

# RENEWABLE ENERGY

## RENEWABLE ENERGY: TECHNOLOGY, TRENDS, AND ECONOMICS

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February 5, 2013

Steve Chalk

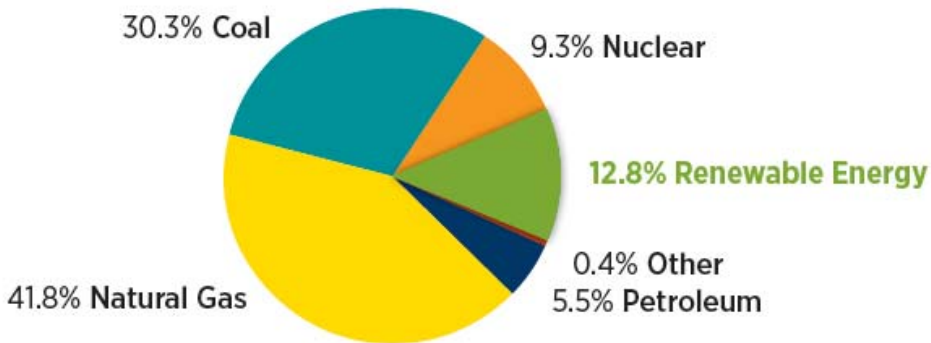
Deputy Assistant Secretary

Office of Energy Efficiency and Renewable Energy

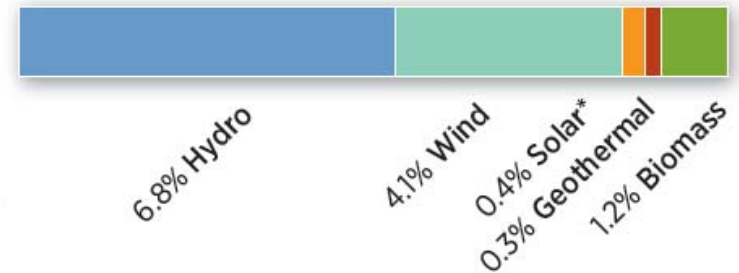
Department of Energy

# U.S. CAPACITY AND GENERATION

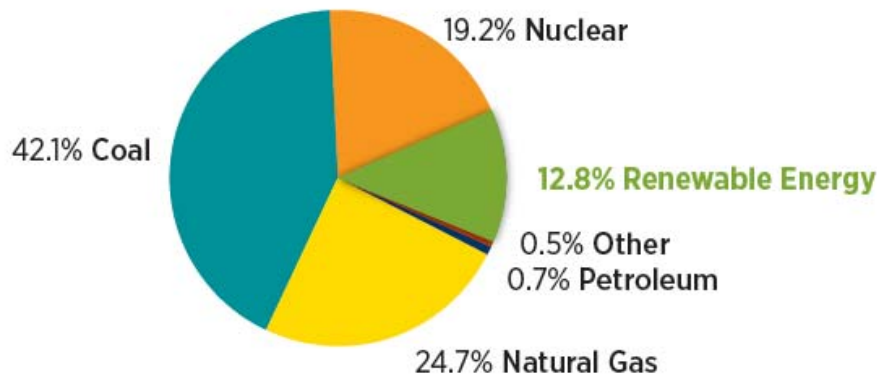
U.S. Electric Nameplate Capacity (2011): 1,146 GW



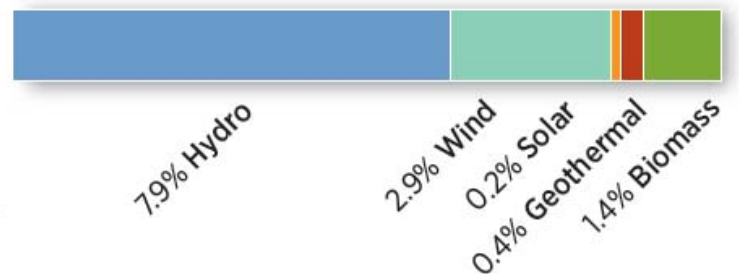
U.S. Renewable Capacity: 146 GW



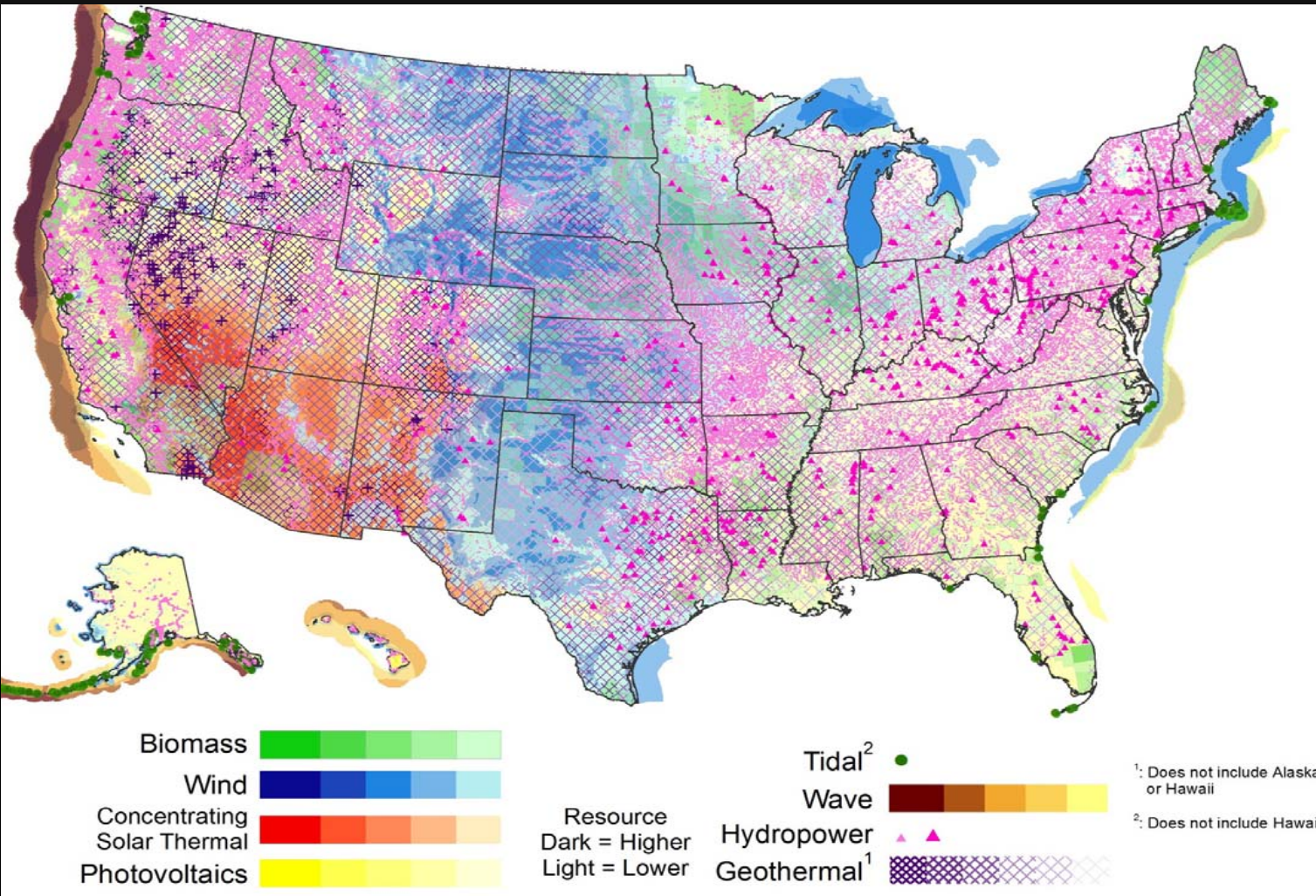
U.S. Electric Net Generation (2011): 4,117 million MWh



U.S. Renewable Generation: 526 million MWh



# DIVERSE AND ABUNDANT DOMESTIC SUPPLY OF NATURAL RESOURCES



| Resource    | Theoretical Potential       |
|-------------|-----------------------------|
| Solar       | 155,000 GW (PV)             |
|             | 38,000 GW (CSP)             |
| Wind        | 11,000 GW (onshore)         |
|             | 4,200 GW (offshore to 50nm) |
| Geothermal  | 38 GW (conventional)        |
|             | 4,000 GW (EGS)              |
| Water Power | ~500 GW                     |
| Biopower    | 62 GW                       |

Sources: NREL's U.S. Renewable Energy Technical Potentials: A GIS-Based Analysis (2012)  
 DOE's Water Resource Potential

# RENEWABLES CAN PLAY A SUBSTANTIAL ROLE IN MEETING THE NATION'S ENERGY NEEDS

- DOE seeks to develop renewable energy technologies so that they are cost competitive with traditional sources of energy without subsidies
- Major barriers that we address, are access to:

## Low Cost Advanced Technology

- performance, materials, manufacturing

## Market

- institutional barriers, soft costs, etc.

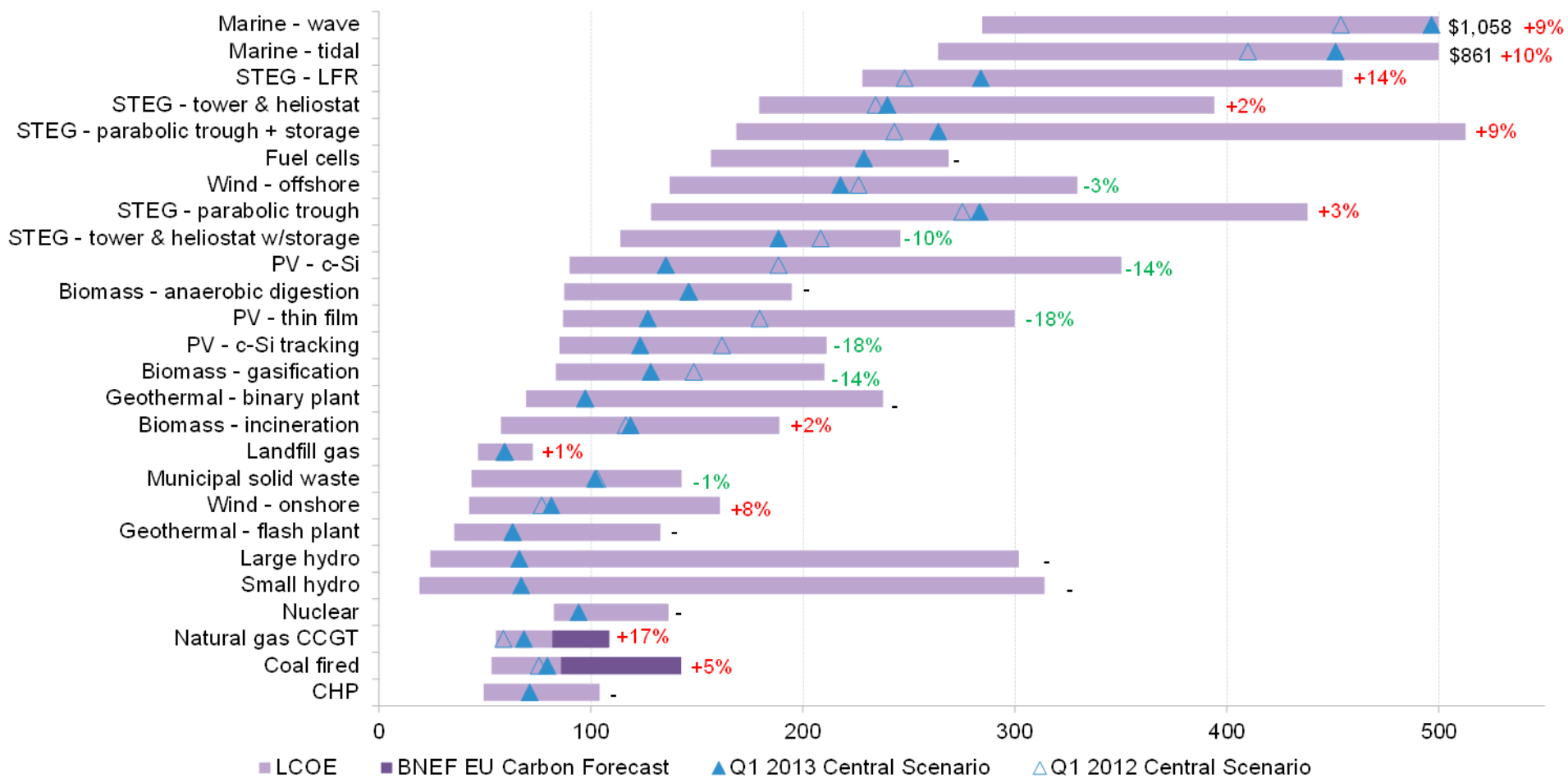
## Low Cost Finance

- scale

# DOE Renewable Power Goal is Cost Parity (Unsubsidized)

## Bloomberg Levelized Cost Of Electricity Q1 2012-Q1 2013 (\$/MWh)

Bloomberg New Energy Finance



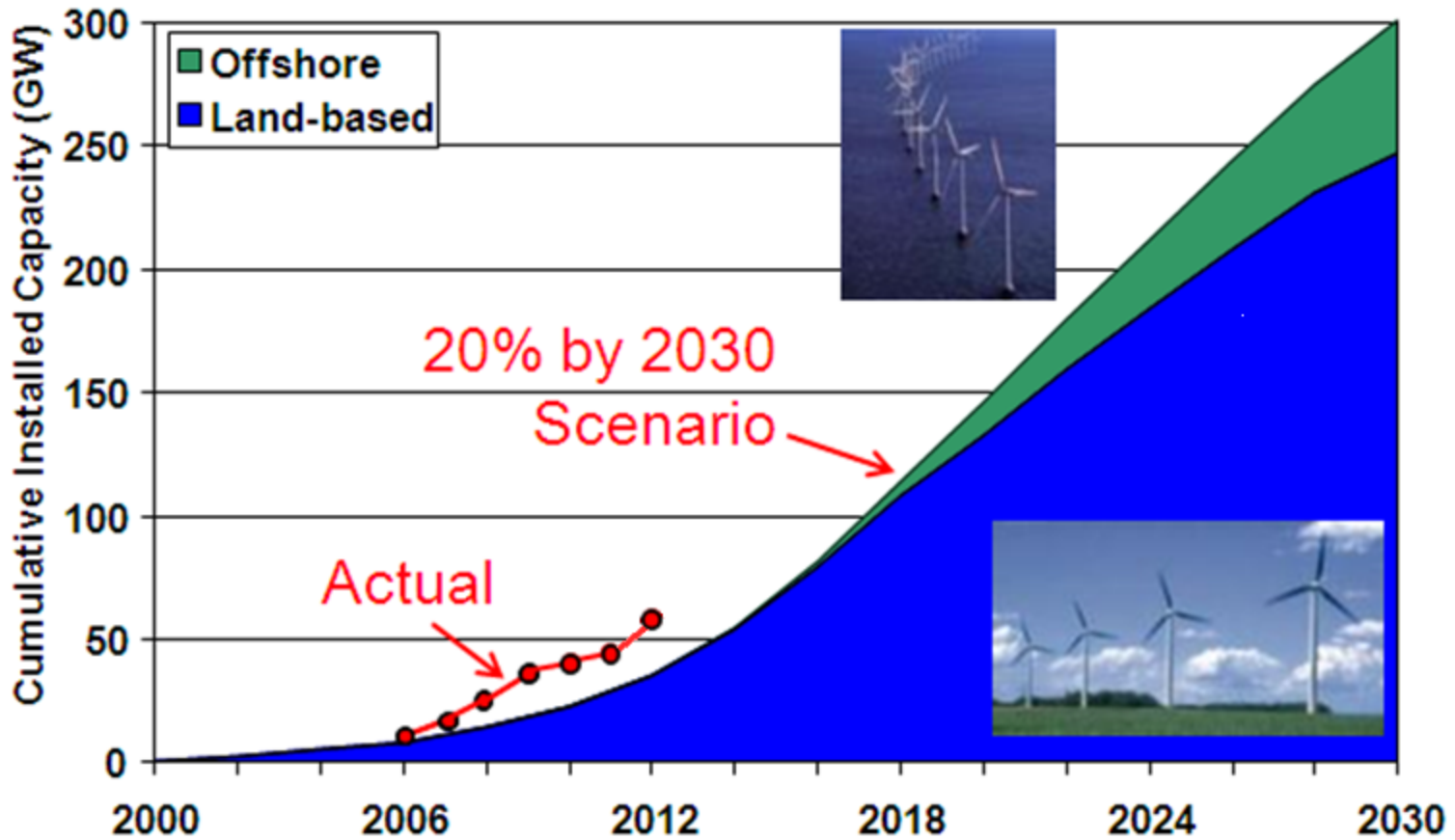
Note: Carbon forecasts from the Bloomberg New Energy Finance European Carbon Model with an average price to 2030 of \$48/mt. Coal and natural gas prices from the US EIA and BNEF. Percentage change represents change from Q1 2012

# STATE OF RENEWABLE ENERGY TECHNOLOGIES



# WIND

## 20% Wind Scenario



# WIND

## DOE EFFORTS



## Land Based Wind

- Optimize wind plant performance/technology
- Advanced component development
- Wind plant reliability improvement

## Offshore Wind

- In 2011, the DOE funded 42 projects around the country to further:
  - Technology development
    - e.g. to advance current state-of-the-art modeling and analysis tools
  - Market barrier removal
    - e.g. analysis to reduce financing costs increase investor confidence
- Late 2012, the DOE announced funding seven advanced technology demonstration projects totaling up to \$168M over six years (subject to appropriations)
  - Phase 1: Seven projects receive up to \$4M to complete the engineering, site evaluation, and planning phase of their project
  - Phase 2: Three of the seven projects would receive funding to advance follow-on design, fabrication, and deployment phases (planned for 2017)



# SOLAR PHOTOVOLTAICS (PV)

Ene

Eco

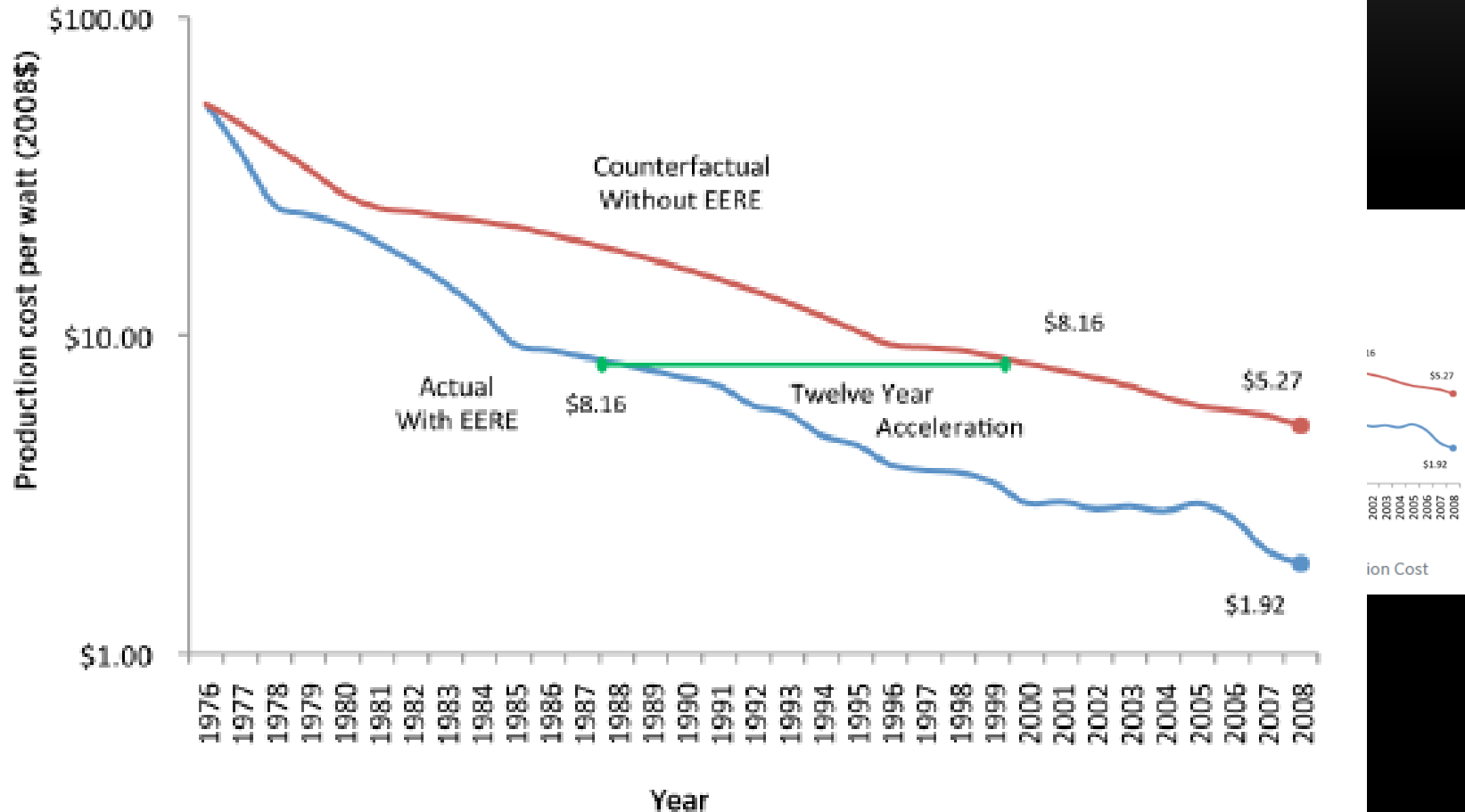
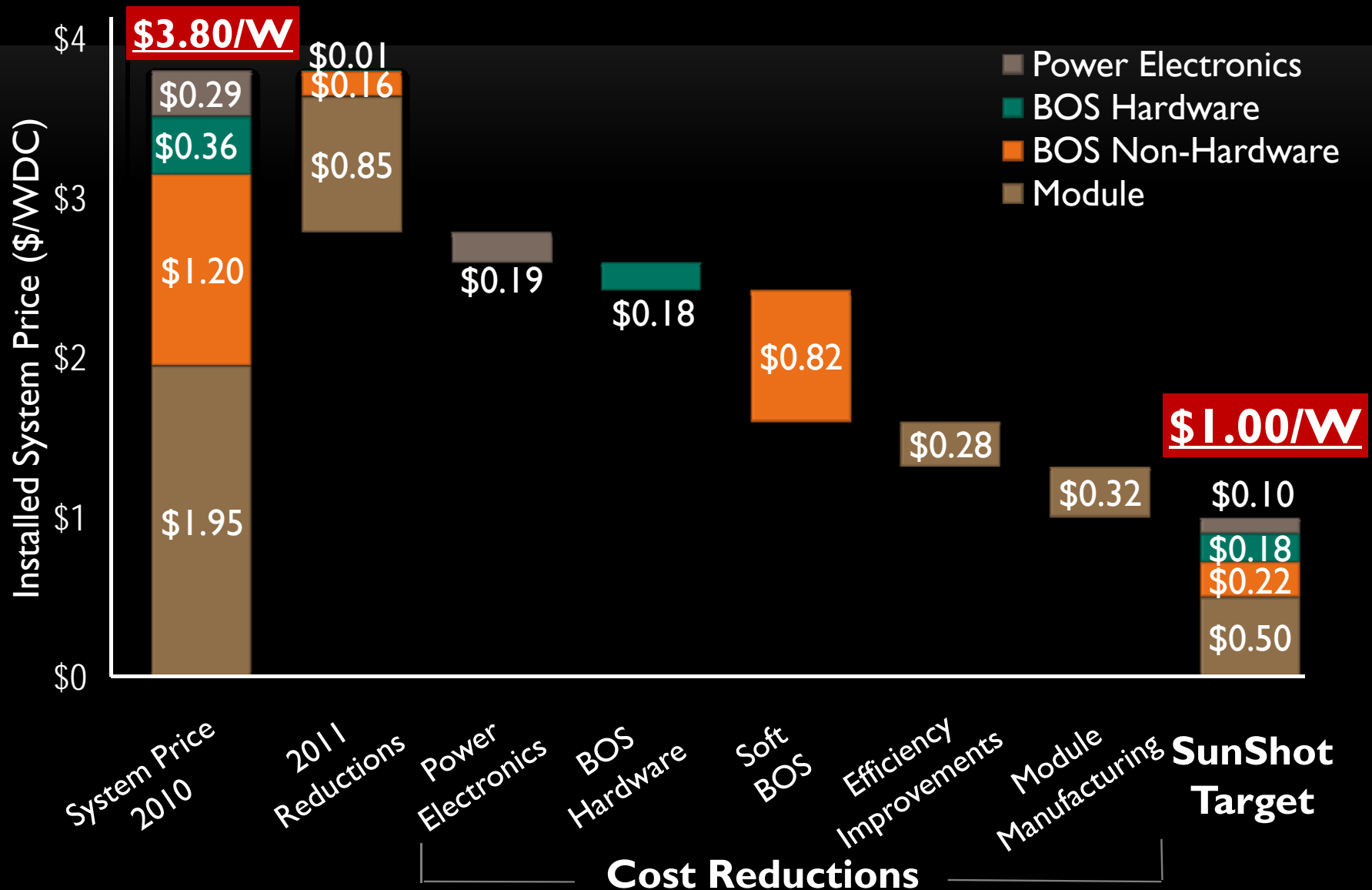


Figure 1: Actual and Counterfactual PV Module Production Cost

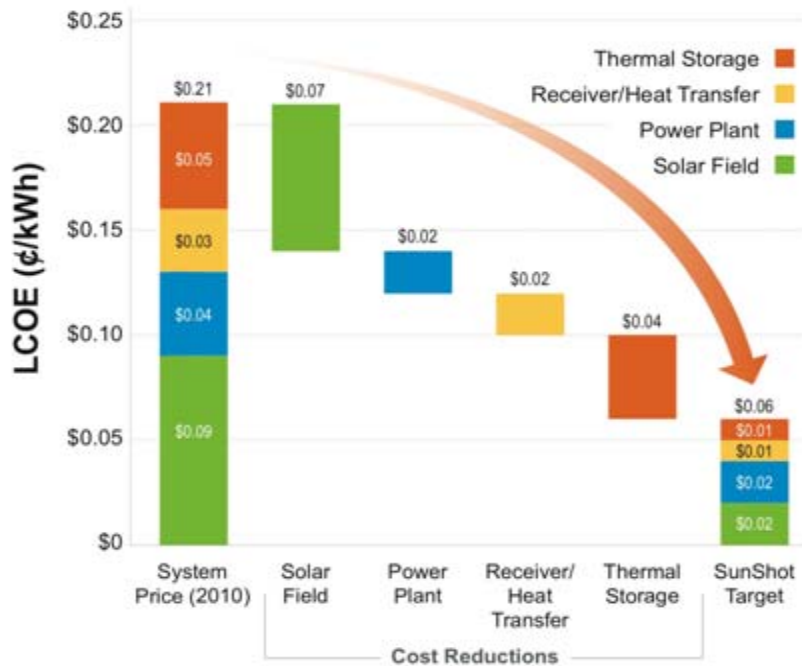
# UTILITY PV – SUNSHOT PV ROADMAP



# SOLAR CONCENTRATED SOLAR POWER ROADMAP

## SunShot Goal

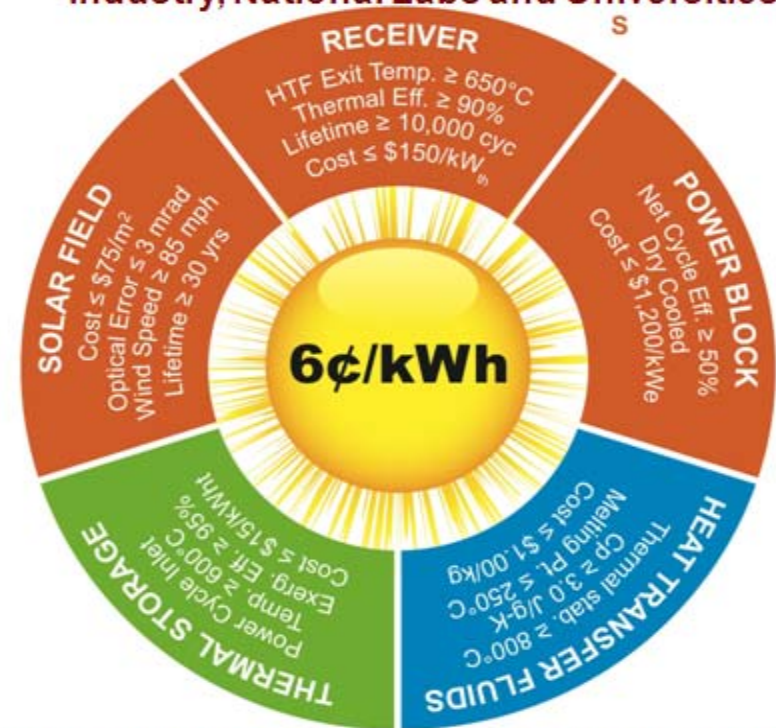
"... The SunShot Initiative is a collaborative national endeavor to make solar energy cost competitive with other forms of energy, without subsidies, by the end of the decade."



## Strategy for CSP FOAs:

### Deconstructing 6¢/kWh

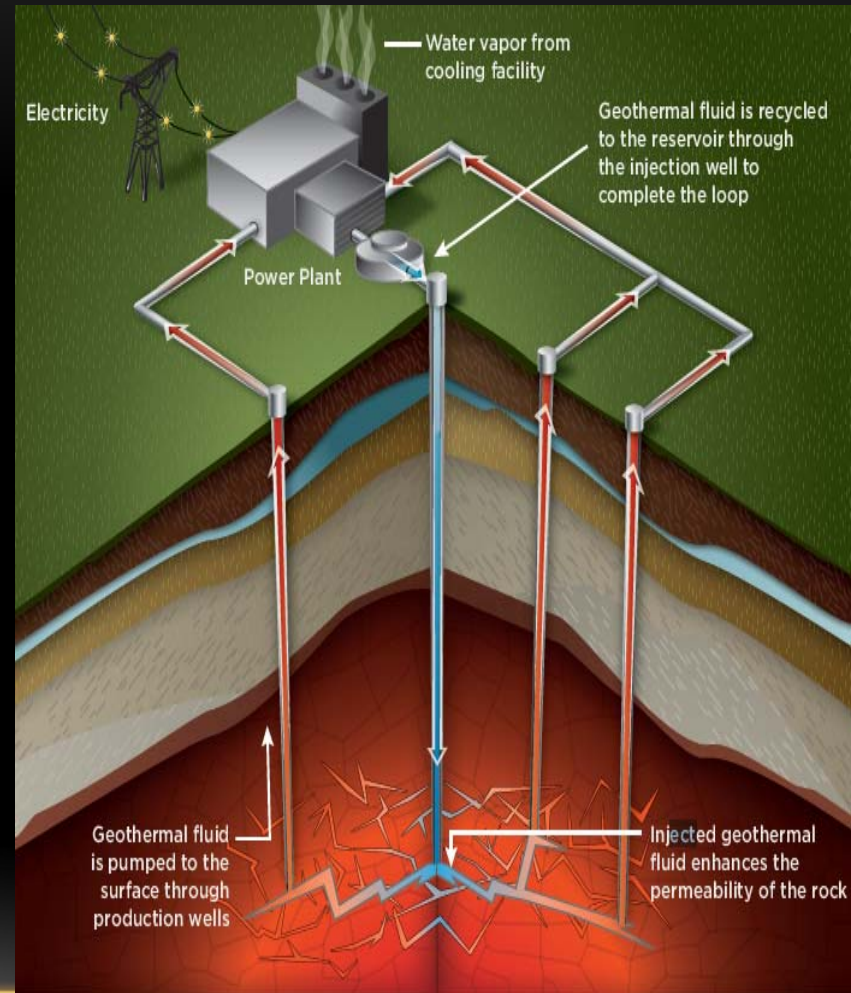
The CSP program competitively funds the Industry, National Labs and Universities



The technical targets have been used as drivers for the competitive funding opportunities

# GEOHERMAL

- Technologies to lower up front risks for near term technologies
  - 7 new geothermal projects came online totaling 147 MW gross capacity in 2012
  - 147 confirmed projects under development in the U.S. with a development capacity of 4.1-4.5 GW
- Enhanced Geothermal Systems (EGS) can tap vast resources and “enhance” current fields
- Focus areas:
  - High temperature logging tools and sensors
  - Zonal isolation
  - Smart tracers
  - Coupled models to predict reservoir development and performance
  - Advanced drilling systems
  - Well Simulation technologies
  - Advanced fracture characterization technologies
  - Induced seismic monitoring, prediction and mitigation tools
- Several EGS demonstrations underway
- Activity in 15 states



# WATER

## Marine and Hydrokinetics (MHK)

Energy from waves, tides, ocean currents, flow of rivers

- Early stage research and development, demonstrating early prototypes



photo: <http://www.orpc.co>

Ocean Renewable Power Company's  
Tidal Energy Project, Maine



photo: <http://climateforce.files.wordpress.com>

First-Ever Grid Connection of a Wave Energy Device  
in the U.S. at Marine Corps Base, Hawaii

## Hydropower

- Has remained stable for the past several decades
- Emphasis on small hydro turbine development

# BIOFUELS

EPA Requires 16.55 billion gallons of renewable fuels in 2013:

- 1.28 billion gallons of biodiesel
  - 1 billion gallons were required in 2012
- 14 million gallons of cellulosic ethanol
  - 8.65 million gallons were required in 2012



## Scaling Cellulosic Ethanol Development

- INEOS Demonstration Project – 8 million gallons of ethanol per year, generate 6MW (gross) power
- Under construction (commercial scale):
  - POET
  - Abengoa

## Cost

- Successfully completed R&D to produce cellulosic ethanol at \$2.65/gal gas equivalent in 2012
- Focus now on bio-based gasoline, diesel, and jet fuel (Goal = \$3/gal (2007 dollars))

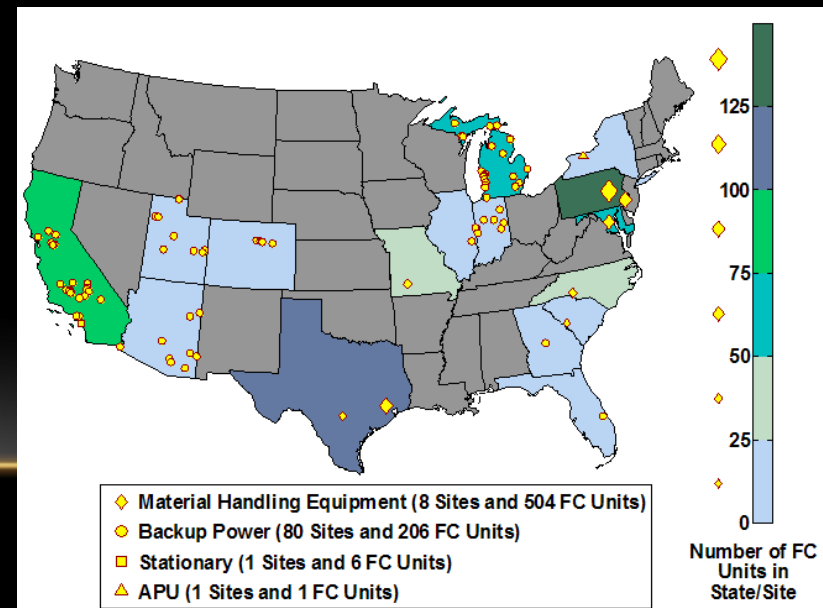
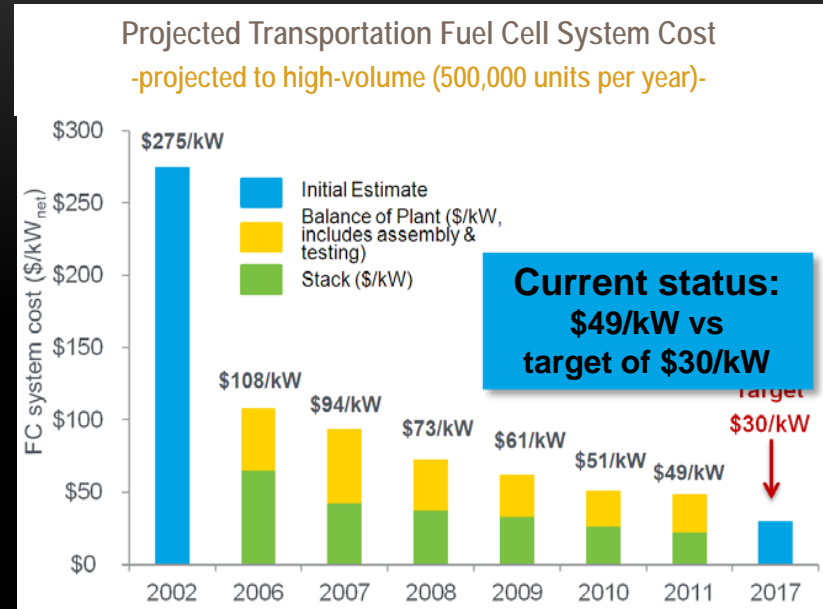
# FUEL CELLS

Projected high-volume cost of fuel cells has been reduced to \$49/kW (2011)

- More than 30% reduction since 2008
- More than 80% reduction since 2002

Real world validation marks progress

- Vehicles & Infrastructure
  - 155 fuel cell vehicles and 24 hydrogen fueling stations with a fill time of 4 to 6 minutes for 4 kg
  - Demonstrated fuel cell efficiency of up to 59%
  - 2,500 hours (nearly 75K miles) durability
  - Validated over 250 mile vehicle range on one fill (430 miles on one vehicle)
- Demonstrated world's first Tri-generation station (CHHP with 54% efficiency)



# Focus on Grid Integration is Key to High Market Penetration of Renewables and Efficiency Technologies

