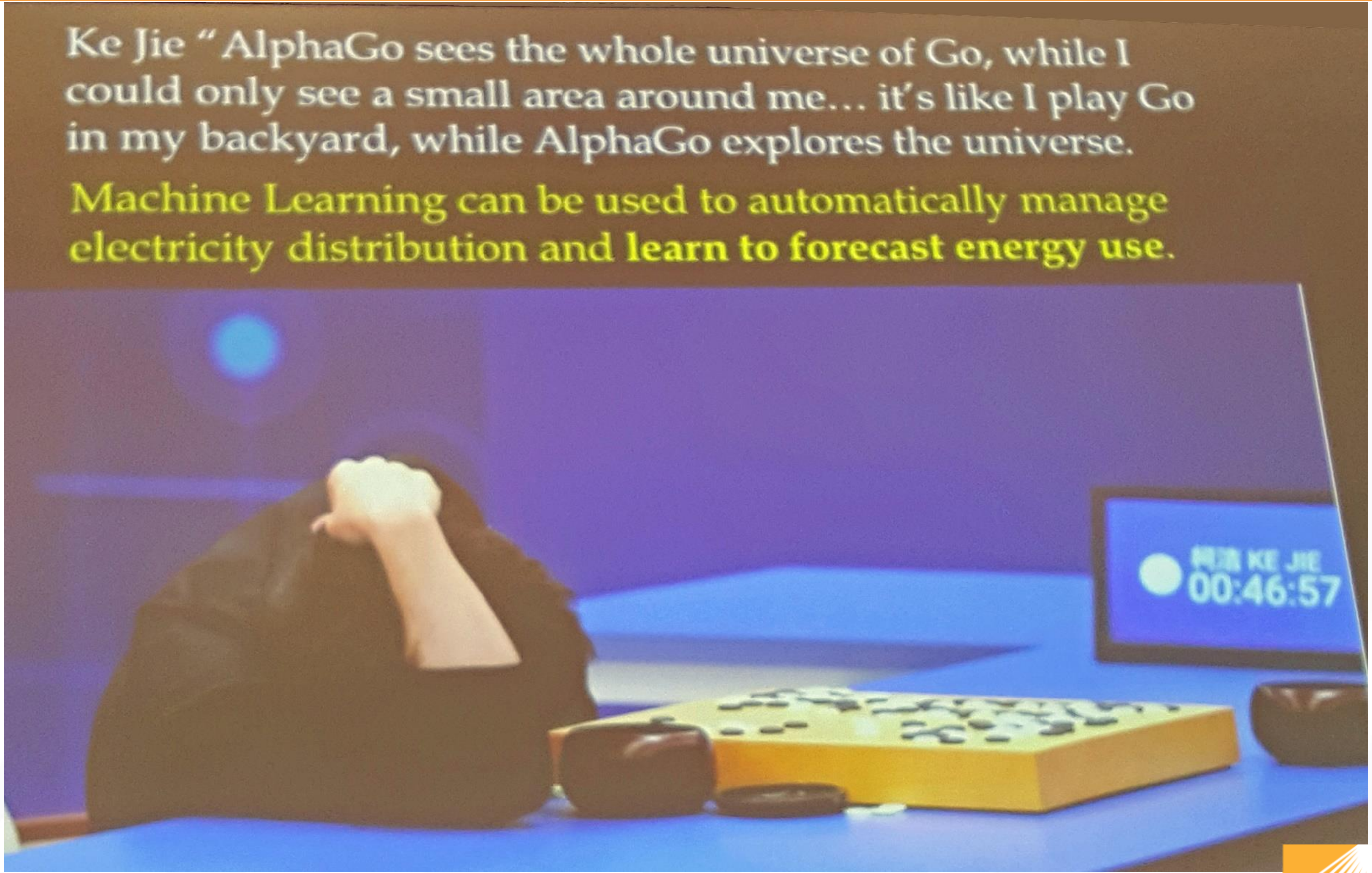
Solar 3.0: Fully Dispatchable

- Storage (hours, not days) time-shifts solar - dispatchable
- Adds **Firm Generation Capacity** Value

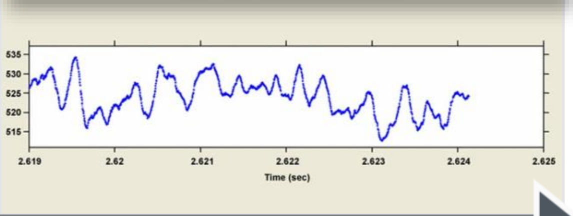
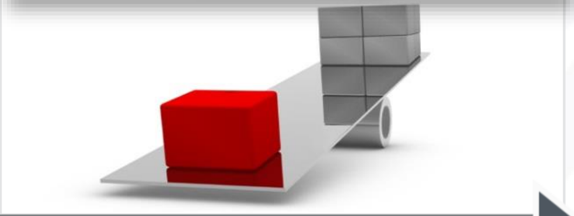


Source: First Solar

Role of Artificial Intelligence



Key Topics –PV Impact on Power Grid & Best Practices

Grid Controls	Scheduling	Power Systems Planning & Design
		
Milliseconds to Minutes	Hours to Days	Years

- Add **Grid Controls** to Support Reliability & Grid Security

- Integrate **forecasting** into daily operation
- Update **operating procedures** - balancing area, frequent updates, ramping support

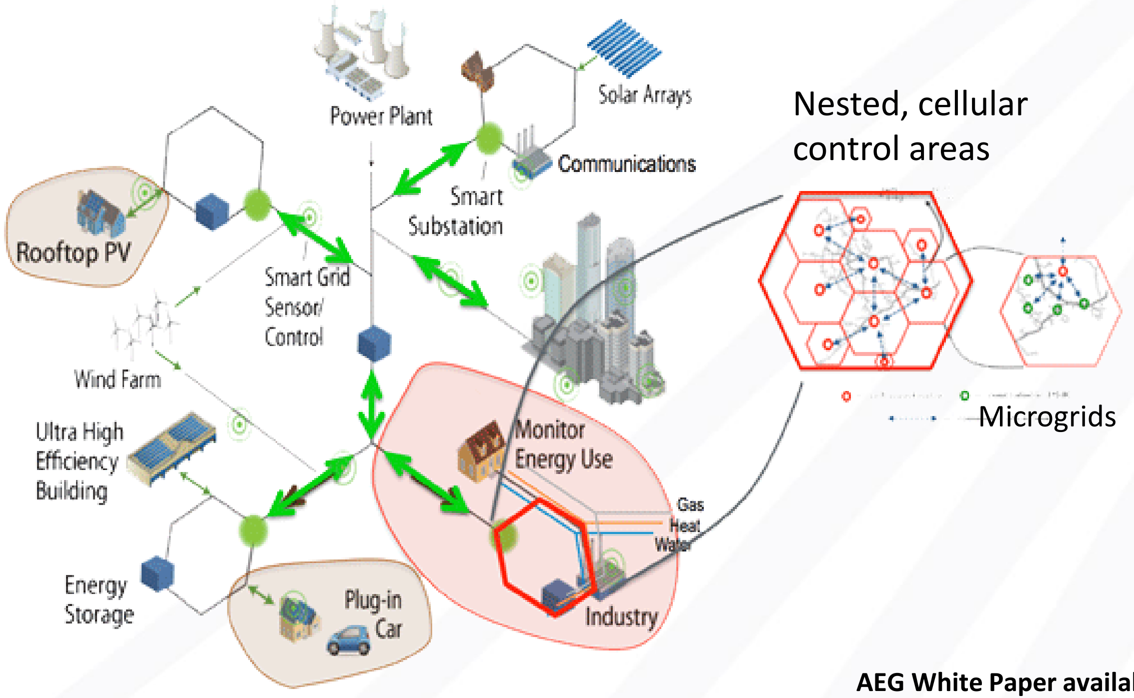
- Adopt **diverse resource** portfolio to reduce risks and increase grid flexibility

Source: First Solar

Autonomous Energy Grids (AEGs)

Optimized for secure, resilient and economic operations

Central-station based Grid



Key Features of AEGs

- **Autonomous** – Makes decisions without operators
- **Resilient** – Self-reconfiguring, cellular building blocks, able to operate with and without communications
- **Secure** – Incorporates cyber and physical security against threats
- **Reliable and Affordable** - Self optimizes for both economics and reliability
- **Flexible** – Able to accommodate energy in all forms including variable renewables

AEG White Paper available at:
https://www.nrel.gov/docs/fy18osti/68712.pdf