United States and Clean Energy: A View from the U.S. Department of Energy (DOE)

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Jeff Miller, U.S. Department of Energy

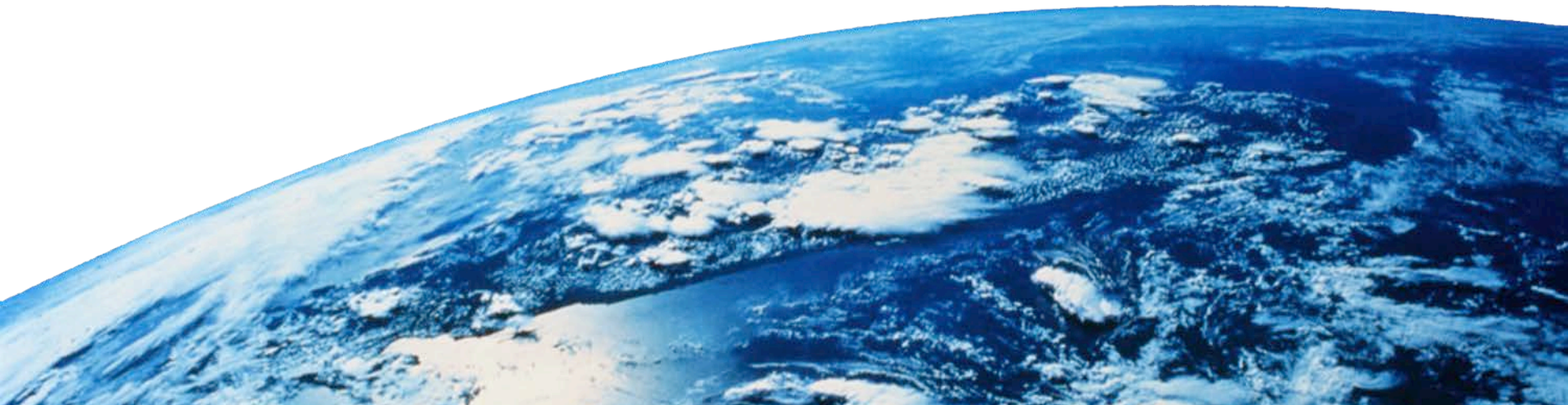
February 12, 2015

Japan Science and Technology Agency
Renewable Energy International Symposium

Climate Change and Clean Energy

“The question now is whether we will have the courage to act on climate change before it’s too late. And how we answer will have a profound impact on the world that we leave behind…”

President Barack Obama
June 2013



President's Climate Action Plan: Three Overarching Themes

Mitigation (Emissions Reduction)

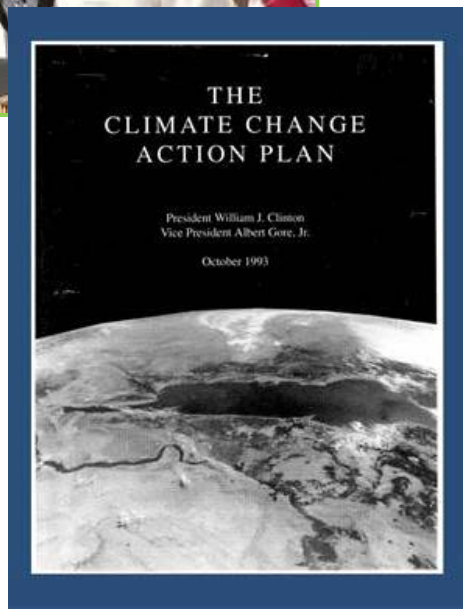
- *ALL OF THE ABOVE*
- Efficiency, Renewables, Nuclear, Gas
- Coal with CCS/CCUS

Adaptation and Resilience

- Smart, reliable grid
- Key infrastructure investments

International Partnerships

- Bilateral efforts
- Coordinated International Efforts



"We will respond to the threat of climate change knowing that the failure to do so would betray our children and future generations."

- President Obama, Second Inaugural Address, January 2013

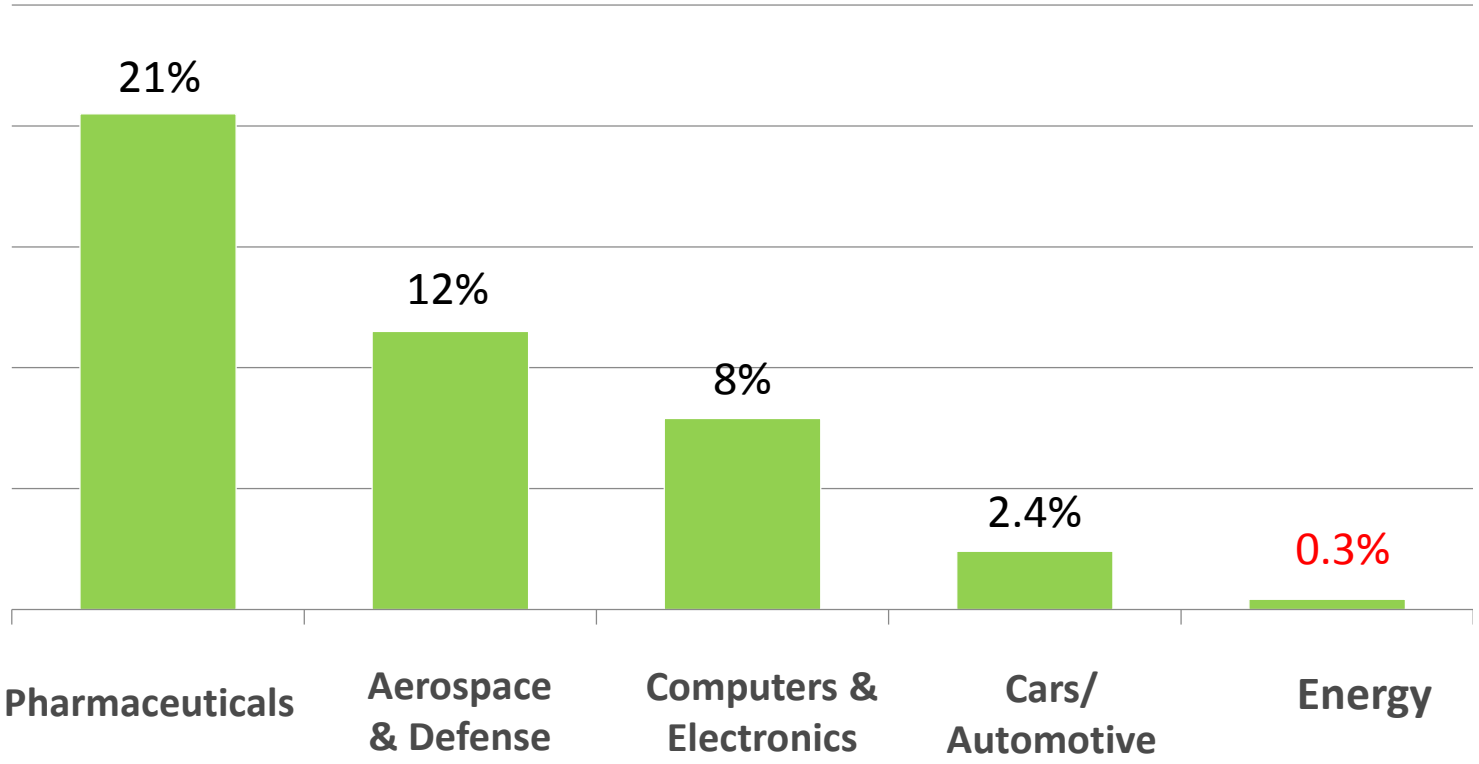
The President's All-of-the-Above Energy Strategy

"This country needs an all-out, all-of-the-above strategy that develops every available source of American energy. A strategy that's cleaner, cheaper, and full of new jobs."

President Barack Obama
State of the Union Address
January 24, 2012

Why Government?

Private Investment in R&D (as % of sales)



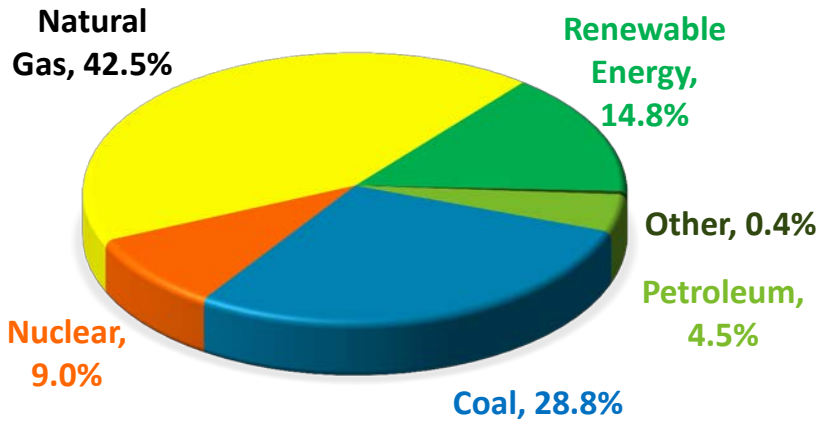
Source: American Energy Innovation Council, *Business Plan for America's Energy Future,* 2010

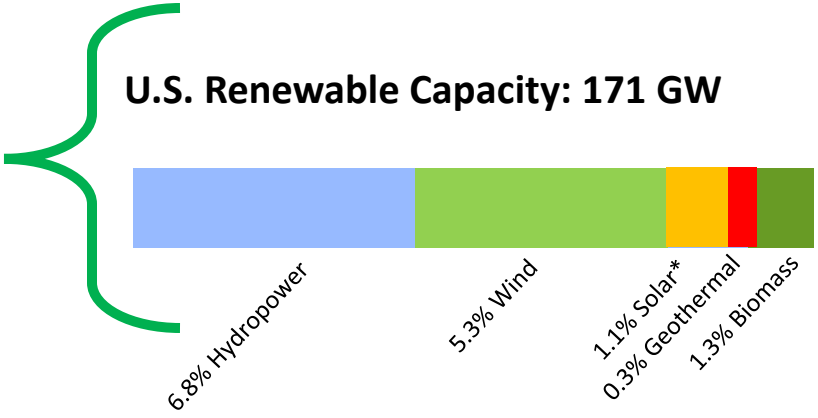
Administration and EERE Goals

	Clean Electricity	Transportation	Buildings/Industry	Federal Sustainability
Administration	Reduce GHG emissions by 17% by 2020 and 83% by 2050 from 2005 baseline			
Administration	-Generate 80% of electricity from a diverse set of clean energy resources by 2035	-Reduce oil imports by 1/3 by 2025 -Put 1 million electric vehicles on the road by 2015	-Make non-residential buildings 20% more energy efficient by 2020 -CHP: 40 new GW by 2020 -Weatherize 1 million homes by 2013	-Reduce Scope 1&2 GHG emissions by 28%; Scope 3 by 13% (2008 baseline) -26% improvement in water efficiency by 2020 -$2B ESPCs by end of 2013
EERE	**SunShot Initiative:** Subsidy-free solar energy cost competitive at $1/watt, or about $0.06/kWh	Biomass – less than $3/gallon for drop-in fuels such as renewable gasoline, diesel, and jet fuel	Improve building efficiency by 50% by 2030	
EERE	**Wind:** LCOE parity with Natural Gas (0.06/kWh), but full market cost competition without subsidization	Cars able to achieve fuel economy greater than 60mpg by 2025	For 2013, issue four Final Rules for Appliance Standards	Support Federal Agencies
EERE	**Water:** Unsubsidized parity with Natural Gas; 30+ GW Water 2020, 123+GW Water 2030	Batteries – ½ today's price in 2015, ¼ today's price in 2020	Reduce industrial energy intensity by 25% over 10 years	DOE Leadership
EERE	**Geothermal:** Lower the EGS cost to $0.09/kWh by 2020; $0.06/kWh by 2030	Fuel cells for vehicles $30/kW; 5000h duration	Improve life-cycle efficiency of targeted products by 50%	

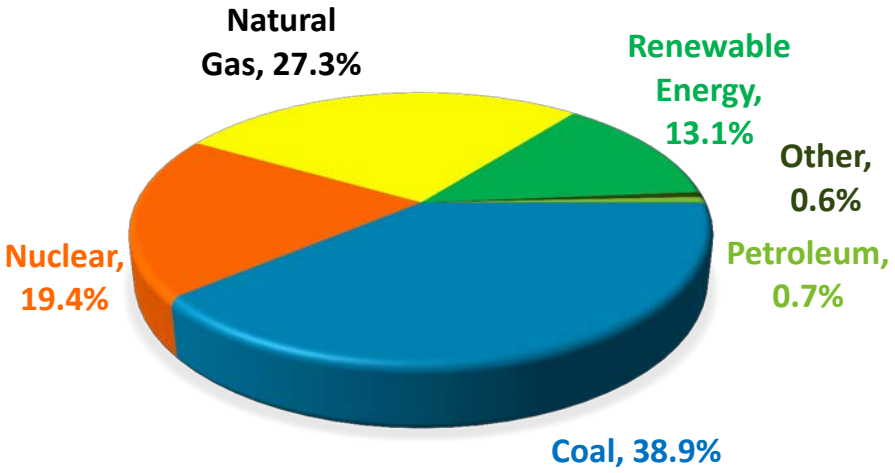
U.S. Electricity Nameplate Capacity and Generation (2013)

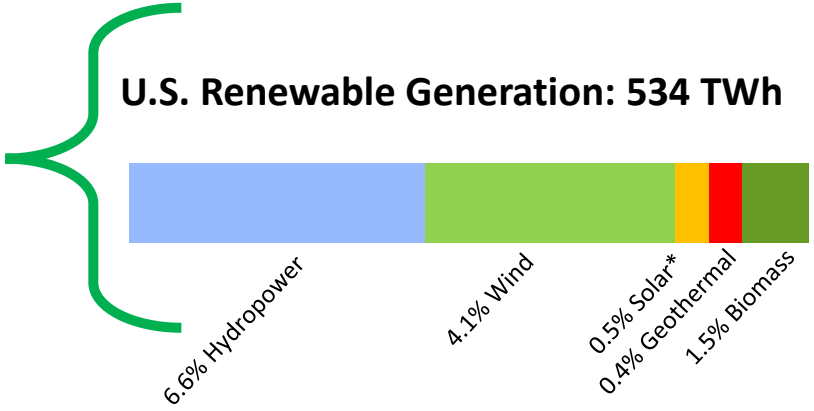
U.S. Electric Nameplate Capacity (2013): 1,155GW





U.S. Electric Net Generation (2013): 4,074TWh



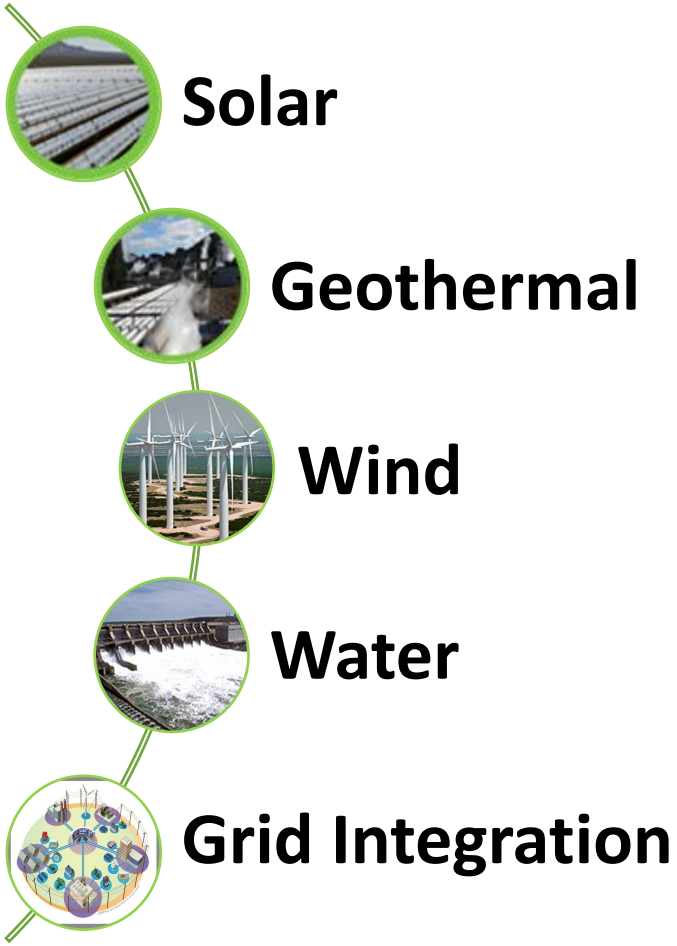


Source: Renewable Energy Data Book 2013

Office of Energy Efficiency and Renewable Energy

Renewable Power Initiatives

DOE seeks to develop renewable power technologies so that they are cost competitive with traditional sources of energy without subsidies



Major Strategic Areas:

- Cost reduction and performance improvement
- Technology validation and risk reduction
- Addressing market barriers

Renewable Electricity Generation

Geothermal Technologies

- To date, 100MW–150MW identified through DOE investments from drilling more than 20 wells across California, Nevada, and Idaho.
- Ormat Technologies' Desert Peak 2 EGS project increased output of its nearby operating geothermal field by nearly 38%—providing an additional 1.7MW of power to the grid and validating this emerging technology.

Solar Energy Technologies

- From 2008–2013, price of solar PV modules dropped by around 75%.
- Net economic benefit of $15 billion, resulting from EERE's $3.7 billion investments in solar PV R&D from 1975–2008 (2008 dollars), due to module efficiency and reliability improvements.

Wind and Water Power Technologies

- Over the past 4 years, the U.S. wind industry represented 35% of all new installed generation capacity.
- First-ever grid-connected tidal power project in the United States is now delivering electricity to the utility grid from an underwater power system in Cobscook Bay, Maine.

U.S. Department of Energy – Loan Guarantee Program Office

December 2013: $8 billion for advanced fossil energy projects

- Carbon capture
- Advanced resource development
- Low-carbon power systems
- Efficiency improvements

February 2014: $6.5 billion for the first two new nuclear reactors in nearly 30 years

- 2,200MW clean energy
- 3,500 on-site construction jobs
- 800 permanent jobs
- Enough power for 1.5 million American homes

"The Energy Department is taking an all-of-the-above approach to American energy to ensure we develop all our abundant energy resources responsibly and sustainably."

U.S. Secretary of Energy Ernest Moniz

"This will be a big year for our loan program . . . It has paid off in may ways – utility scale, photovoltaics, CSP, we could go on and on. But, what I want to emphasize now is that we have just recently completed our full suite of call for proposals for an additional $40 billion of loan guarantees. That's $4 billion roughly in renewables and efficiency, $8 billion for fossil technologies that lower emissions, roughly $12 billion for advance nuclear technologies, and roughly $16 billion for new vehicle technologies."

- Remarks by U.S. Secretary Moniz at the Wilson Center, January 7, 2015

U.S. DEPARTMENT OF ENERGY
LOAN PROGRAMS OFFICE

Concentrating Solar Power: Ivanpah (*BrightSource*)

Location: Ivanpah Dry Lake, CA

Technology: Power Tower

Size: 3,500 acres (federal land)

Power: 392 MW

DOE Loan Guarantee: $1,600M

Homes Served: 140,000

Customers: PG&E and SCE

Partners: NRG, Google, Bechtel

Ivanpah is the largest concentrating solar power plant in the world!

Desert Peak EGS Demonstration

"If we can go to all the hundred or thousands of wells that are unproductive and tinker with them to make them productive, this is a game changer."

Paul Thomsen, Director of Policy and Business Development, Ormat Technologies – MIT Technology Review, 4/2013

- Ormat Technologies' Desert Peak EGS project successfully supplied 1.7 MW electricity to the grid – a first-in-the-nation achievement
- DOE invested $5.4 million, with a private costshare of $2.6 million
- Desert Peak represents a near-term opportunity to develop EGS at lower cost and risk; potential for reserve additions at highly competitive costs ($0.02-05/kwh)

Pathway to larger, more complex and more challenging R&D efforts

Revolution Now: What we're doing is working!

U.S. DEPARTMENT OF ENERGY

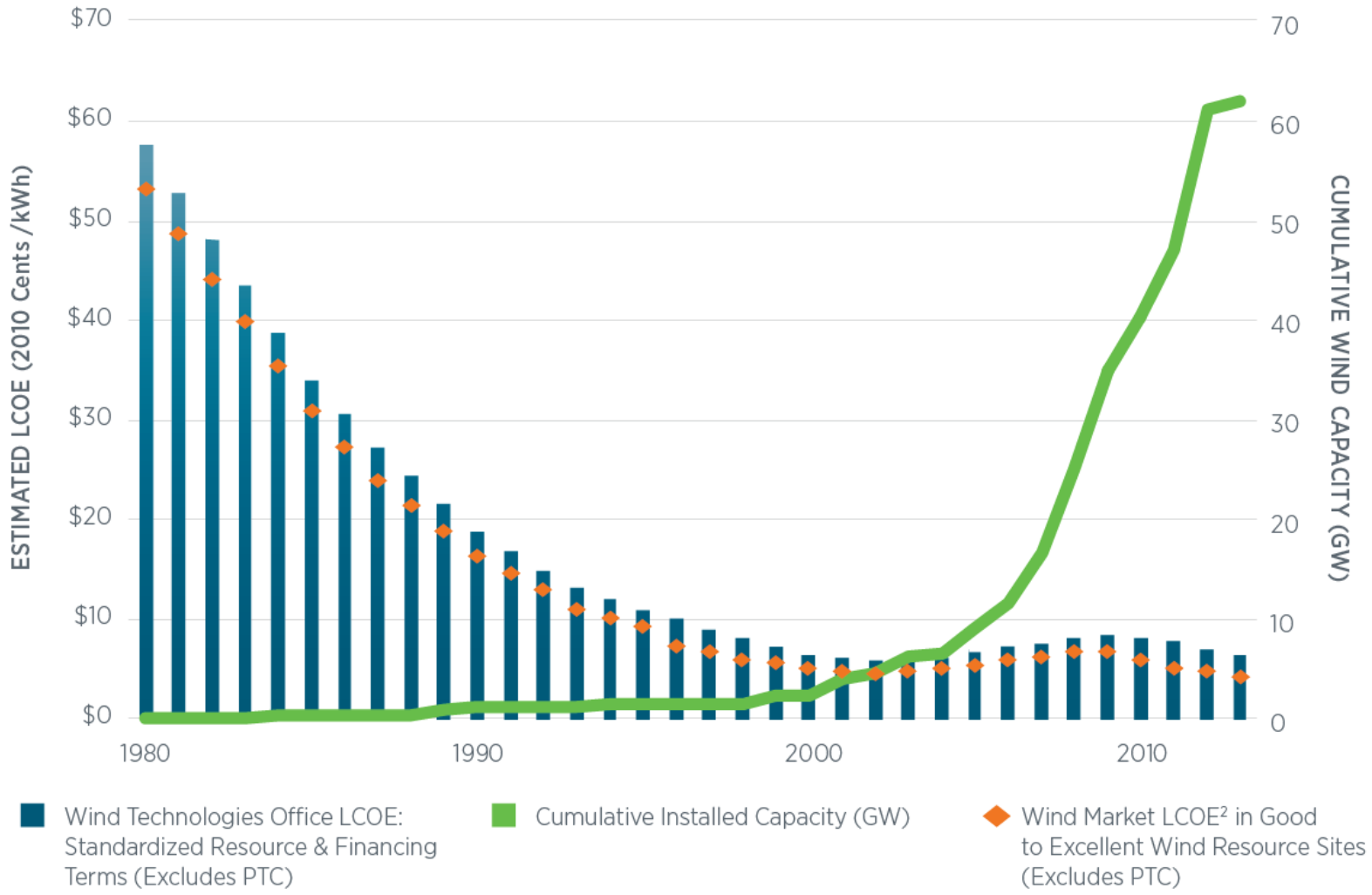
Revolution Now

The Future Arrives for Four Clean Energy Technologies – 2014 Update

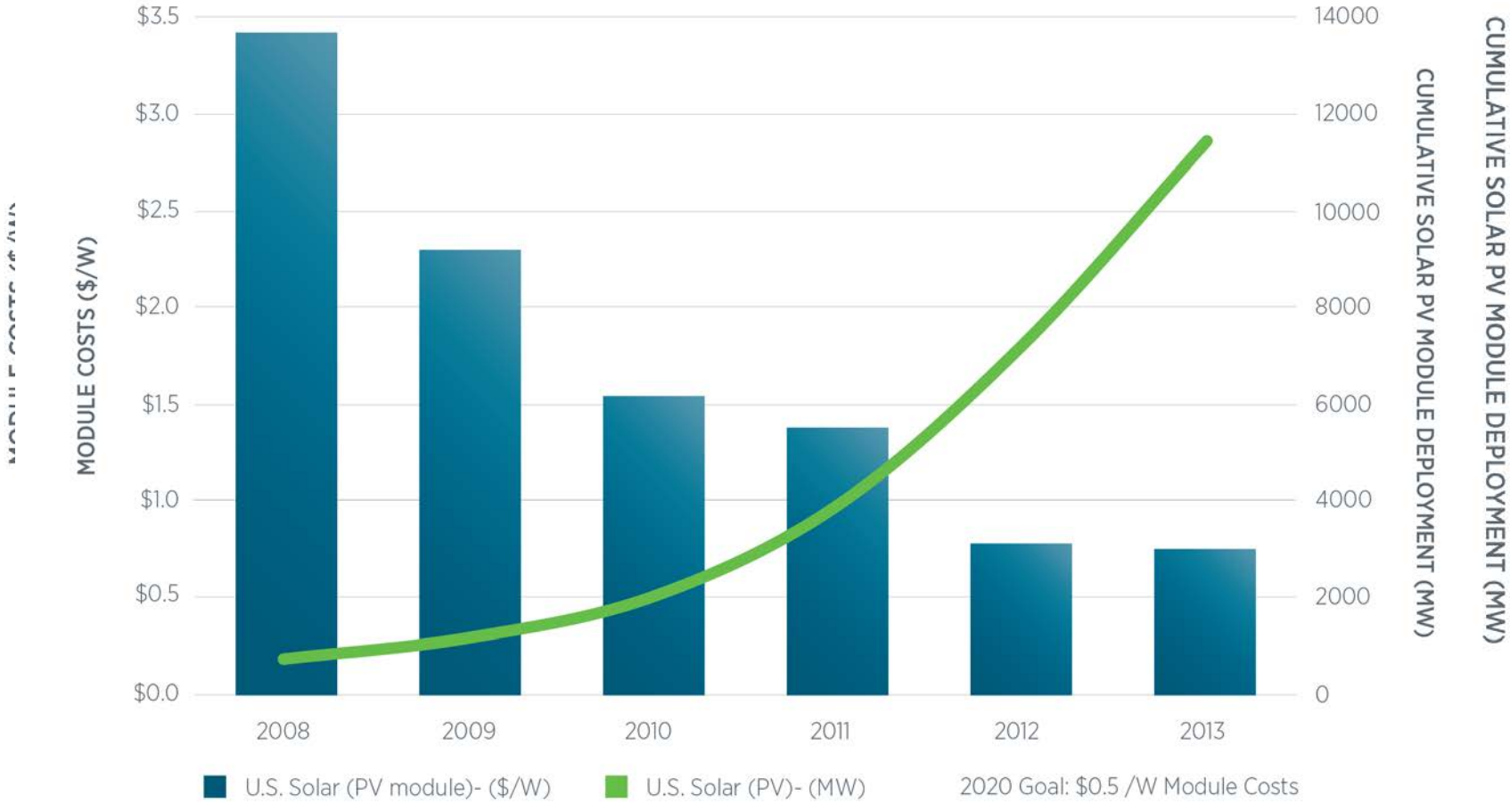
October 2014

We are on the cusp of greatness; the clean energy revolution is real, and it is possible.

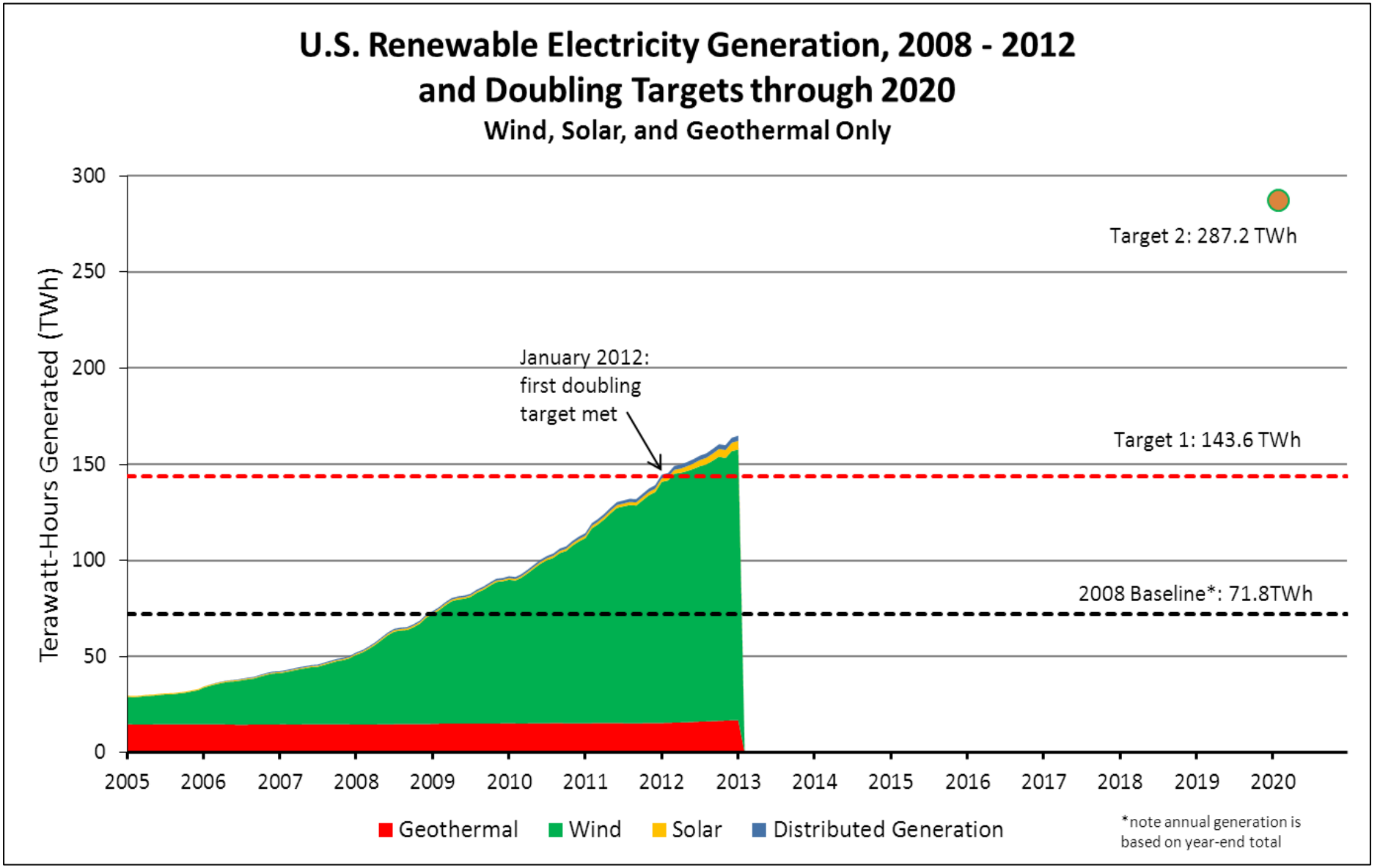
A Revolution Now: Wind Power



A Revolution Now: Solar PV

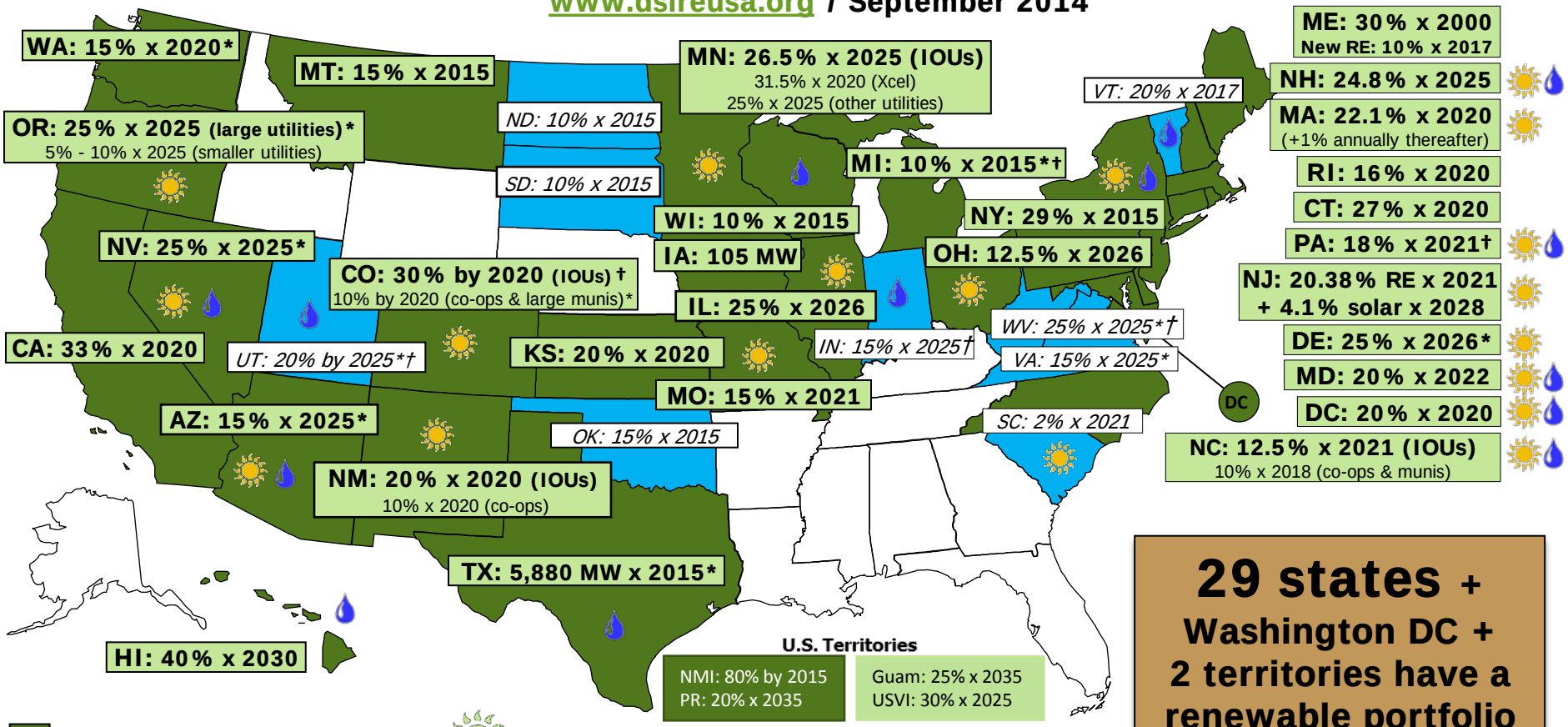


U.S. Doubles Renewable Energy



Renewable Portfolio Standard Policies

www.dsireusa.org / September 2014



Renewable portfolio standard

Renewable portfolio goal

Solar water heating eligible

Minimum solar or customer-sited requirement

* Extra credit for solar or customer-sited renewables

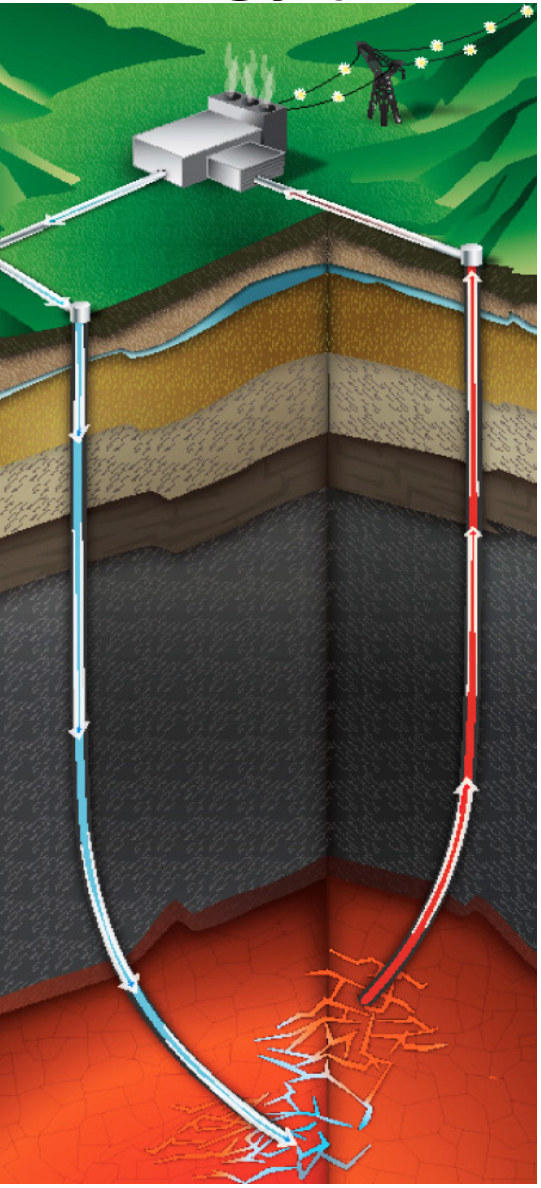
† Includes non-renewable alternative resources

29 states + Washington DC + 2 territories have a renewable portfolio standard

(9 states and 2 territories have renewable portfolio goals)

*Source: Database of State Incentives for Renewables & Efficiency

Frontier Observatory for Research in Geothermal Energy (FORGE)

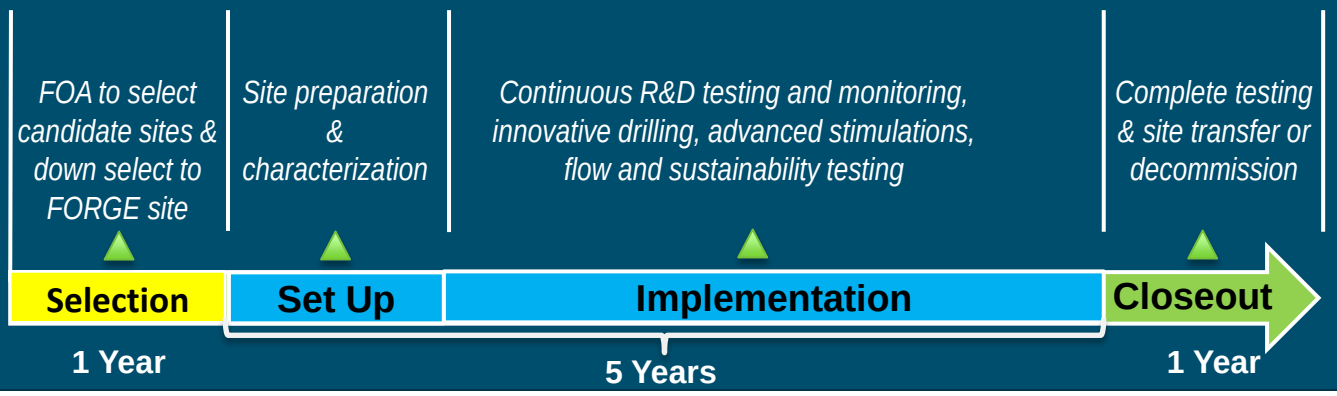


Goal: Promote transformative science and engineering to:

- Validate and optimize enhanced geothermal systems (EGS) technologies
- Create a commercial pathway to large-scale EGS power generation in the U.S.
- Provide global leadership in a new renewable energy sector with expectation of accelerated domestic and international adoption of EGS

Why Now:

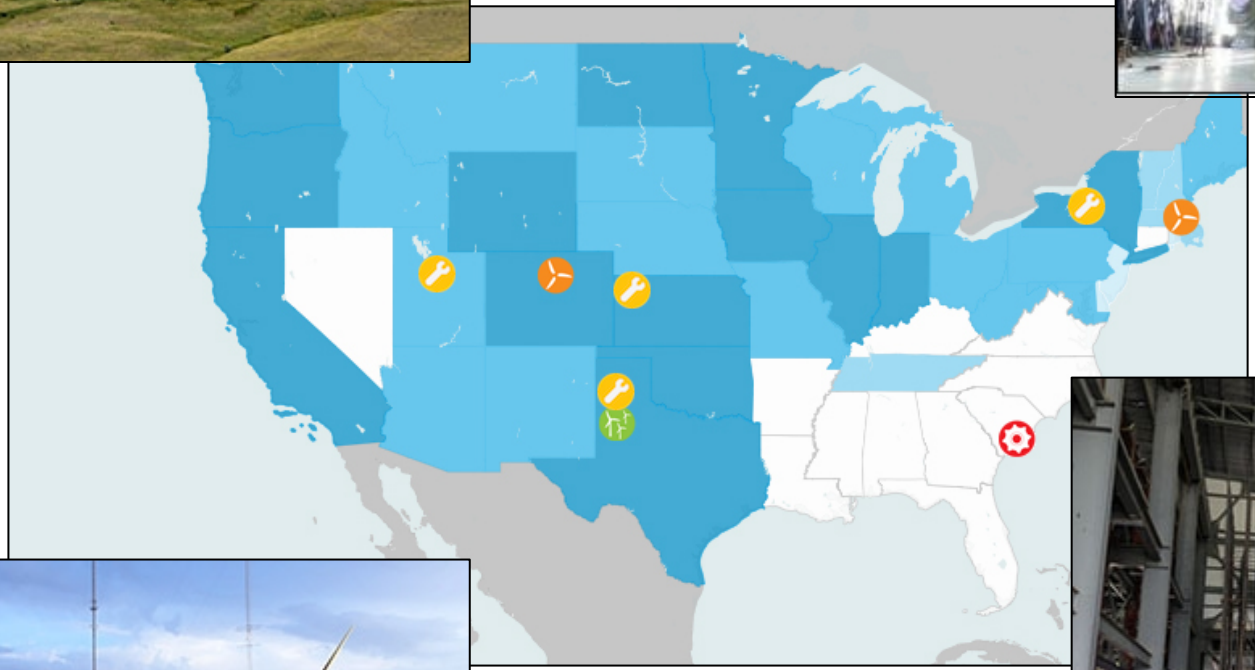
- Build on success of the EGS demonstrations project portfolio; demos provide foundational knowledge that a FORGE-scale effort can accelerate
- Test technologies and take technical risks not possible in private sector
- Work under an aggressive timeframe
- Retain U.S. leadership in EGS innovation and advancement



EERE Wind Testing Sites

National Wind Technology Center
just south of Boulder, Colorado

Wind Technology Testing Center
near Boston, Massachusetts

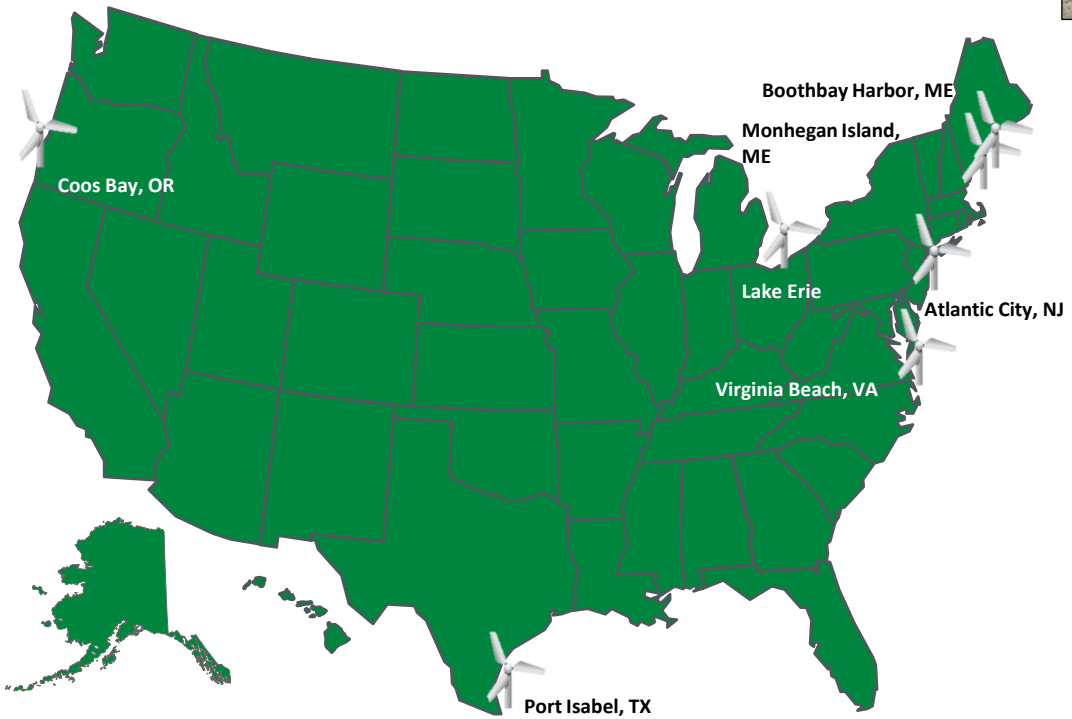


Scaled Wind Farm
Technology Facility
located at Texas Tech
University's Reese
Technology Center in
Lubbock, Texas

Clemson Drivetrain Testing Facility
near Charleston, South Carolina

Technology Development and Testing: Offshore Wind

To promote and accelerate responsible U.S. commercial offshore development through DOE cost-sharing partnerships.



Facilitate gigawatt-scale industry growth by:

- Increasing the knowledge base related to pre-permitting siting studies
- Reducing foundation and balance-of-station costs
- Enabling full-scale testing of components, turbines and arrays
- Supporting deployment of innovative technology.

Projects selected in May 2014 to achieve operation by 2017.

SunShot

Over *60%* Progress toward the SunShot Goal

Less than 4 years into the decade-long SunShot Initiative, the solar industry is already **more than 60%** of the way to achieving cost target of $0.06 per kilowatt-hour for utility-scale PV.

American Solar Manufacturing

- **Solar City/Silevo** to build one of the *world's largest* module factories in Buffalo, NY.
- **Suniva** just began construction on a 200 MW solar manufacturing plant in Saginaw Township, MI
- **Solar World** announced it will add 200 jobs next year and increase its module production capacity by 40%.

U.S. PV manufacturing capacity is poised to *DOUBLE* by 2015

Water Power: Marine and Hydrokinetic (MHK) Technologies

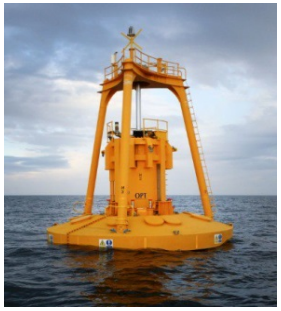
Prior investment successes have accelerated industry development and provided real-world measurable outcomes.

Marine and Hydrokinetics

The Program completed a core set of R&D activities and baseline analytical efforts including:

- **10 Open Water MHK Device Demonstrations**
- **8 System Performance Advancement projects under development**
- **9 MHK Environmental Effects projects**
- **Published 4 MHK cost-reduction pathways reports and models**

These activities provide the necessary guidance from which to identify the MHK industry's highest-leverage R&D and infrastructure development pathways, culminating in the program's Techno-Economic Report to Congress describing cost-reduction potential in MHK technologies and the program's future R&D strategy.



With funding and technical assistance from DOE and landmark permits by FERC, three U.S. companies (ORPC, Verdant Power, and OPT) are putting wave and tidal energy projects in the water

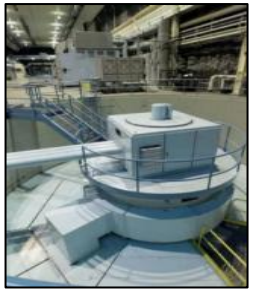
Marine and Hydrokinetics	Technical Resource Estimates CONUS		% US AEP
Wave Energy	472-378 TWh/yr	DOE, 2011	12-9%
Tidal Current Energy	22-15 TWh/yr	DOE, 2011	0.5-0.4%
Ocean Current Energy	163-45 TWh/yr	DOE, 2013	4.0-1.1%
River Current Energy	100 TWh/yr	DOE, 2012	2.5%
Total	**757-538 TWh/yr**		19-13%

Initial estimates suggest significant addressable potential, with Wave Energy contributing the largest proportion of MHK contribution to U.S. Annual Energy Production

Hydropower Opportunities

Existing Facility Improvements

Pumped Storage Hydropower



New Hydro

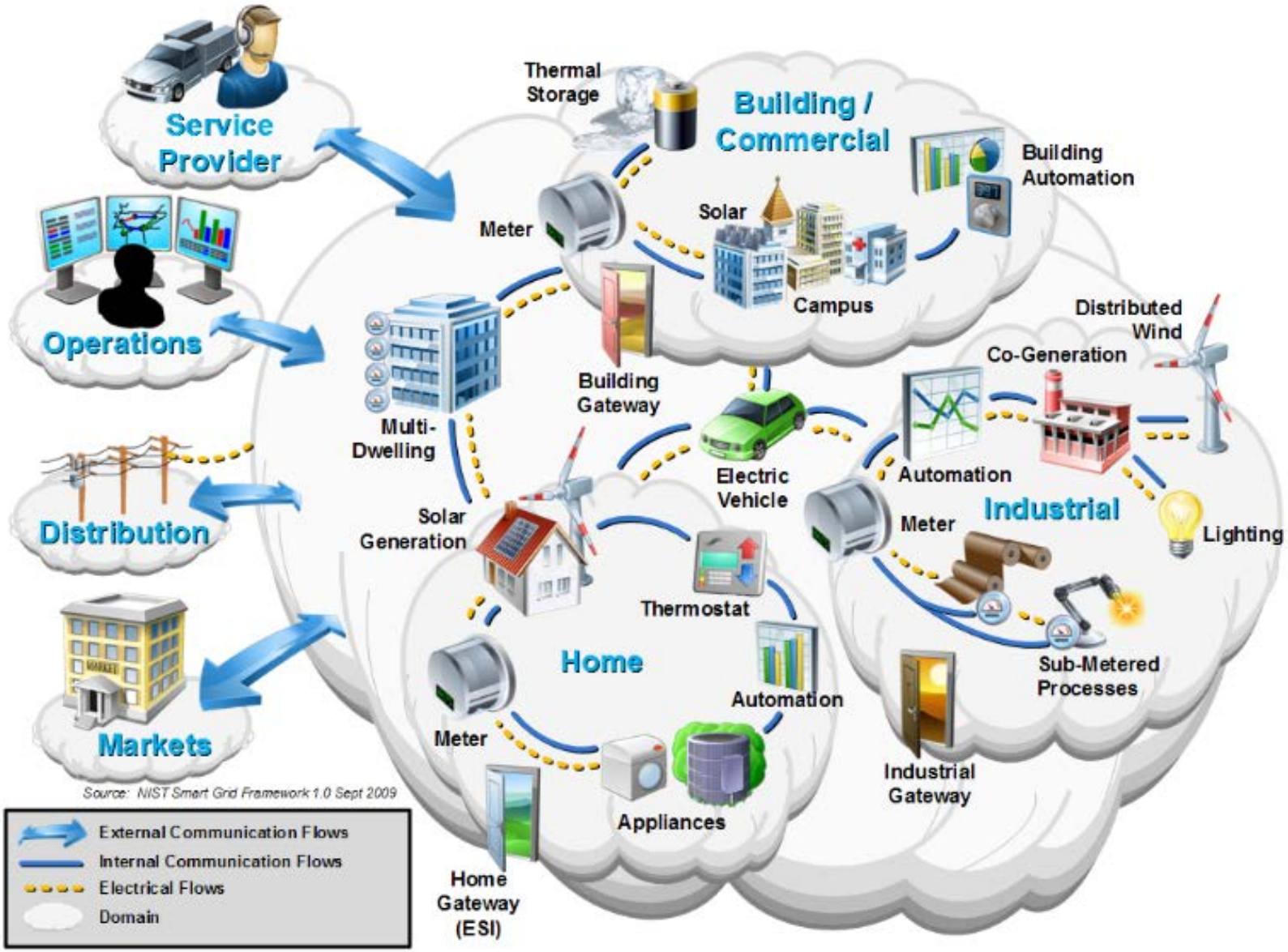
Constructed Waterways

Non-Powered Dams

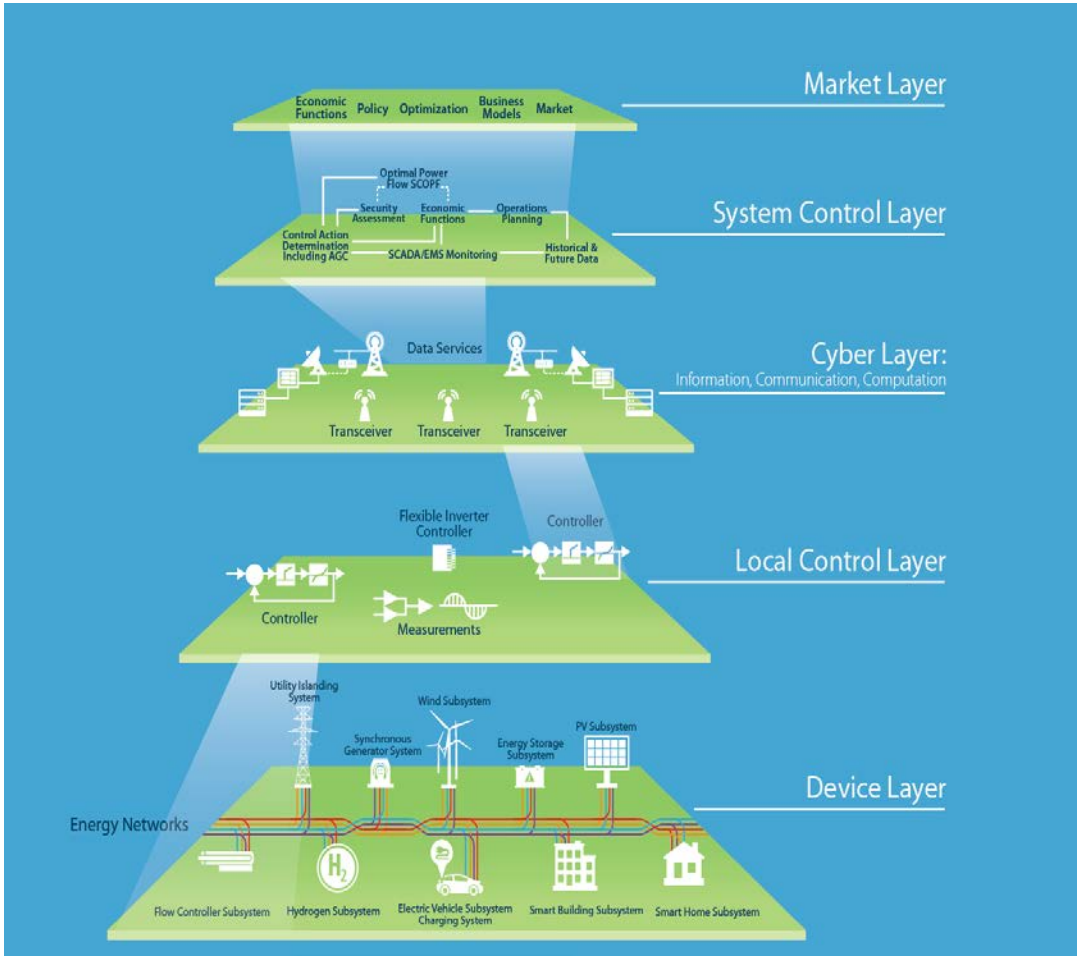
Hydropower has been reliable, flexible, baseload power generation to the U.S. for more than a century, there are significant opportunities to expand generation from hydropower.

- **Existing Water Resources Infrastructure:** Performance improvements of up to 20% can be readily and cost effectively achieved at existing hydro assets. Up to 15 GW of new capacity can be quickly added at existing non-powered dams and CW's.
- **New Stream-Reach Development:** There are more than 80 GW of potential at new hydro sites on undeveloped stream reaches.
- **Pumped Storage Hydropower:** A proven and successful grid-scale energy storage solution with a wide range of ancillary benefits that facilitates the integration of other variable renewable generation resources.

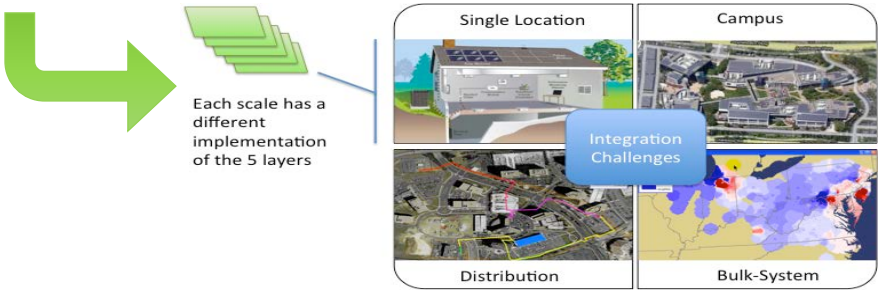
Grid Integration Initiative



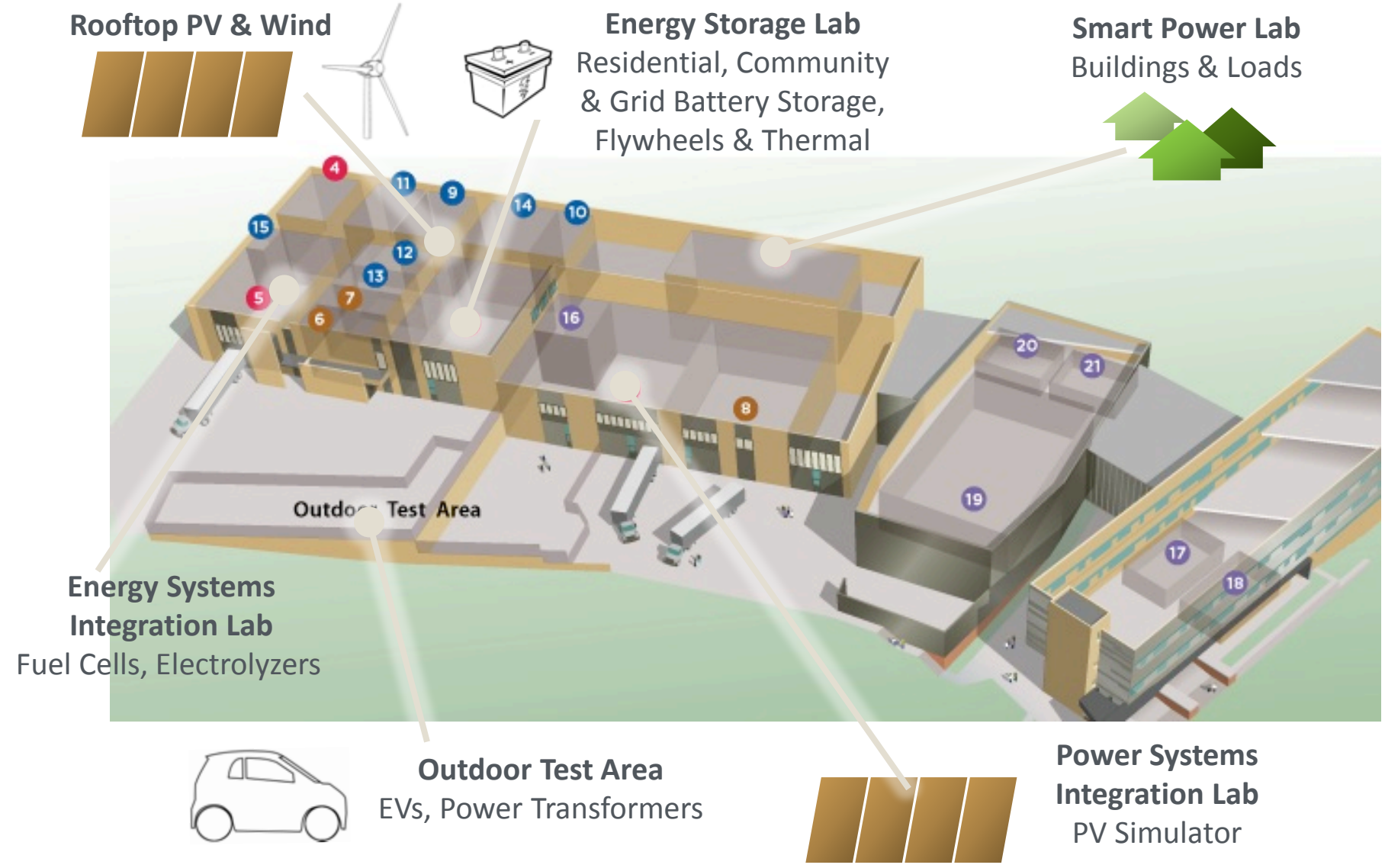
Layered Energy System Integration Capability



- **Market Layer**, responsible for addressing economic, optimization, regulatory, financial, and policy aspects of the system and its environment.
- **System Control Layer**, responsible for the system level concerns of security and reliability of a collection of connected devices interconnected to hosting infrastructures. This layer includes monitoring, system estimation, energy network security assessment, etc.
- **Cyber Layer**, including communications, information and computation platforms, necessary to support control applications at the system level.
- **Local Control Layer**, consisting of the electromechanical, electronic or software based modules necessary to control a single device (in the Device Layer) in a stand-alone manner.
- **Device Layer**, consisting of the physical energy devices that produce, consume, store or transport energy (e.g. high voltage wires, a wind turbine and generator, a battery, a pipe, the power elements of a transformer, a refrigerator motor, or a dishwasher).



Grid Integration Initiative Energy Systems Integration Facility



Other Energy Policy Points of Emphasis

Secretary Moniz on Nuclear Energy

February 19, 2014

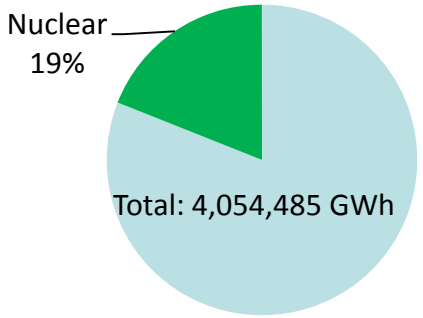
"The Energy Department is committed to strengthening nuclear energy's continuing important role in America's low carbon future, and new technologies like small modular reactors will help ensure our continued leadership in the safe, secure and efficient use of nuclear power worldwide."
New Investment in Innovative Small Modular Reactor, December 12, 2013

"All-of-the-above is not merely a slogan, but a clear-cut pathway to creating jobs and at the same time reducing carbon emissions, which recently stood at their lowest level in 20 years…
President Obama has made clear that he sees nuclear energy as part of America's low carbon energy portfolio. And nuclear power is already an important part of the clean energy solution here in the United States."
The National Press Club, February 19, 2014

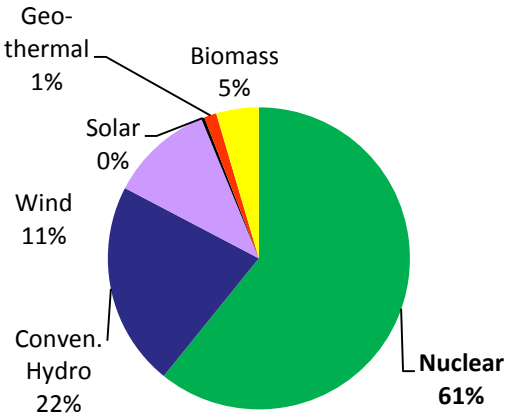
Nuclear Energy Plays an Important Role in US Energy Supply

- Nuclear power is a clean, reliable base load energy source
  - Provides 19% of U.S. electricity generation mix
  - Provides 61% of U.S. emission-free electricity
  - Avoids about 700 $MMTCO_2$ each year
  - Helps reduces overall NOx and SOx levels
- U.S. electricity demand projected to increase ~28% by 2040 from 2011 levels
- 100 GWe nuclear capacity - 100 operating plants
  - Application for license renewal for 60 years of operation under consideration

Electricity Production, 2014

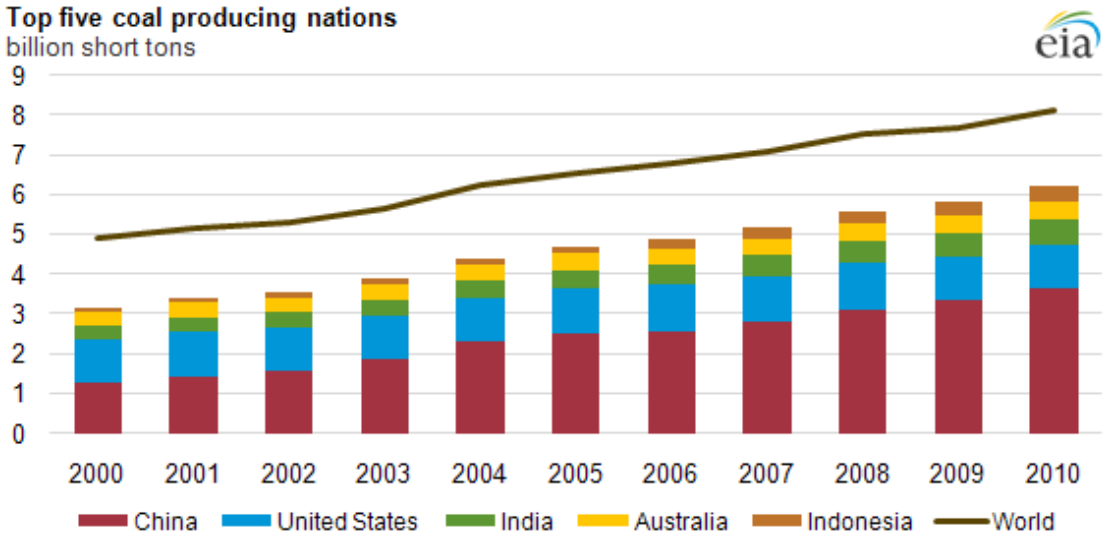


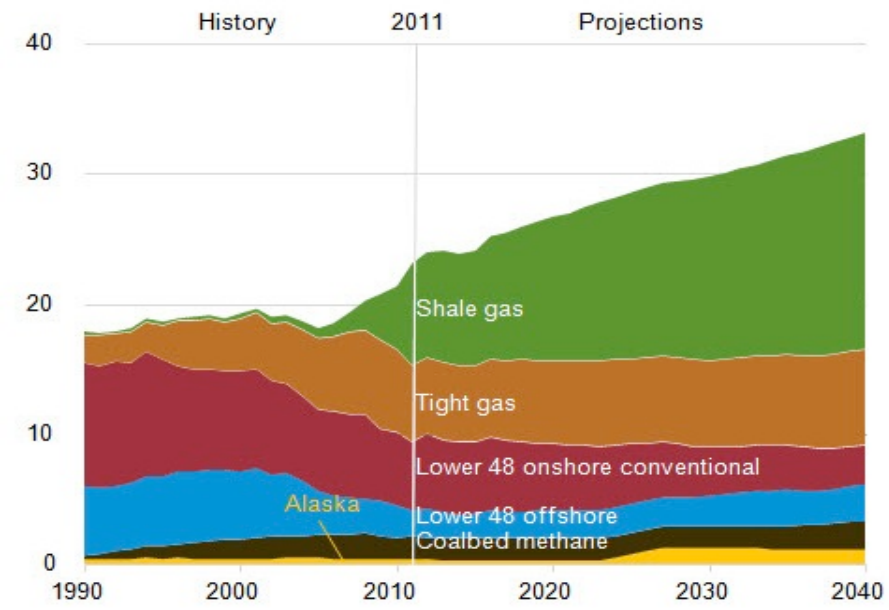
Net Non-Carbon Emitting Sources of Electricity, 2014

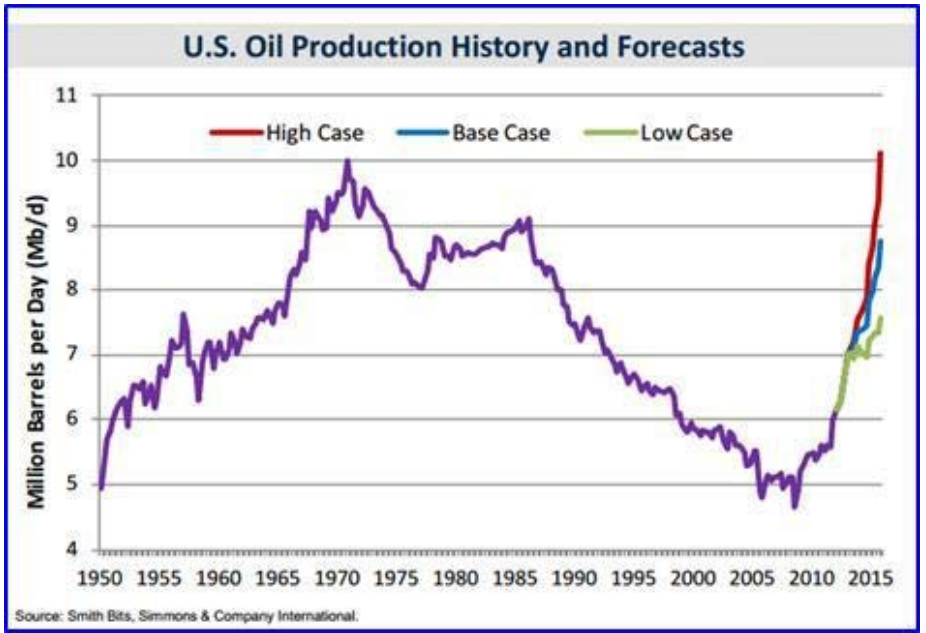


Source: Energy Information Administration

US Energy Picture: Abundant Coal, Gas, and Oil

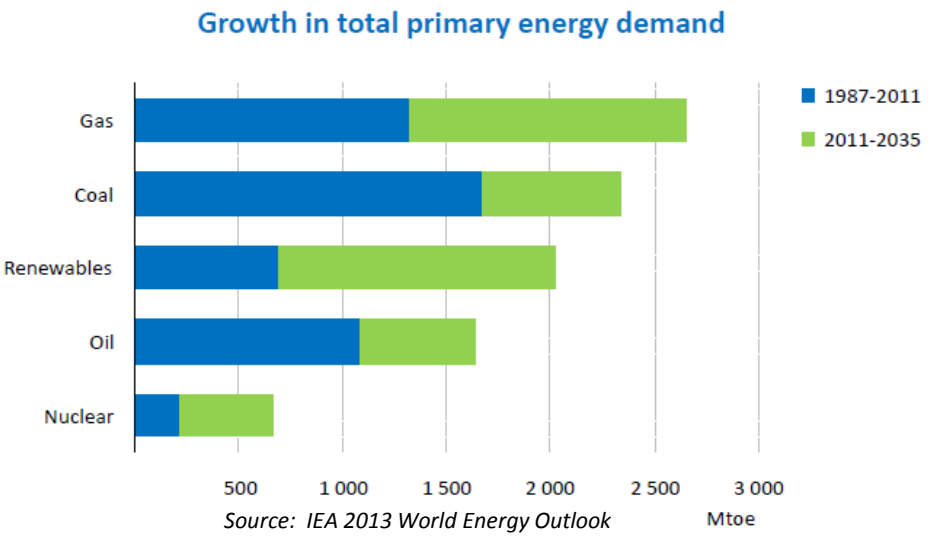






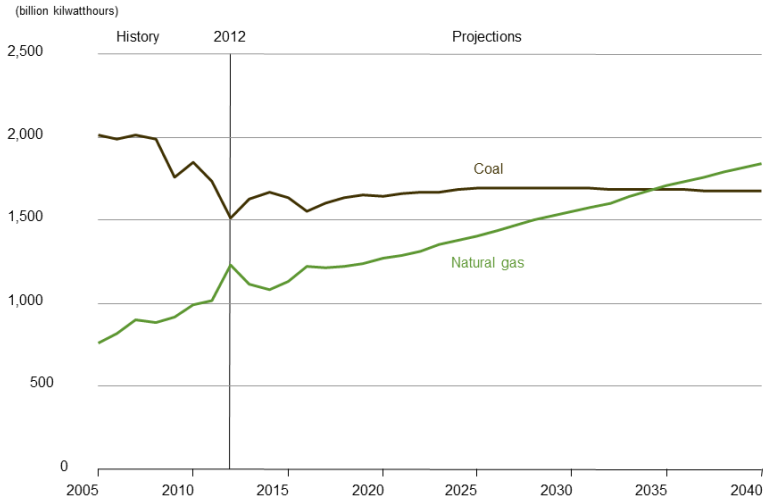
Future of Fossil Energy Demand and Generation

- Fossil fuel use still robust, accounts for 75% of global primary energy demand in 2035
- Even with robust natural gas growth, coal is still a major source of global energy demand and domestic electricity generation
- Fossil Energy remains dominant share (68%) of United States electricity generation in 2040
- ***With this continued use and growth is a need to address CO2 emissions***



Source: IEA 2013 World Energy Outlook

Figure 3. Electricity generation from natural gas and coal, 2005-2040



Source: EIA 2014 Annual Energy Outlook

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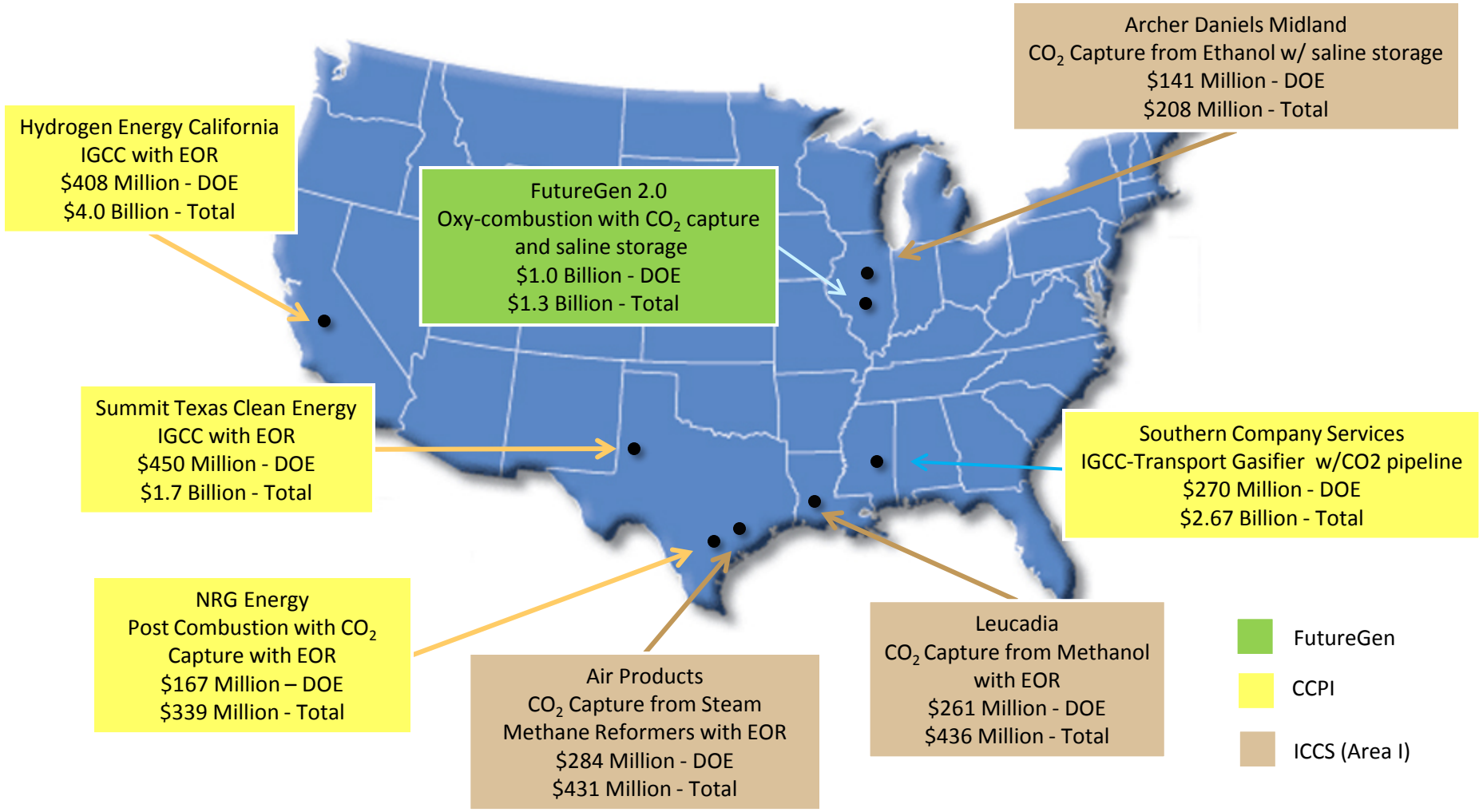
DOE CCUS Demonstration Projects

Focus – Large-scale commercial demonstration of CCUS integrated with coal power generation and industrial sources.



THANK YOU