SOLAR ENERGY TECHNOLOGIES OFFICE
U.S. Department Of Energy

PORTFOLIO REVIEW 2018

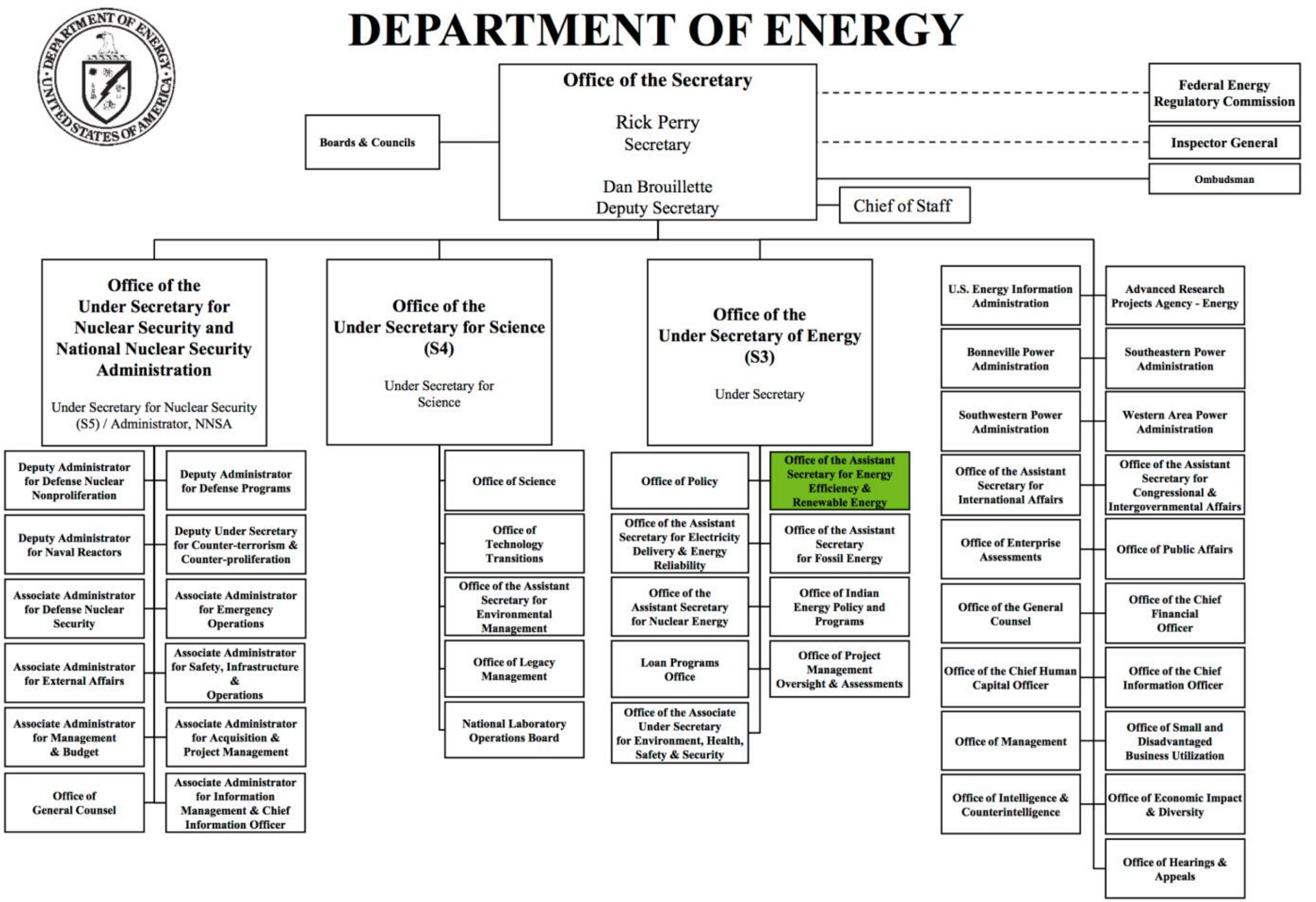
SOLAR ENERGY
TECHNOLOGIES OFFICE
U.S. Department Of Energy

2018 SETO Portfolio Review

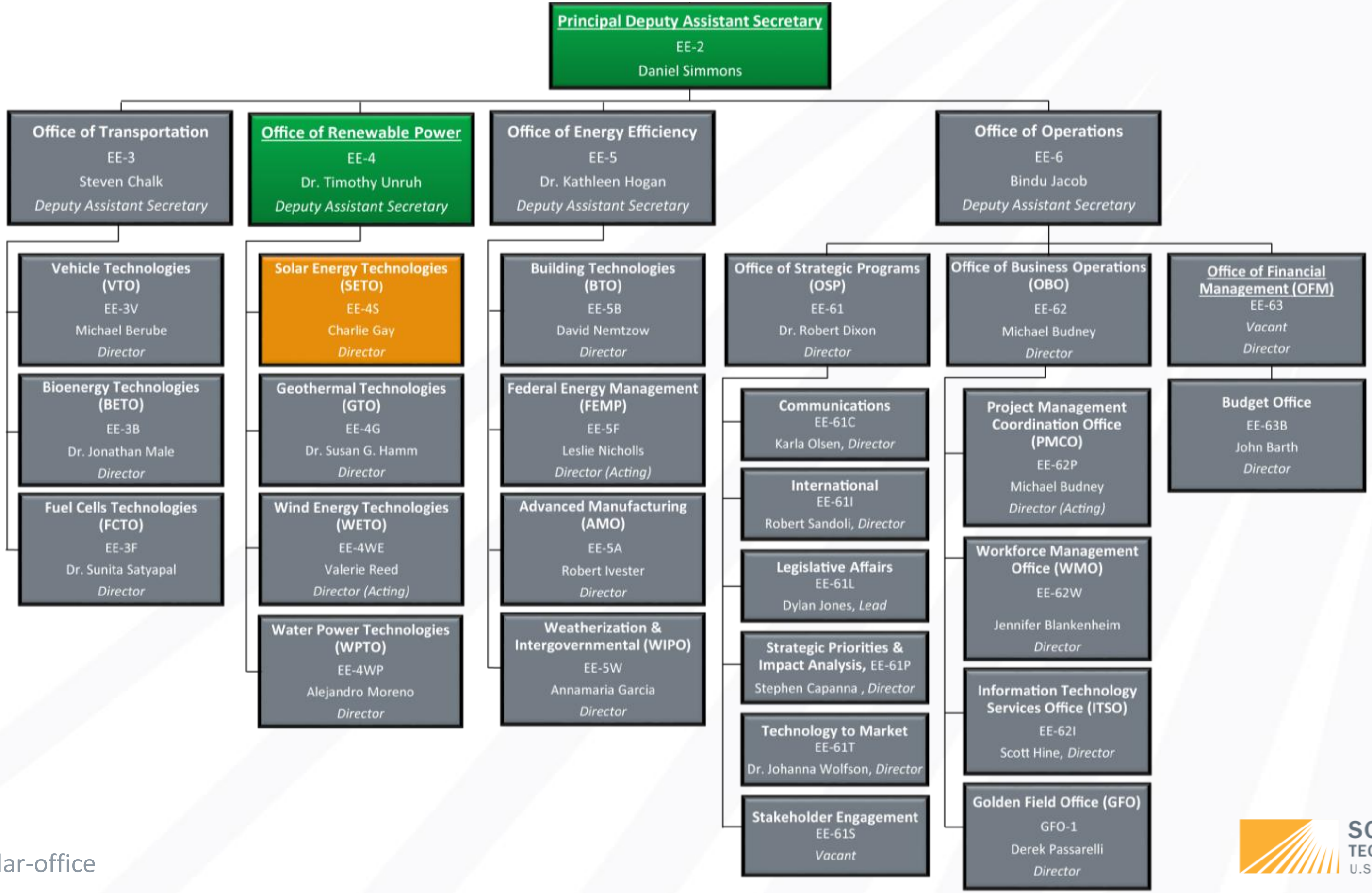
2018 Solar Energy Technologies Office
Portfolio Review Day 1 Keynote

Dr. Charlie Gay
Director, Solar Energy Technologies Office

Department of Energy Organization Chart



Energy Efficiency and Renewable Energy Org Chart



Solar Energy Technologies Office (SETO) SubPrograms and Project Managers

Concentrating Solar Power
Dr. Avi Shultz,
Program Manager (Acting)

Photovoltaics
Dr. Lenny Tinker,
Program Manager

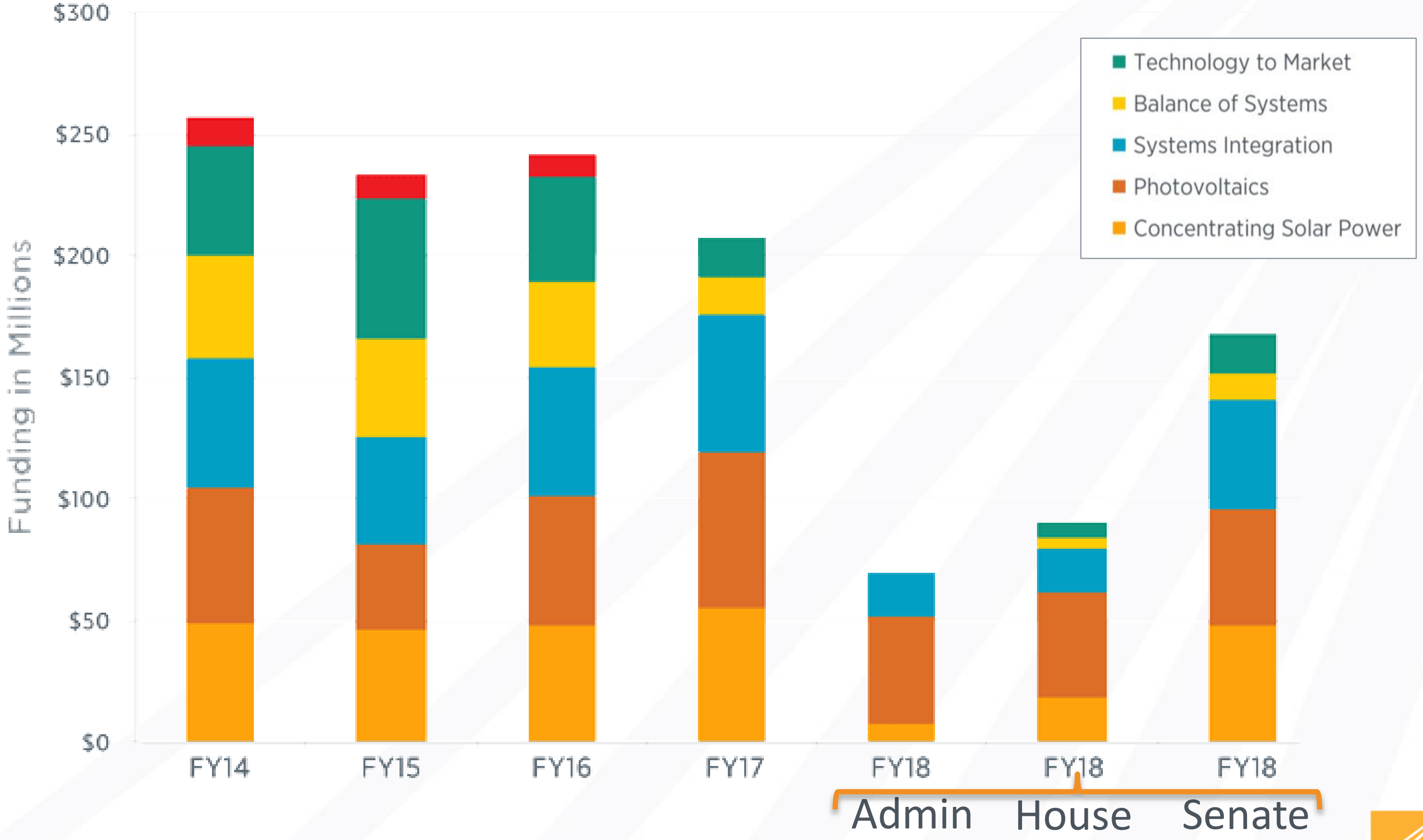
Systems Integration
Dr. Guohui Yuan,
Program Manager

Technology to Market
Garrett Nilsen, Program Manager

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

Solar Energy Technologies Office Staff

SETO Historical Funding and Range for FY 2018

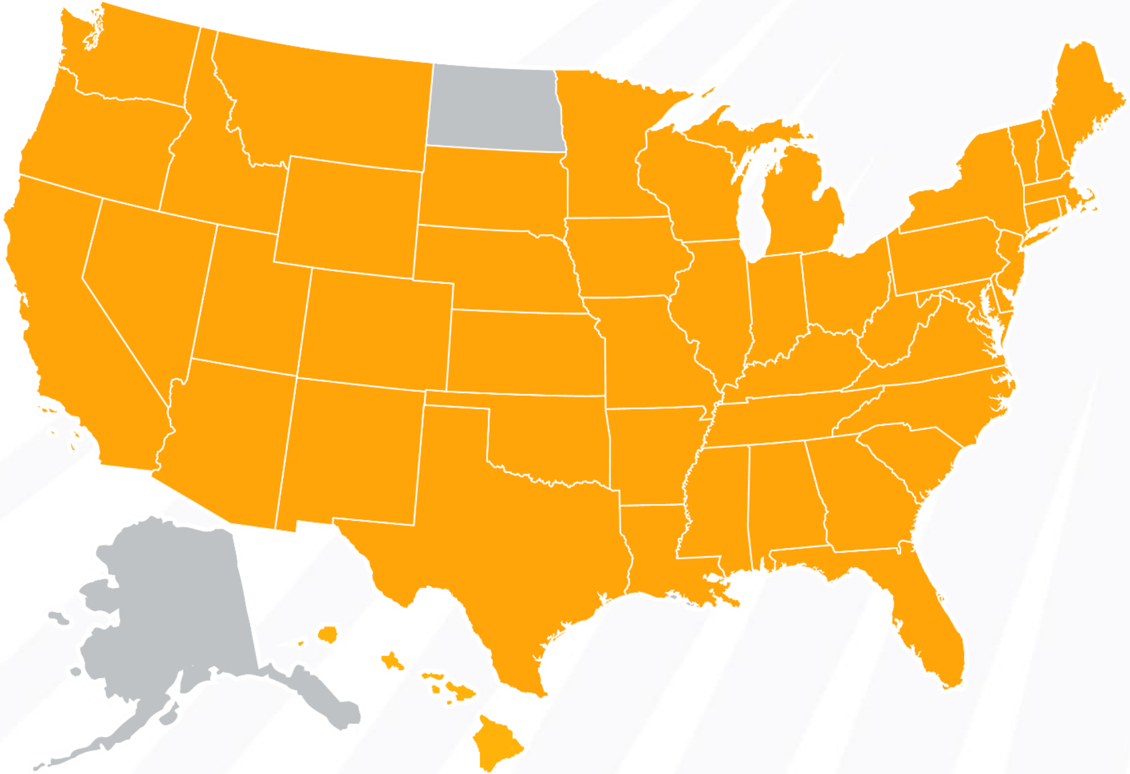


SETO Funds Innovation Across the Country

Projects and partners in

48 states plus the

District of Columbia



70% of projects at **national labs & universities**

energy.gov/solar-office

Note: SETO has funded past projects in North Dakota and Alaska.

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National Lab Funding in 3 Year Cycles

SETO competitively selects multi-year lab projects on a 3 year cycle, to provide continuity of effort in areas of critical importance to DOE's mission. The call for proposals for the next multi-year funding program is targeted for a November release, to select projects for FY19-21.

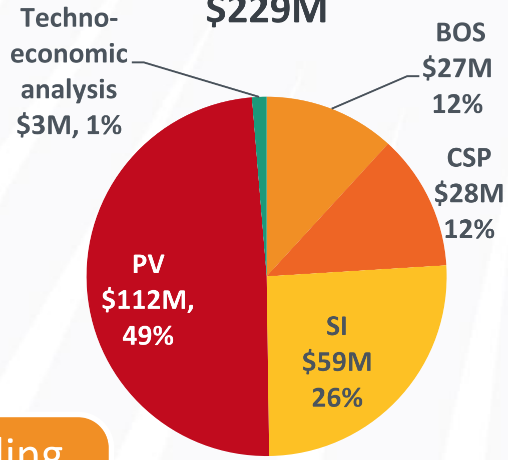
Labs are also involved in FOA projects

Lab Proposal Development Process
FY13-FY15 ($227M*)

SunShot National Laboratory Multiyear Partnership (SuNLaMP)
FY16-FY18 ($229M*)

SETO Multi-year Lab Funding
FY19-FY21 ($120M**)
$45M lab call + $75M in funding for core capabilities

FY16-18 Funding
$229M



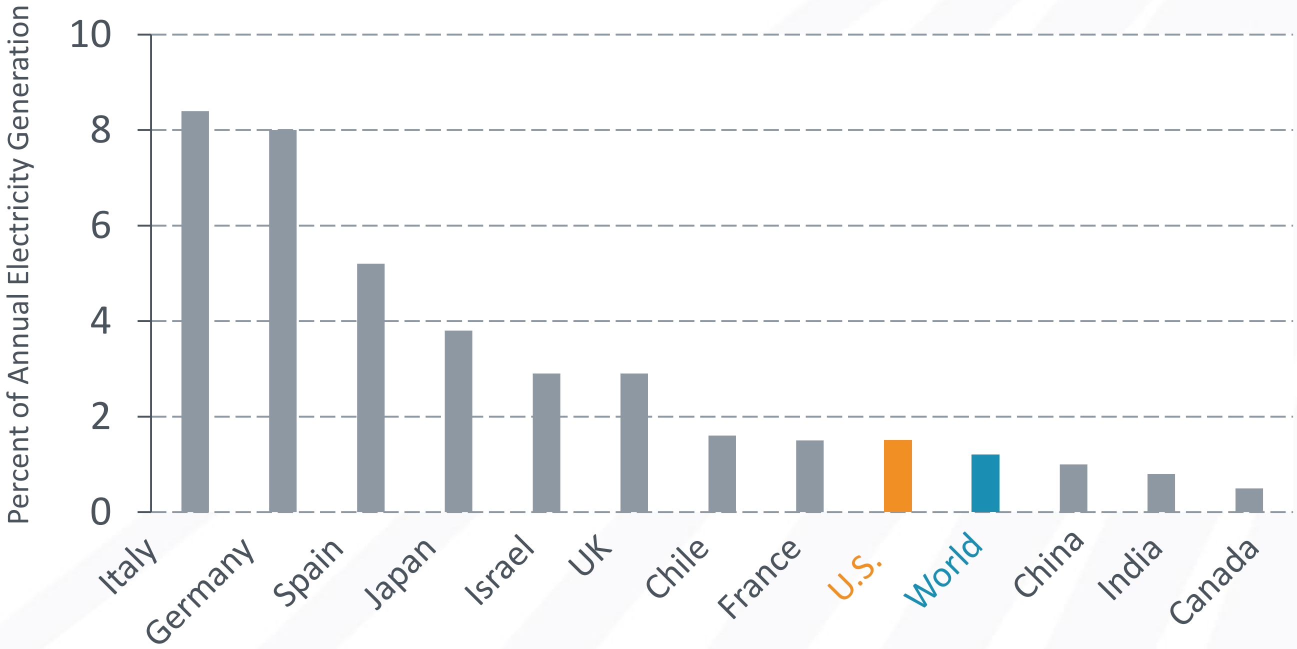
* Includes ~$27M of NREL sitewide funding
** Uses FY19 request level for 3 years

SETO 2017 Highlights

- Announced the solar industry met SunShot's utility-scale solar goal 3 years ahead of schedule, and, as a result of the dramatic progress in cost reduction, SETO is expanding its emphasis on how solar integrates with and supports the grid
- Announced nearly $100M in new funding opportunities and the investment of $80M in more than 60 projects.
- Closed out 112 projects

Solar Supplies Nearly 2% of U.S. Electricity

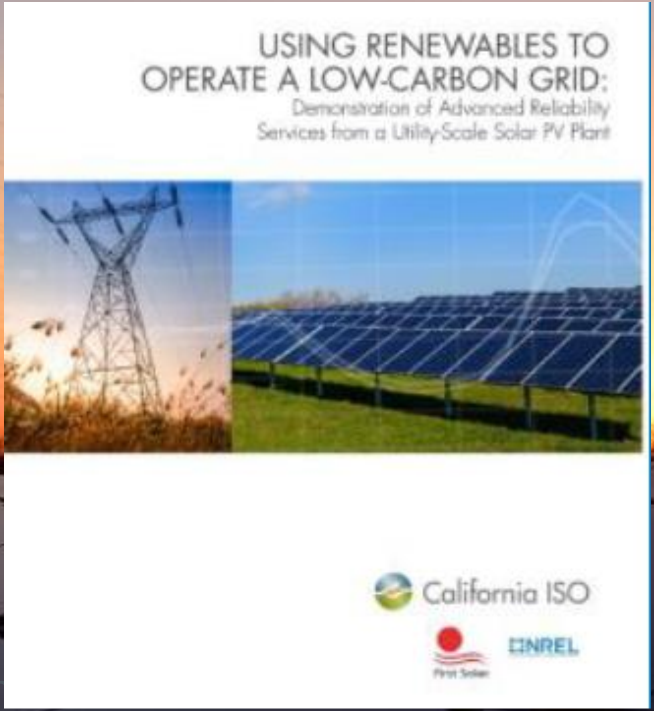
More progress must be made in order to take advantage of this domestic energy resource and to compete in the growing global market.



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”.

Tests Successfully Conducted on 300 MW Solar PV plant

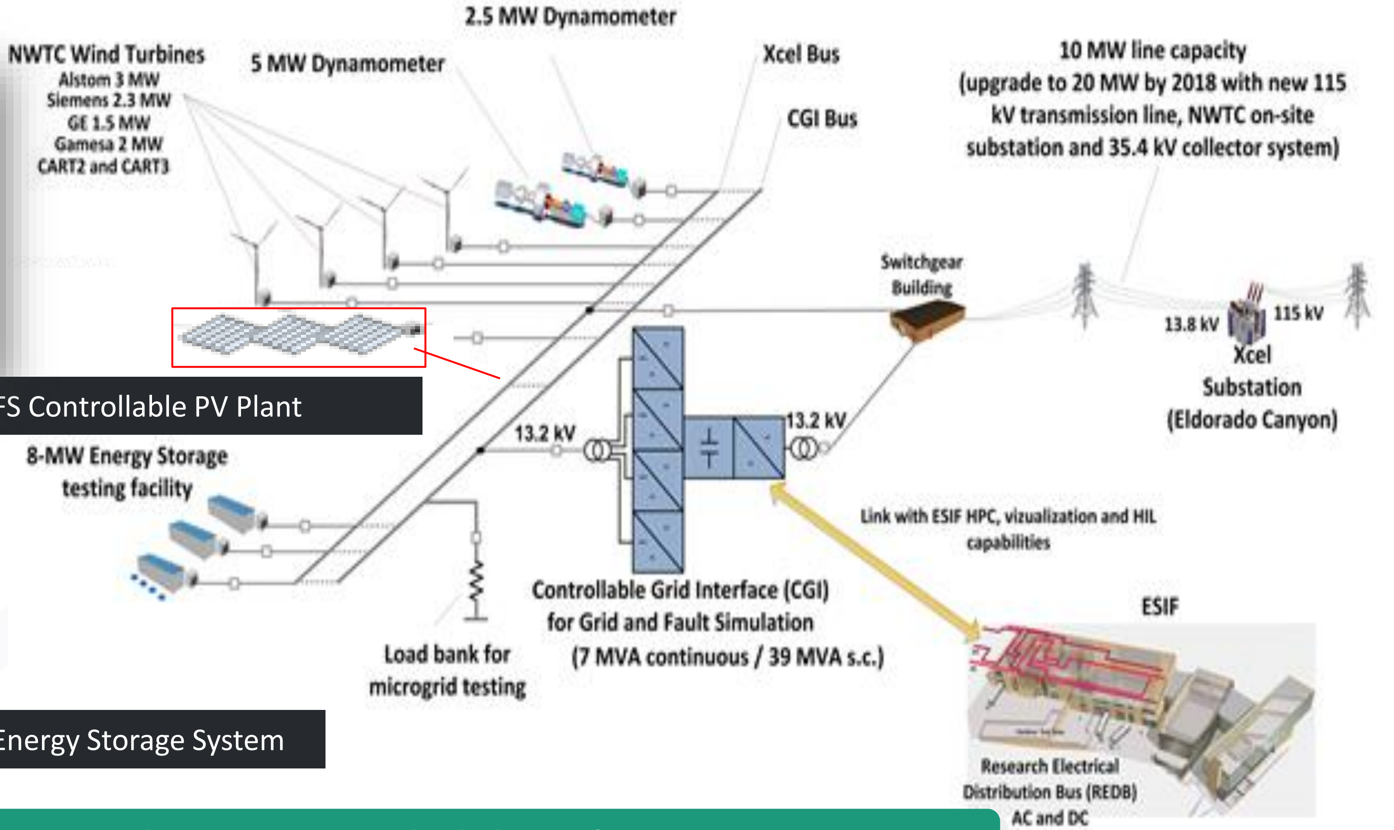
- Power Ramping
  - ✓ Ramp its real-power output at a specified ramp-rate
  - ✓ Provide regulation up/down service
- Voltage Control
  - ✓ Control a specified voltage schedule
  - ✓ Operate at a constant power factor
  - ✓ Produce a constant level of MVAR
  - ✓ Provide controllable reactive support (droop setting)
  - ✓ Provide reactive support at night
- Frequency
  - ✓ Provide frequency response for low frequency & high frequency events
  - ✓ Control the speed of frequency response
  - ✓ Provide fast frequency response to arrest frequency declin



Utility-Scale PV Plant Contributes to Grid Stability & Reliability Like Conventional Generation

NREL/First Solar R&D Program on PV & Storage

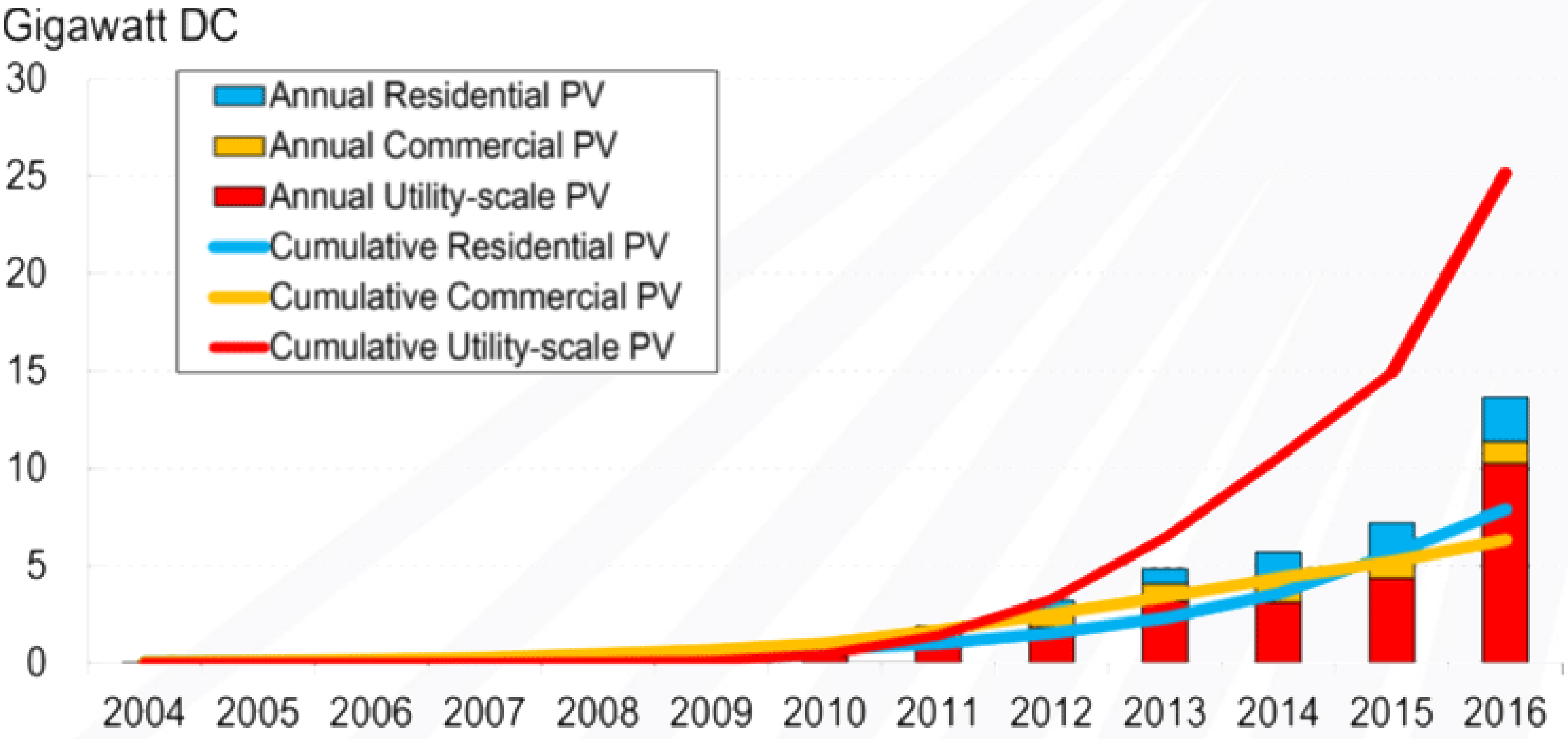
FS Controllable PV Plant



Energy Storage System

Enhance Dispatchability of PV Systems

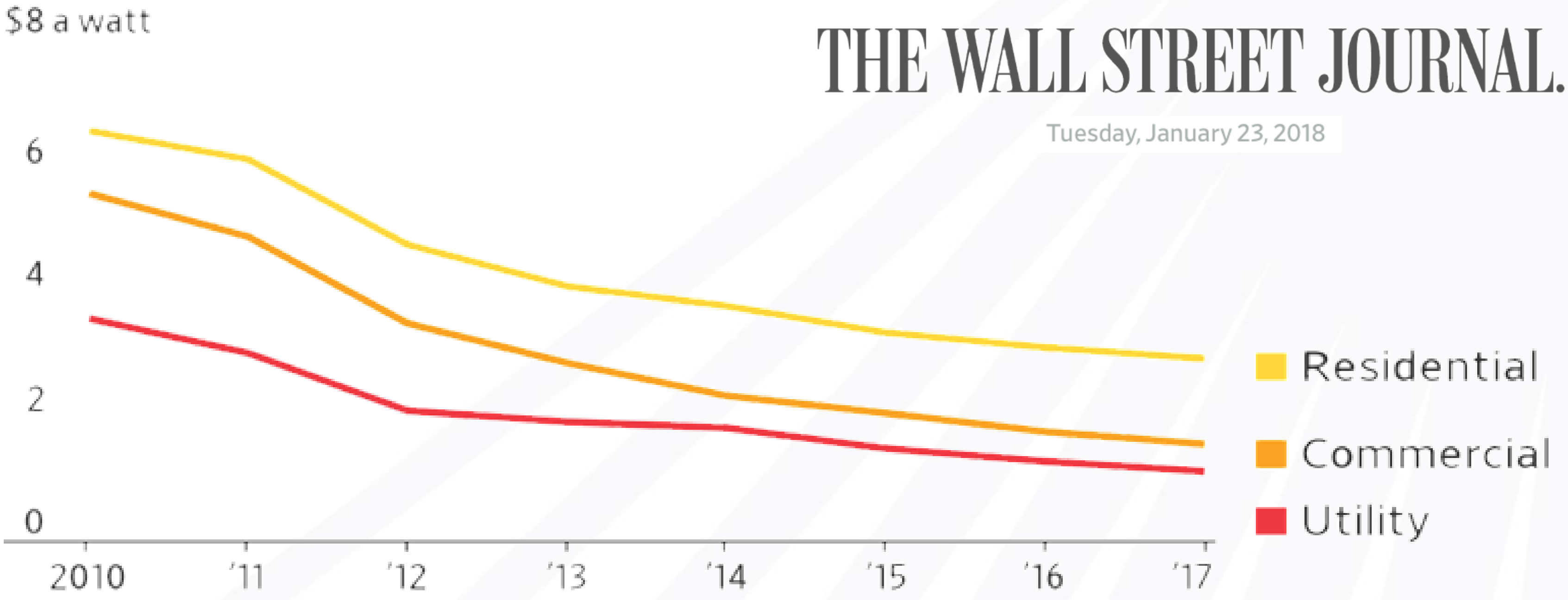
US Solar PV Market Growth



U.S. PV market growth, 2004–2016, in gigawatts of direct-current (DC) capacity (Bloomberg 2017)

Source: NREL/PR-6A20-68580

Average PV System Pricing by Type



Note: 2017 capacity data is estimated

Sources: Solar Energy Industries Association (capacity); GTM Research (pricing and capacity)

The Accelerating Pace of Change

Levelized cost of energy at a couple of the preeminent utility-scale solar sites around the world is going below **3¢/kWh** the SunShot 2030 cost goal

- October 2017: Saudi Arabia's 300 MW PV plant was bid at **1.79¢/kWh**
- September 2016: Abu Dhabi Electricity and Water Authority's 350 MW PV plant accepted a bid from JinkoSolar–Marubeni at **2.42¢/kWh**

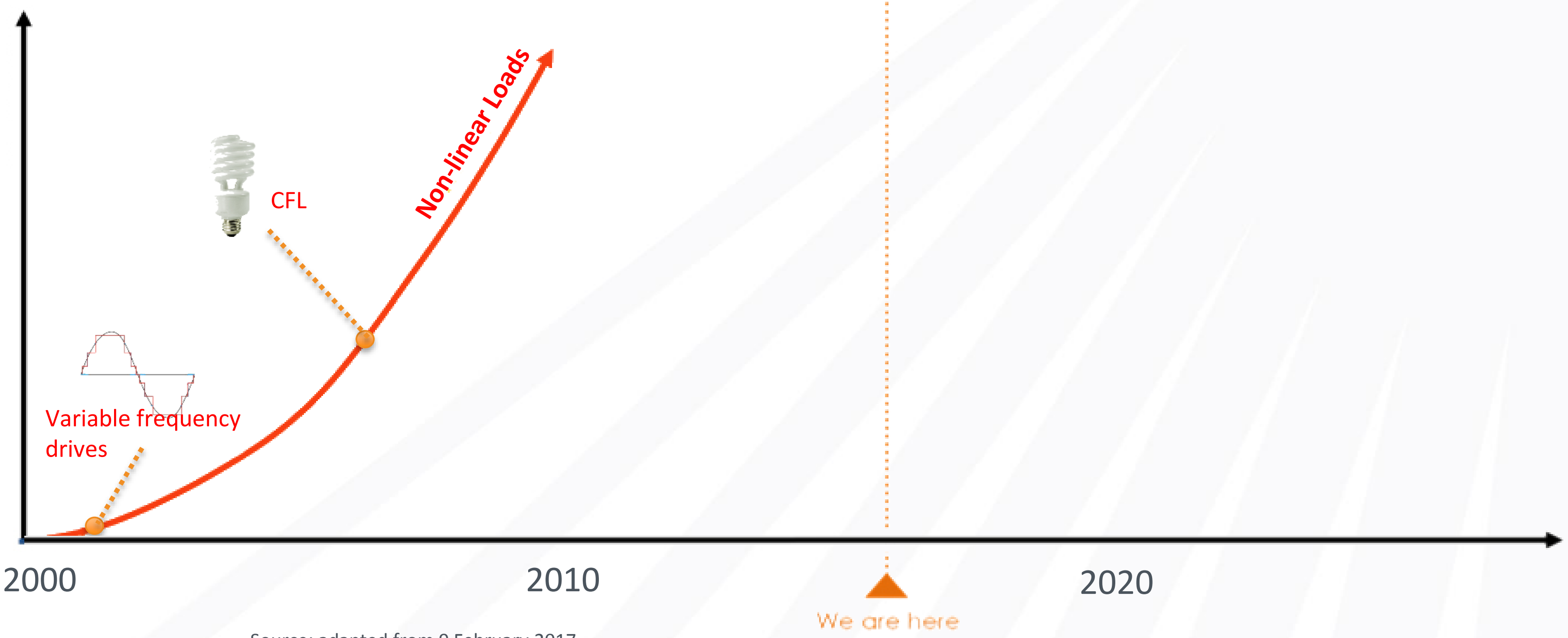
The **full cost of renewable energy** includes:

Backup generation capacity

Enhanced transmission and distribution systems

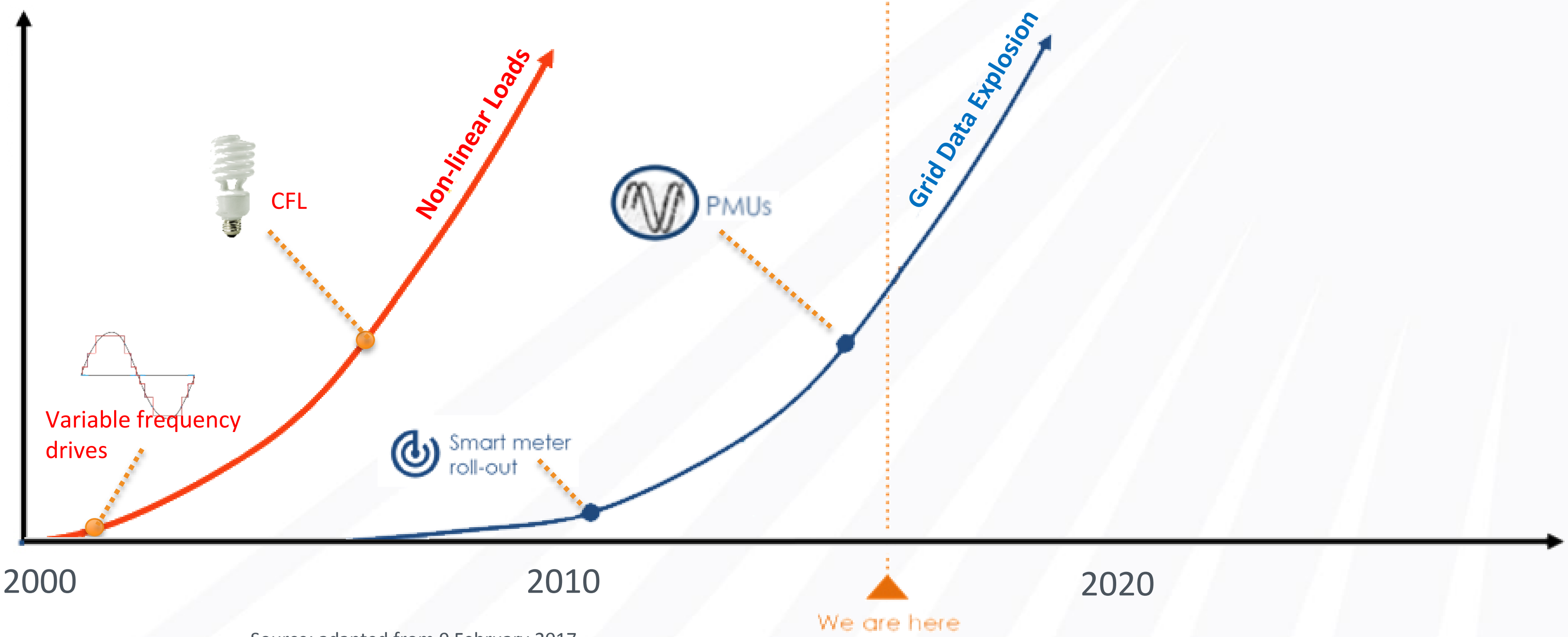
Energy storage

Electricity Mega-Trends



Source: adapted from 9 February 2017
National Association of State Energy Officials
Chandu Visweswariah, IBM

Electricity Mega-Trends



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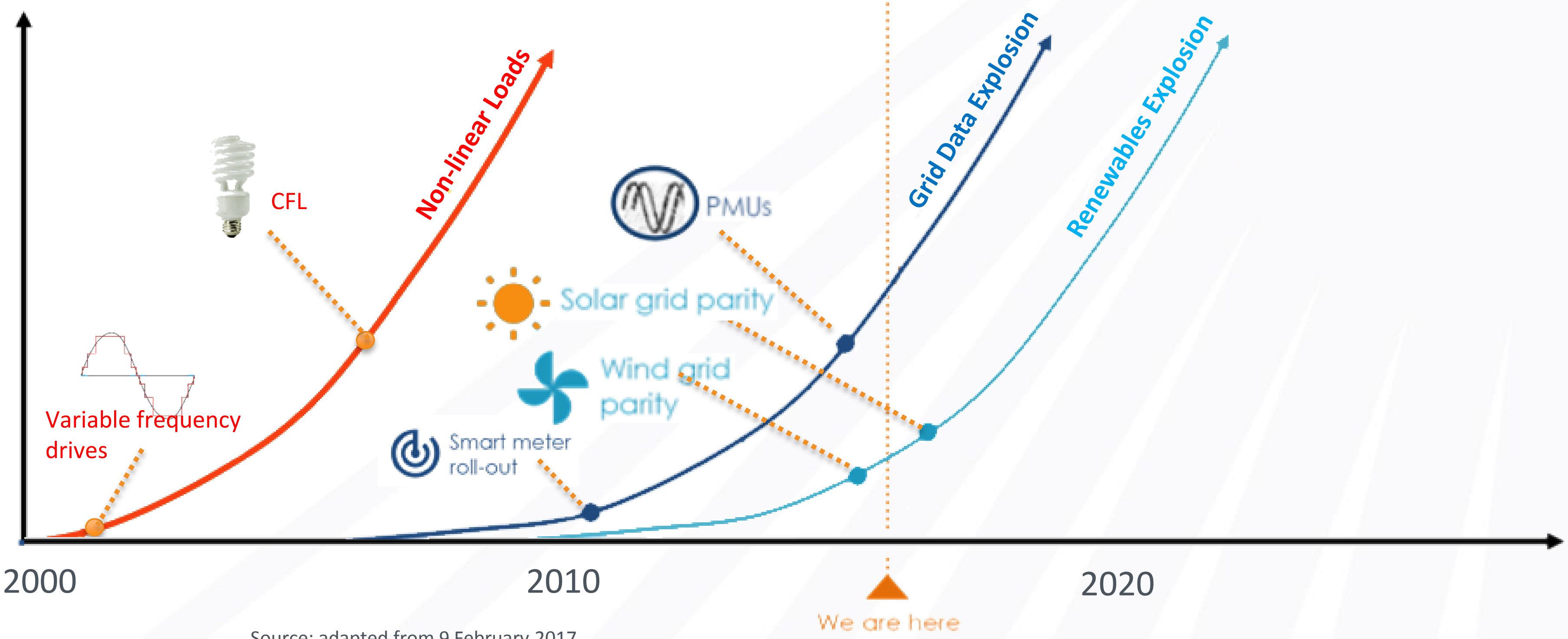
Electricity Mega-Trends



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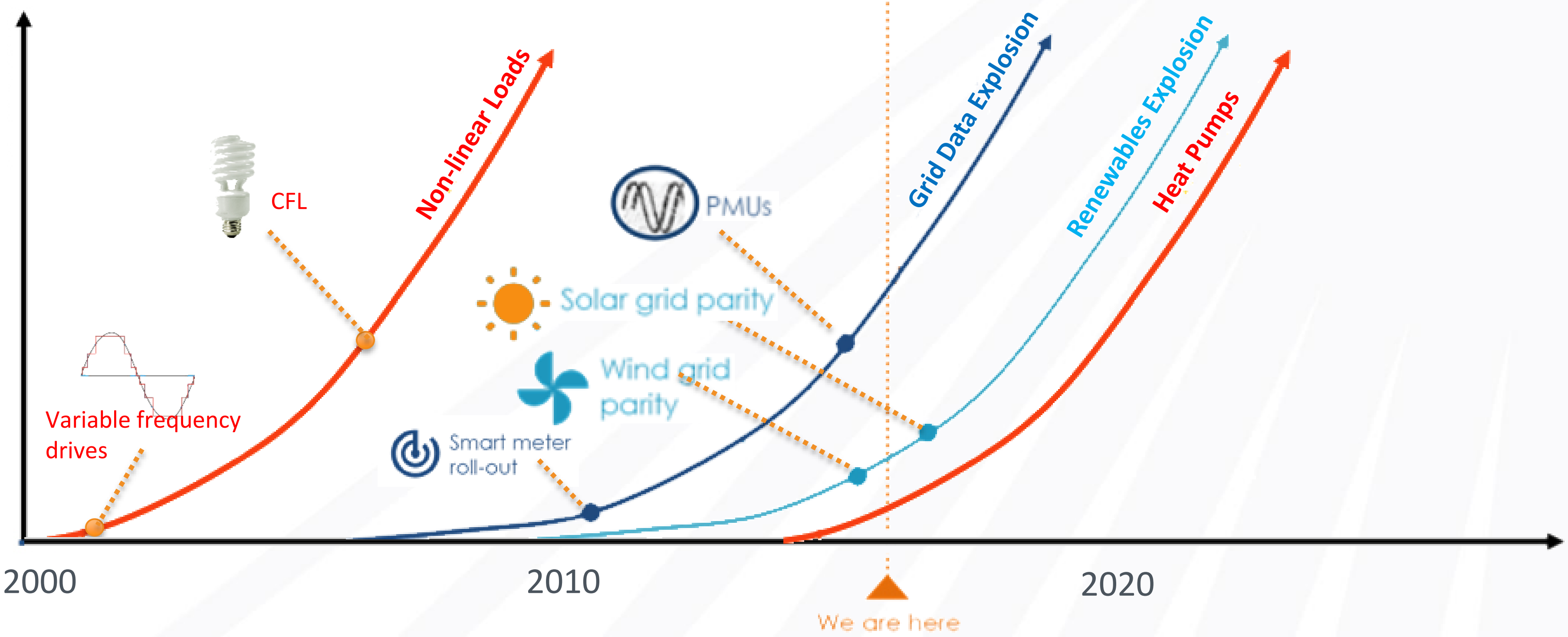

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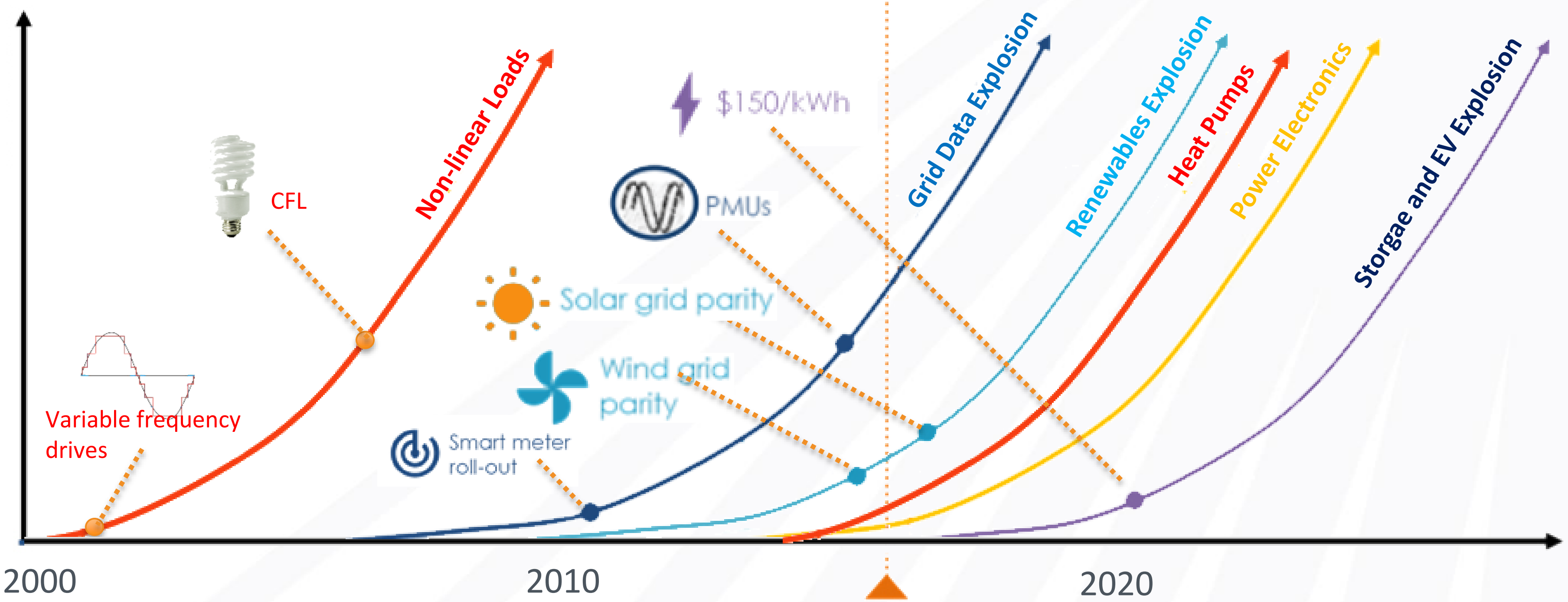
Electricity Mega-Trends



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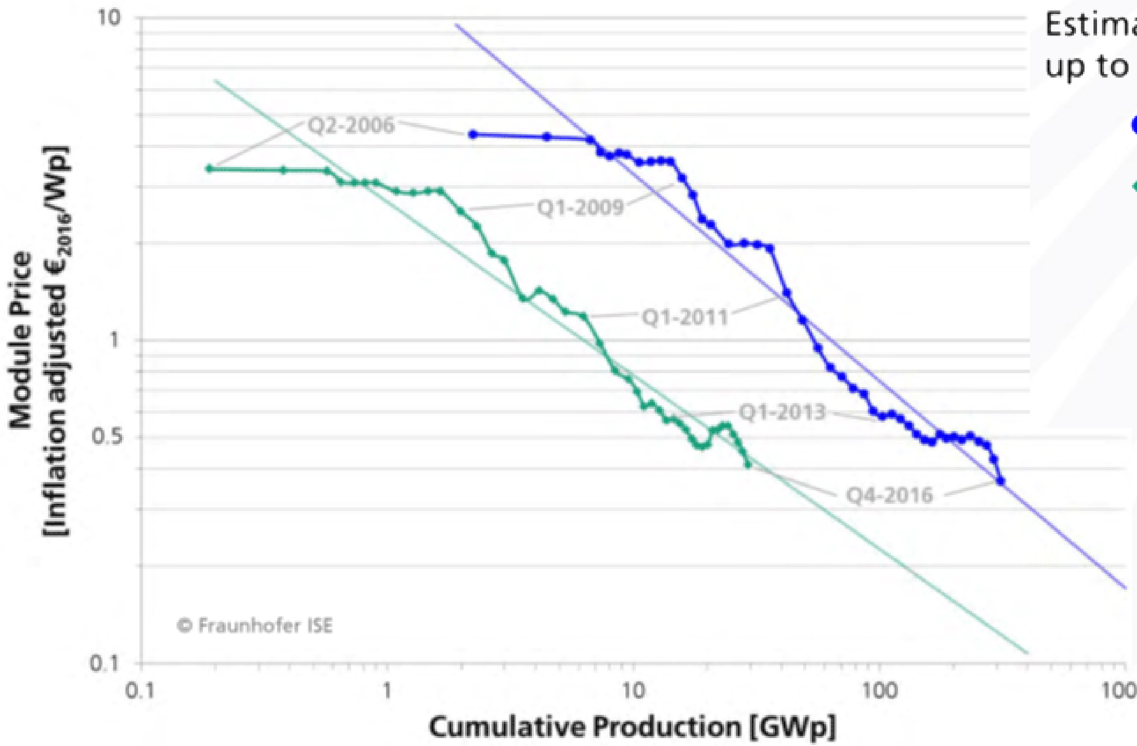
National Association of State Energy Officials
Chandu Visweswariah, IBM

Renewables accounted for >50% of new worldwide electricity-generating capacity in 2016

PV Learning Curves



Estimated cumulative production up to Q4, 2016 :

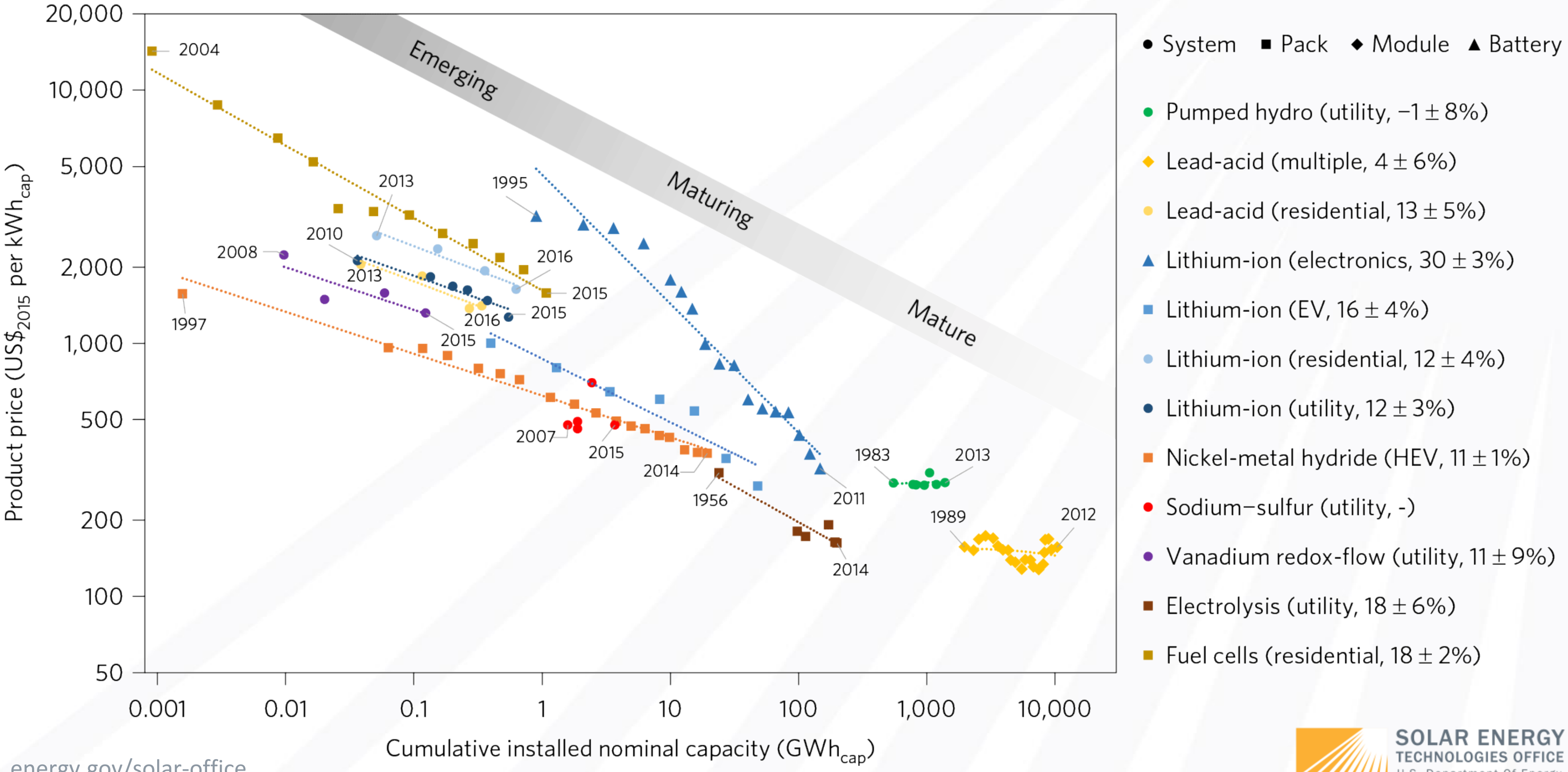
●	c-Si	312 GWp
◆	Thin Film	29 GWp

Crystalline Technology
(from Q2-2006 to Q4-2016) **LR 29**

Thin Film Technology
(from Q2-2006 to Q4-2016) **LR 25**

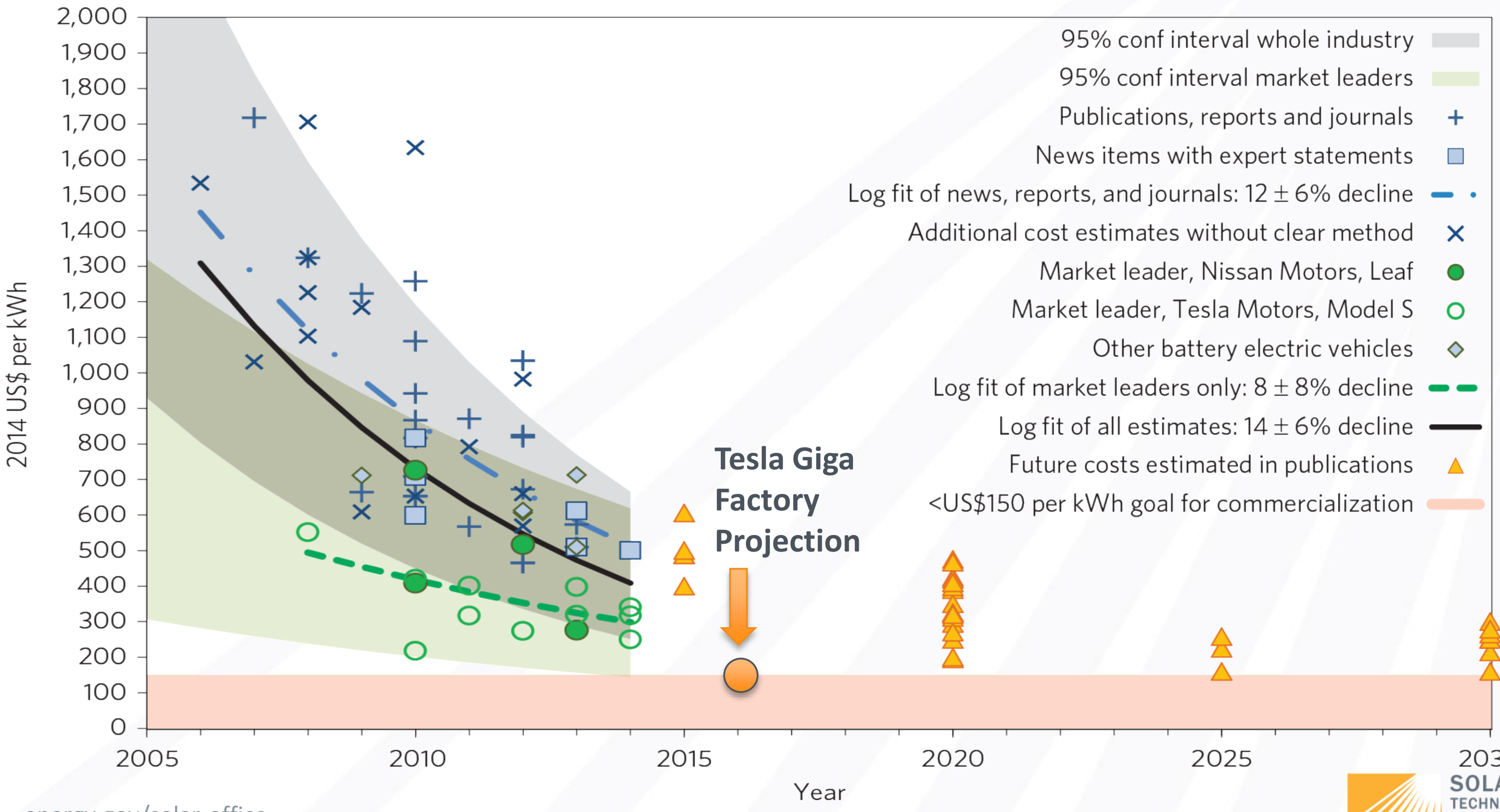
Data: from 2006 to 2010 estimation from different sources : Navigant Consulting, EUPD, pvXchange; from 2011 to 2016: IHS. Graph: PSE AG 2017

Experience Curves for Energy Storage



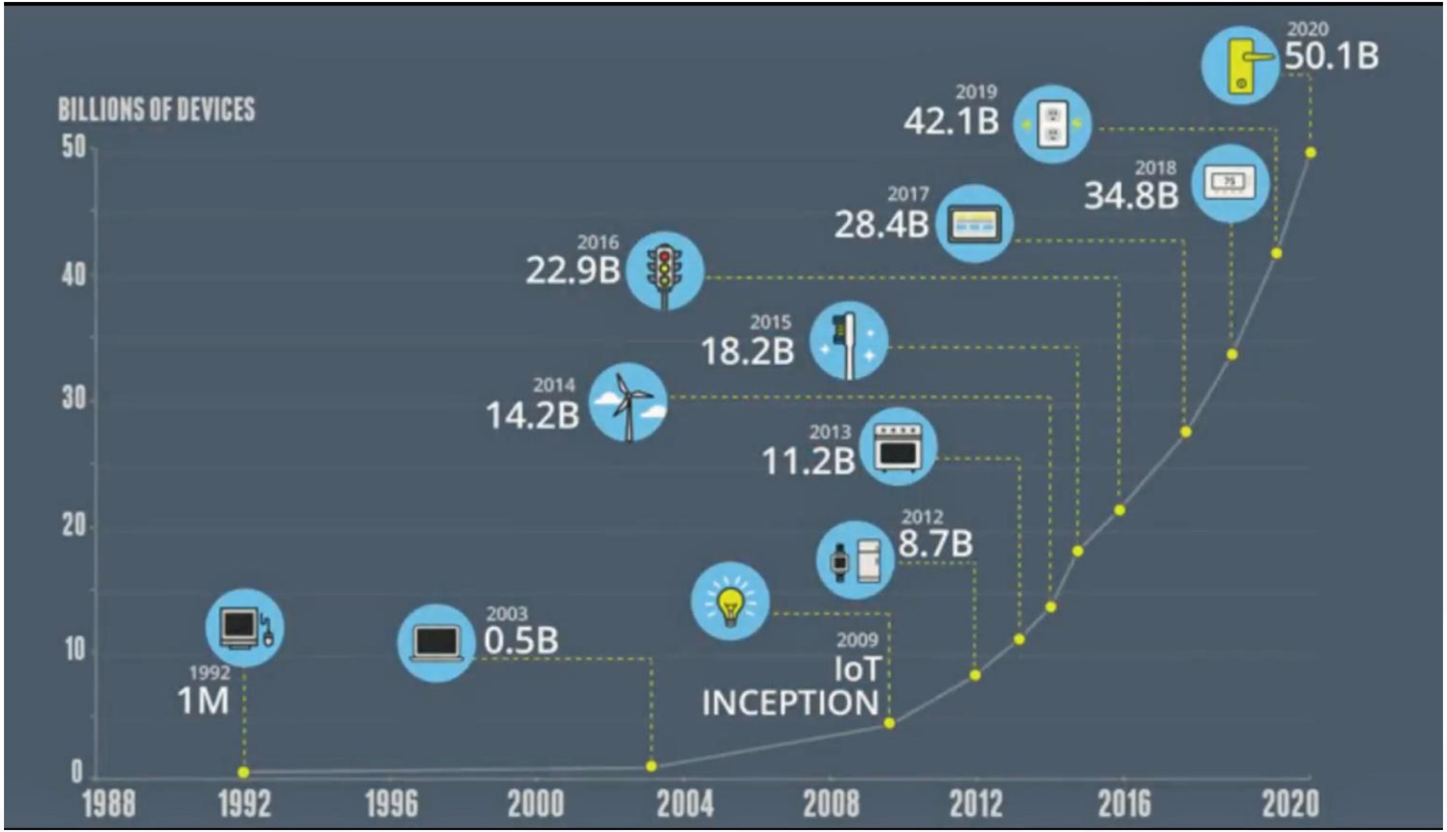
Nature Energy 10 JULY 2017, VOLUME: 2, ARTICLE NUMBER: 17110

Lithium Ion Battery Pack Costs / Projections : EV

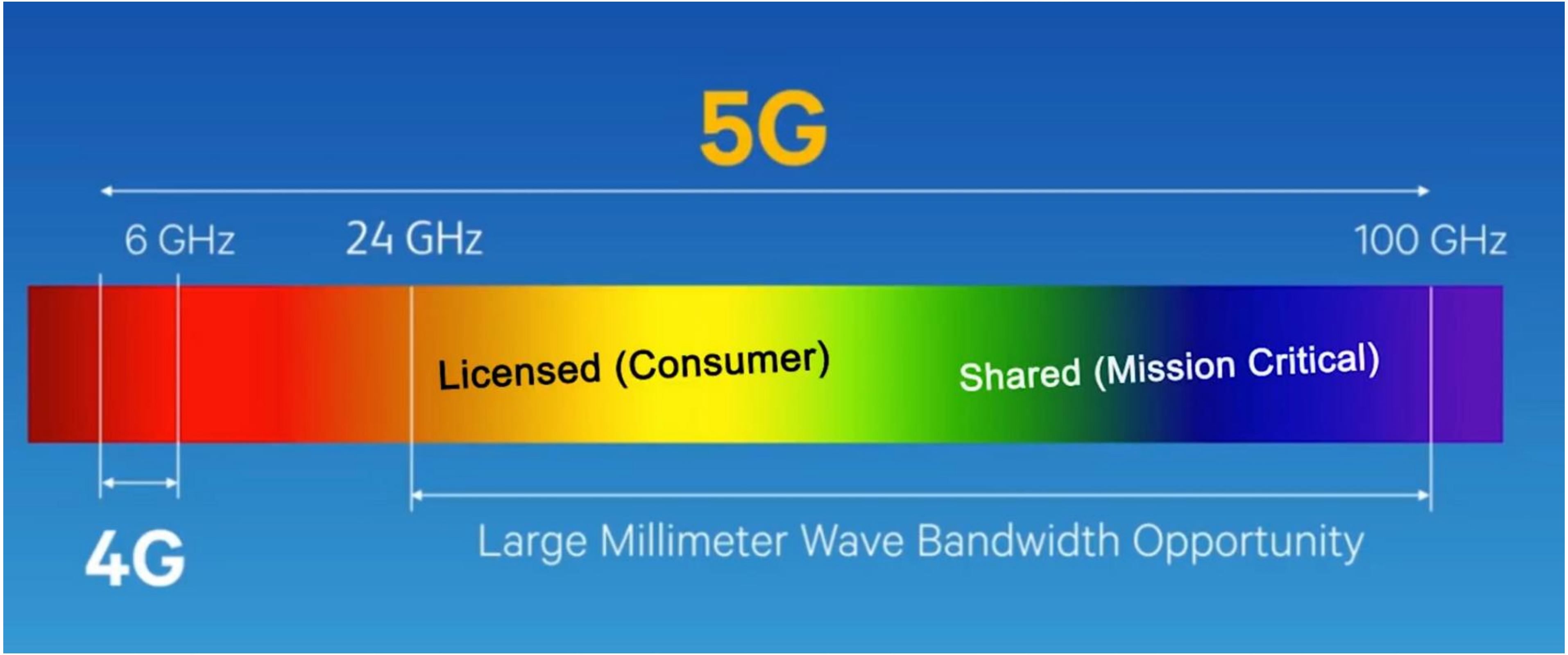


Nature Climate Change; 23 MARCH 2015; DOI: 10.1038; NCLIMATE2564

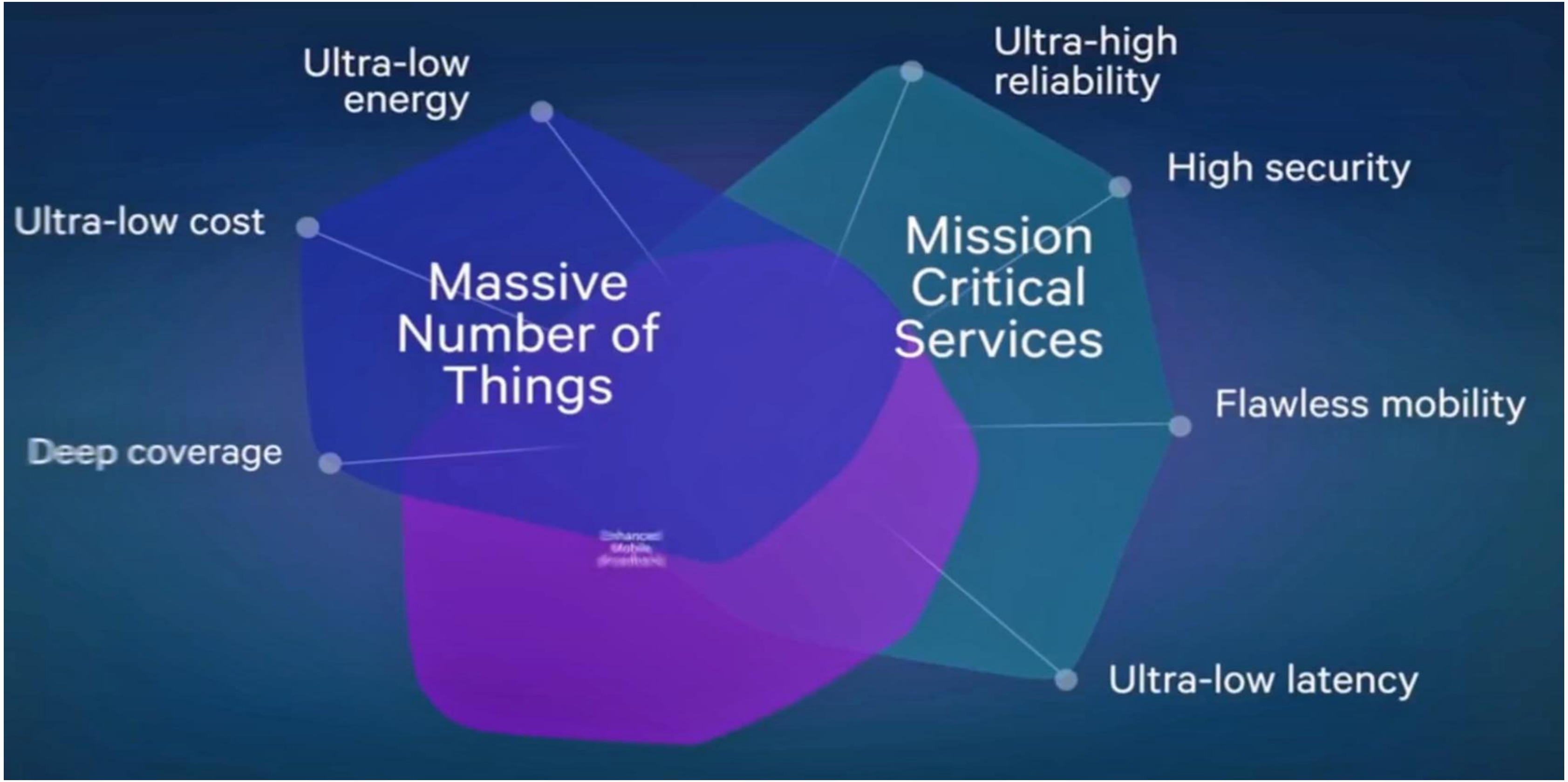
Telecommunications Mega-Trends



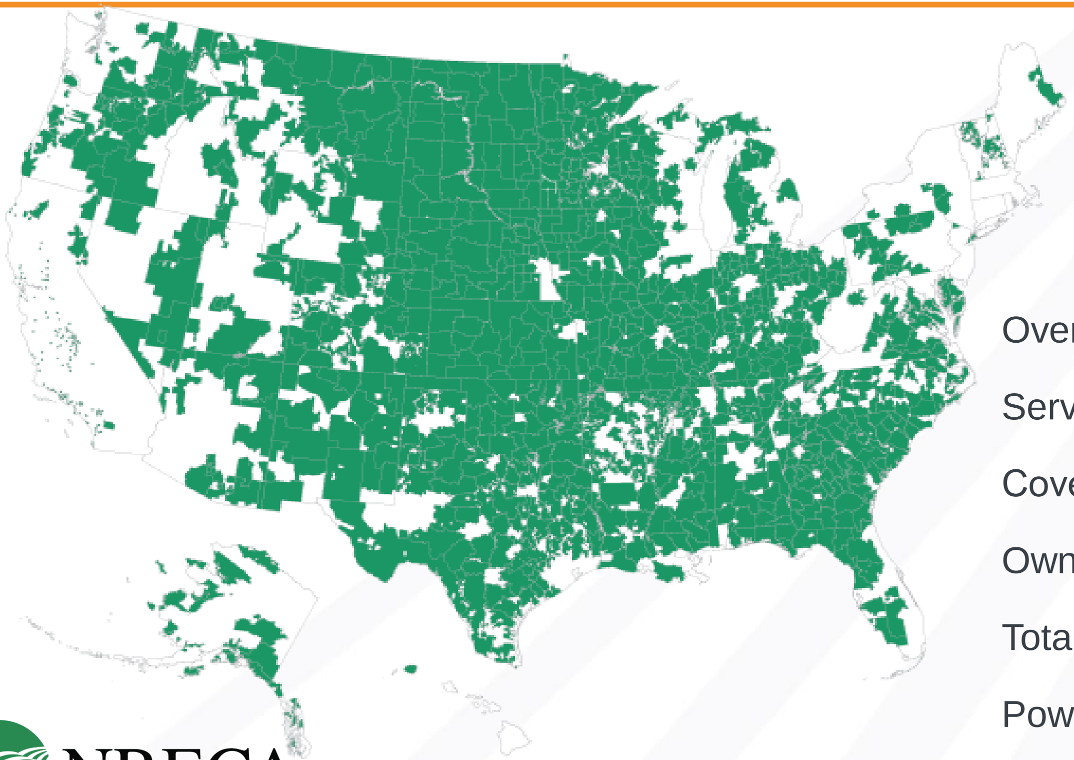
Telecommunications Mega-Trends



Telecommunications Mega-Trends



America's Electric Cooperative Network



Over 900 Co-ops

Serves 42 Million Americans in 47 States

Covers 75% of Nation's Land Mass

Owns 42% of all Distribution Lines

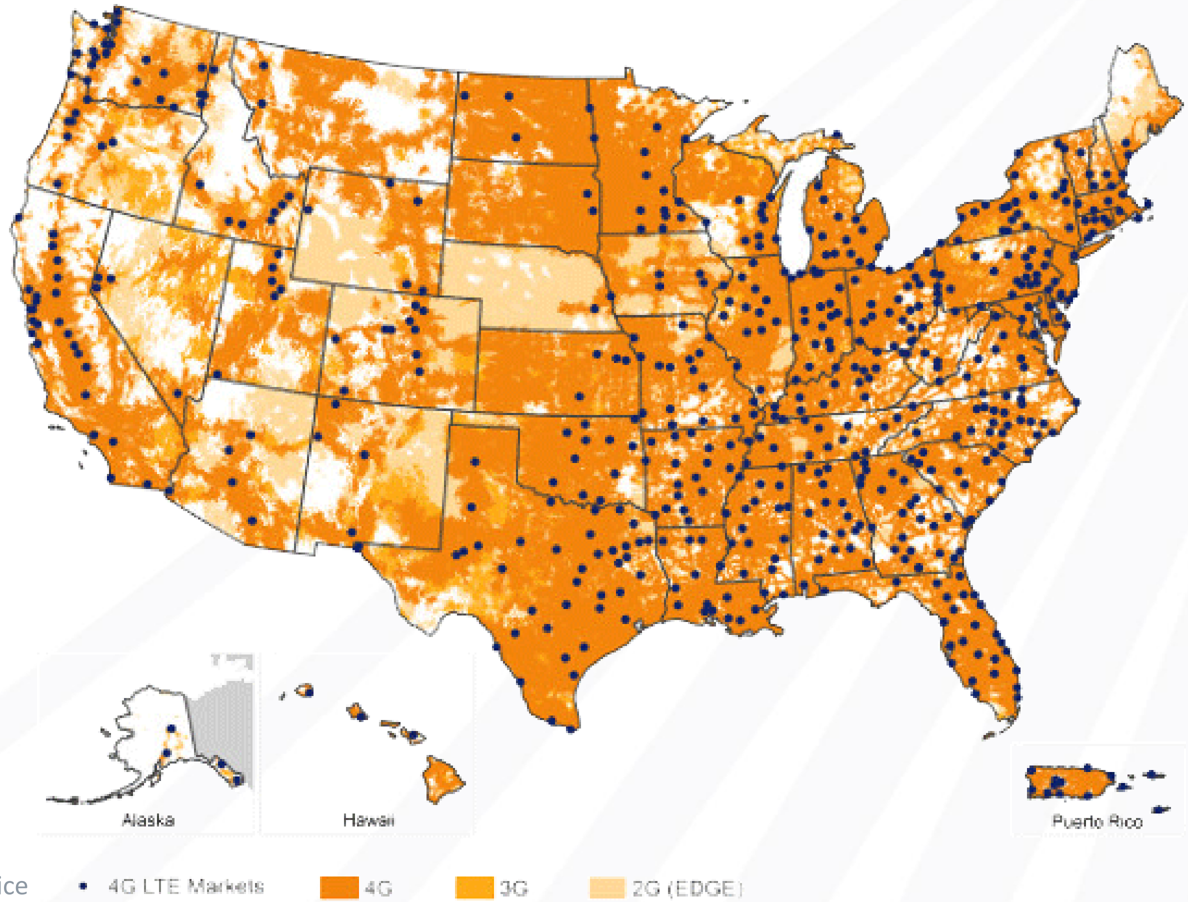
Totals 2.4 Million Line Miles

Powered by 55,000 MW

Delivers 178 Billion kWh of Generation Annually

NRECA
America's Electric Cooperatives

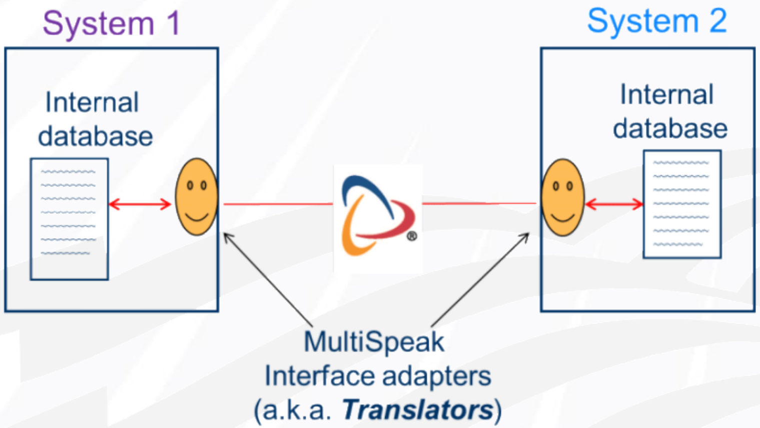
America's Cellular Network Coverage



Multispeak Interoperability Solution

What is MultiSpeak?

- Developed in **2000** by NRECA
- Allow **Data Sharing between stand-alone SOFTWARE systems** in a STANDARDIZED way
- ***Cost-effective, real-time, cyber secure, scalable, testable & certifiable***
- **Worldwide** Leading INTEROPERABILITY Standard & INTEGRATION SOLUTION
- **Used by 800+** Utilities in **20+ Countries** Globally
- **Enabler** of Smart Grid & Cyber Security

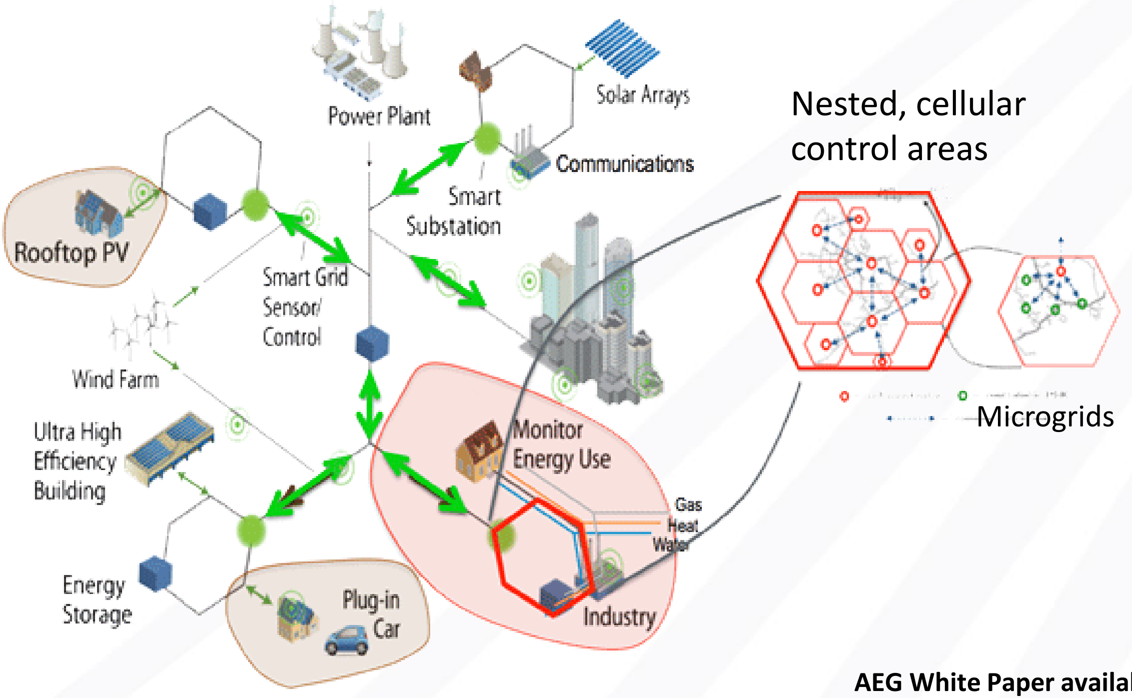


NRECA
America's Electric Cooperatives

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

Key Challenges to Grid Integration of Solar Energy

Maintaining reliability with increasing distributed solar

- The electric power grid has been designed for power flow in one direction. When more solar is generated than is used locally, two-way power flows increase the complexity of system operations.

Best practices for integrating solar and distributed energy storage are all local

- Effective utilization of energy storage or load shifting is in early development.

Unpredictable variability of solar power over time

- Solar generation levels vary due to the variability of cloud cover and weather, which can cause challenges for grid optimization.

Inefficient distribution and power quality challenges

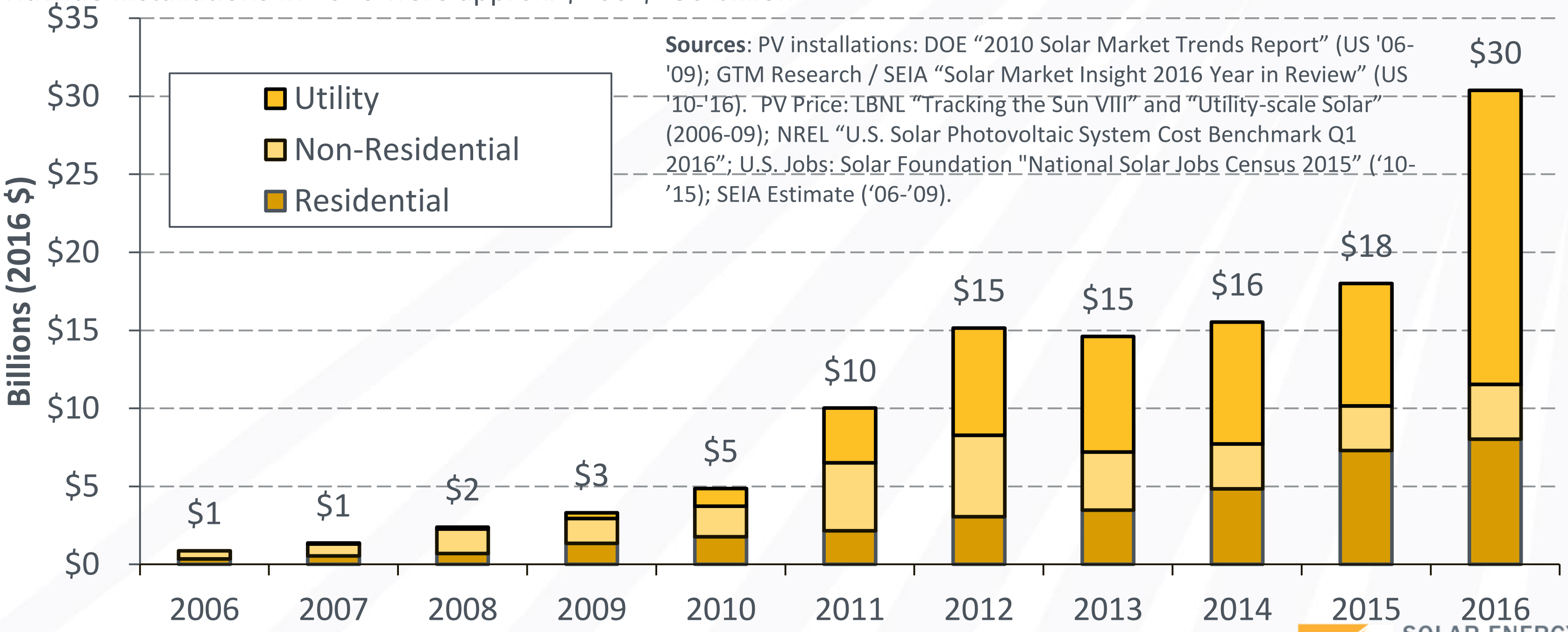
- Distribution sensing and control systems have yet to leverage advanced power electronics.

Incompatible or insecure grid-interface standards

- In order for all elements of the grid to work together, communications are necessary, which makes cyber-security issues important.

Estimated Value of U.S. Solar Installations

- The estimated value of U.S. PV Installations in 2016 was approximately $30 billion
  - This represents an increase of 69% over 2015
  - 62% of 2016 annual value was in the utility sector, 26% in the residential sector, and 12% in the non-residential sector
- Worldwide installations in 2016 were approx. $100-$150 billion



Sources: PV installations: DOE "2010 Solar Market Trends Report" (US '06-'09); GTM Research / SEIA "Solar Market Insight 2016 Year in Review" (US '10-'16). PV Price: LBNL "Tracking the Sun VIII" and "Utility-scale Solar" (2006-09); NREL "U.S. Solar Photovoltaic System Cost Benchmark Q1 2016"; U.S. Jobs: Solar Foundation "National Solar Jobs Census 2015" ('10-'15); SEIA Estimate ('06-'09).

Leapfrogging China

Trichloro-silane Gas → Polysilicon Processing → Ingot Growth → Wafer Slicing → Cell Processing → Module Processing

*Excludes: Construction financing, O&M, monitoring, site security, and sub station transformers (if needed).

	Poly	Ingot	Wafer	Cell	Module	Sub Total	Inverter	Field 1X Tracking*	Total
Cost ($/W)	$0.06/W	$0.03/W	$0.03/W	$0.10/W	$0.13/W	**$0.35**	$0.06	$0.70	**$1.11**
CapEx ($/kg or $/W)	Siemens $45/kg FBR $80/kg	Czochralski: $0.14/W Multi: $0.05/W	$0.03/W	$0.10/W	$0.07/W				

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Office of Management and Budget Guidance

EXECUTIVE OFFICE OF THE PRESIDENT

WASHINGTON, D.C.

August 17, 2017

M-17-30

MEMORANDUM FOR THE HEADS OF EXECUTIVE DEPARTMENTS AND AGENCIES

FROM: MICK MULVANEY
DIRECTOR, OFFICE OF MANAGEMENT AND BUDGET

MICHAEL KRATSIOS
DEPUTY ASSISTANT TO THE PRESIDENT
OFFICE OF SCIENCE AND TECHNOLOGY POLICY

SUBJECT: FY 2019 Administration Research and Development Budget Priorities

Office of Management and Budget Guidance

American Security

Special attention should be paid to R&D that can support the safe and secure integration into society of new technologies that have the potential to contribute significantly to American economic and technological leadership.

American Energy Dominance

Development of domestic energy sources should be the basis for a clean energy portfolio composed of fossil, nuclear, and renewable energy sources. Agencies should invest in early-stage, innovative technologies that show promise in harnessing American energy resources safely and efficiently. As initiated in the FY 2018 budget, Federally-funded energy R&D should continue to reflect an increased reliance on the private sector to fund later-stage research, development, and commercialization of energy technologies.

Modernizing and Managing Research Infrastructure

Innovative partnership models involving other agencies, state and local governments, the private sector, academia, and international partners can help maximize utilization of underused facilities and lead to sharing the costs of new R&D facilities.

American-Made Challenges

Department of Energy Announces Prize Competition to Accelerate U.S.-Based Solar Manufacturing

JANUARY 24, 2018

American-Made Challenges

American-Made Solar Prize

Manufacturing Accelerator for Domestic Energy in the U.S.

The U.S. Department of Energy (DOE) Solar Energy Technologies Office and the National Renewable Energy Laboratory (NREL) are working together to launch the first prize challenge associated with the American-Made Challenges.

The **American-Made Solar Prize (Solar Prize)**:

- Accelerates the development of technologies and solutions that will advance the solar industry
- Enables rapid prototyping of ground-breaking solar solutions and prove their viability
- Provides connections to a network of solar industry experts, fabricators, and developers
- Connects entrepreneurs with the investor community to help solar businesses and technical solutions scale

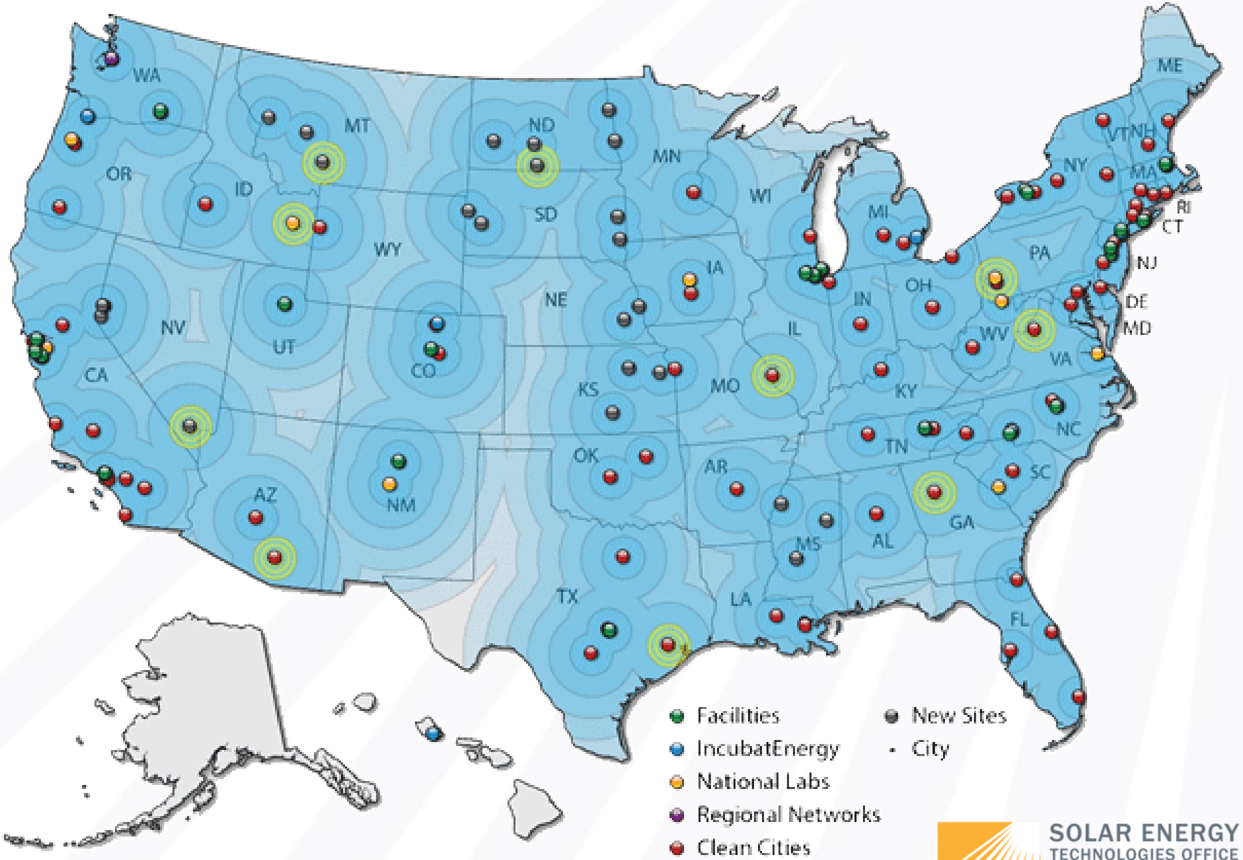
Pre-registration is now open!

Activate Nation-wide Innovation at the Local Level and Replicate

17
National Labs

35
Incubators

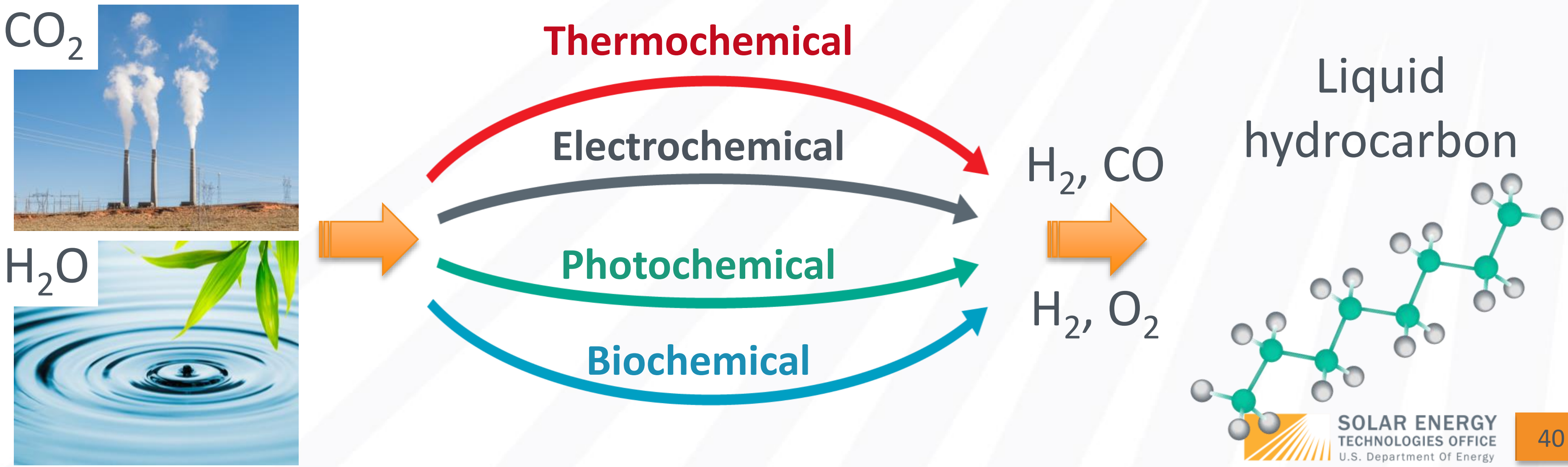
83
City Coalitions



Buffers shown in 50 mile increments out to 300 miles.

A Challenge for the Our Century – and - Our Ability to Team

We need to produce liquid hydrocarbons from splitting water into H_2 and O_2 and reducing CO_2.



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