State Energy Advisory Board Meeting

Update and Overview of Renewable Energy Programs

March 13, 2013

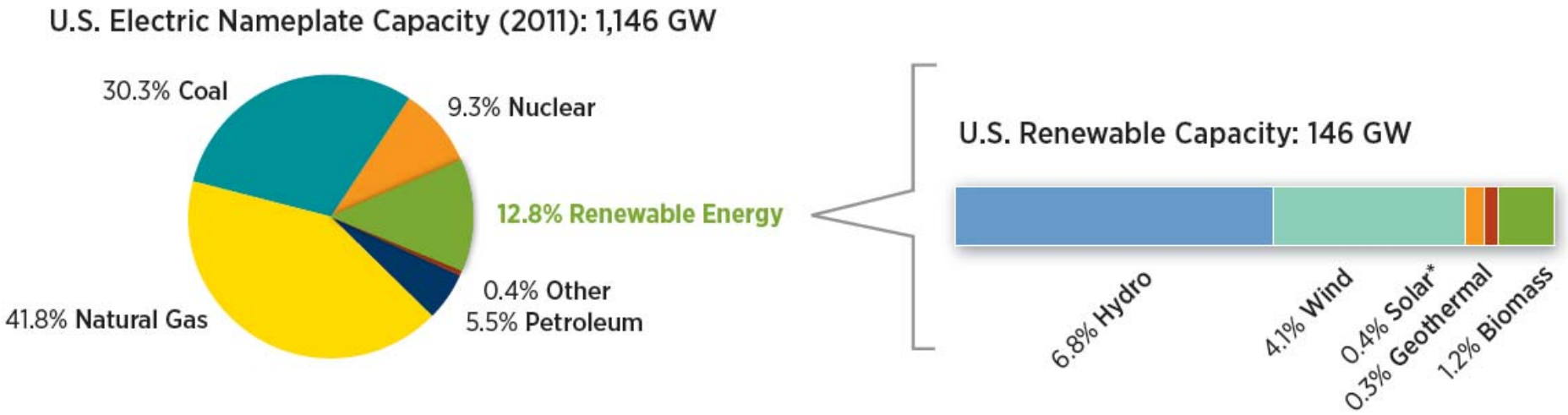
Steve Chalk

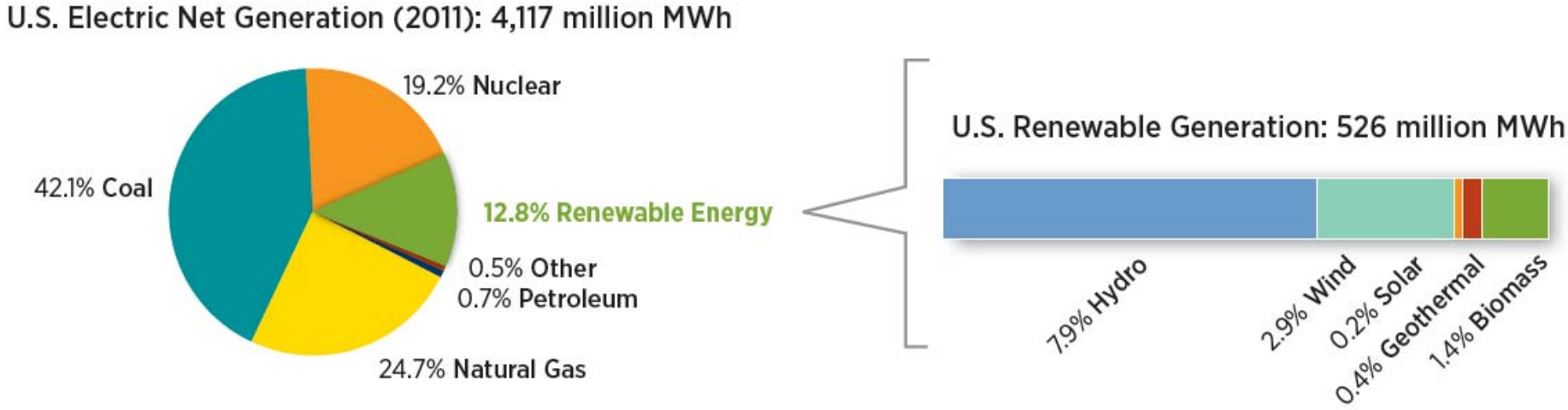
Deputy Assistant Secretary

Office of Energy Efficiency and Renewable Energy

Department of Energy

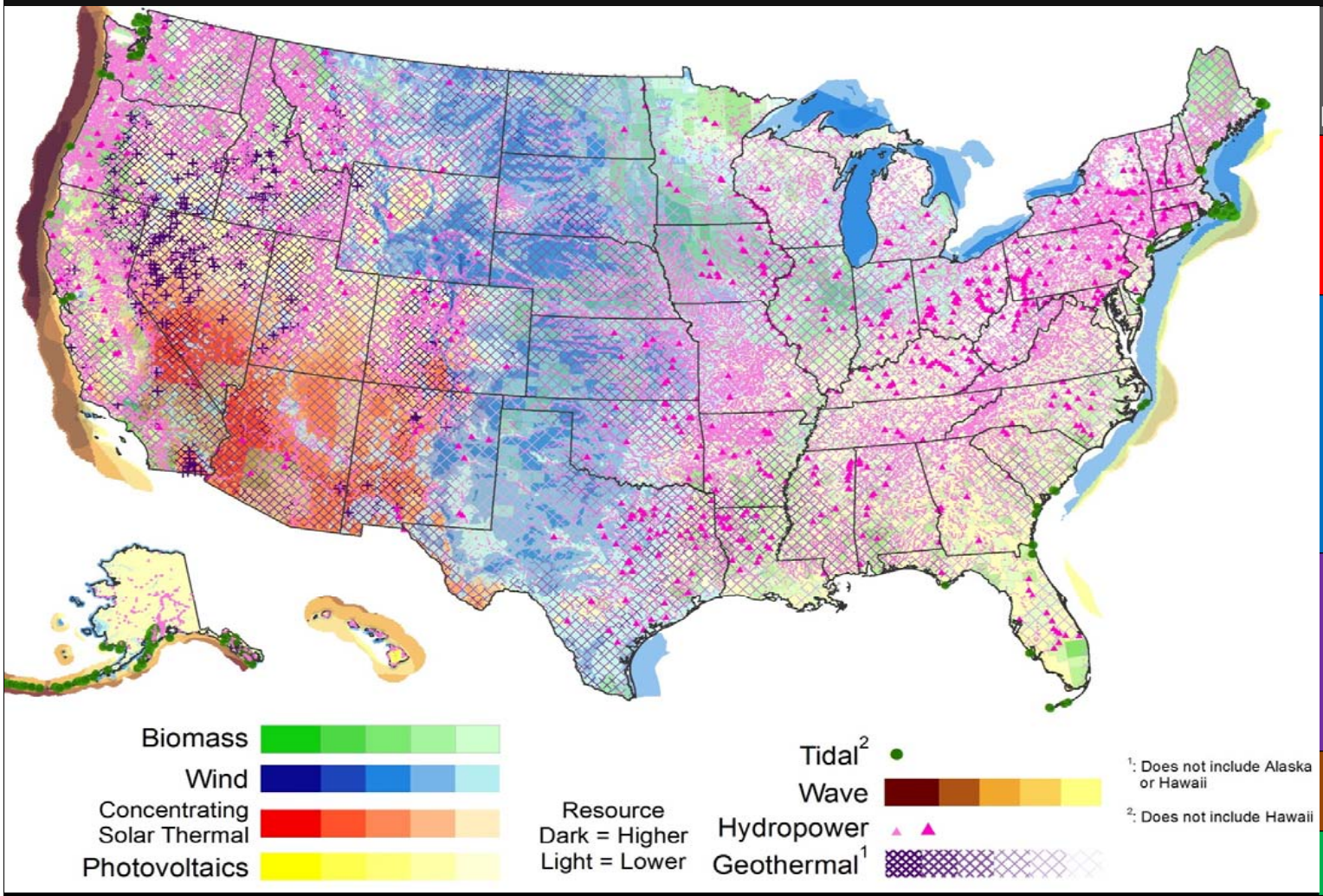
U.S. CAPACITY AND GENERATION





Source: NREL Data Book

DIVERSE AND ABUNDANT DOMESTIC SUPPLY OF NATURAL RESOURCES

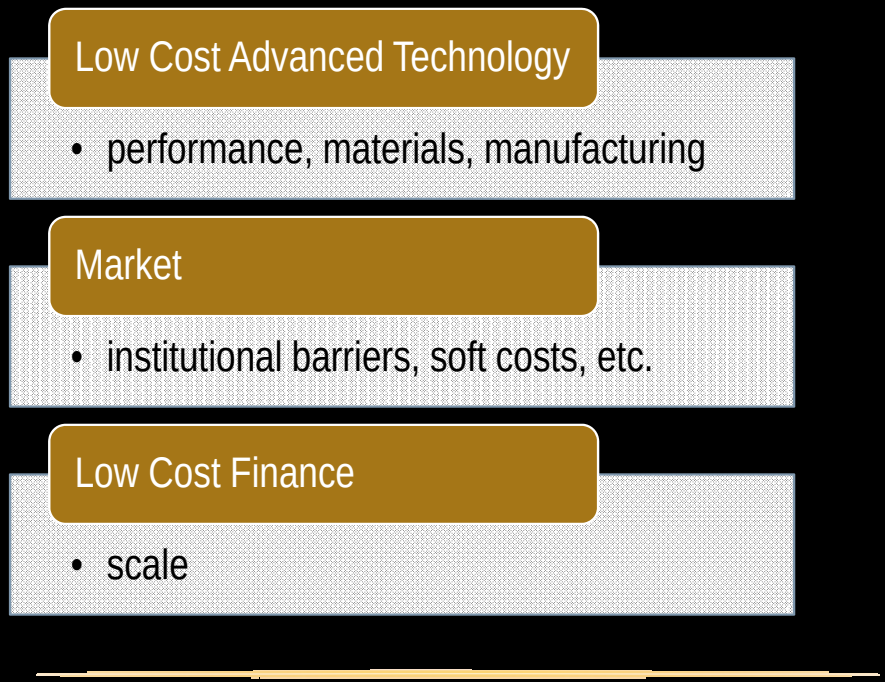


Resource	Theoretical Potential
Solar	155,000 GW (PV)
	38,000 GW (CSP)
Wind	11,000 GW (onshore)
	4,200 GW (offshore to 50nm)
Geothermal	38 GW (conventional)
	4,000 GW (EGS)
Water Power	~500 GW
Biopower	62 GW

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

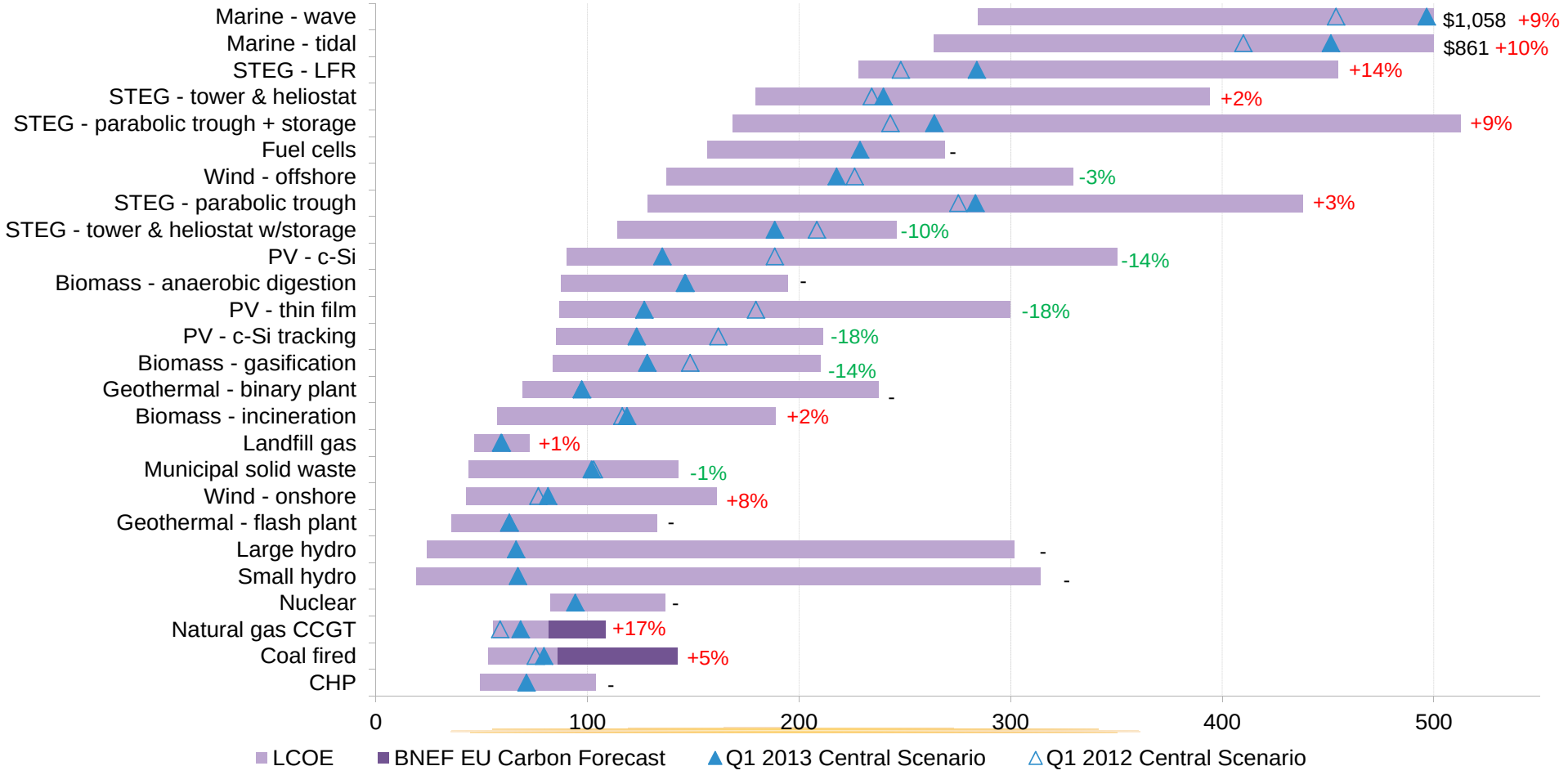
RENEWABLES CAN PLAY A SUBSTANTIAL ROLE IN MEETING THE NATION'S ENERGY NEEDS

- 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:



DOE Renewable Power Goal is Cost Parity (Unsubsidized)
Bloomberg Levelized Cost Of Electricity Q1 2012-Q1 2013 ($/MWh)

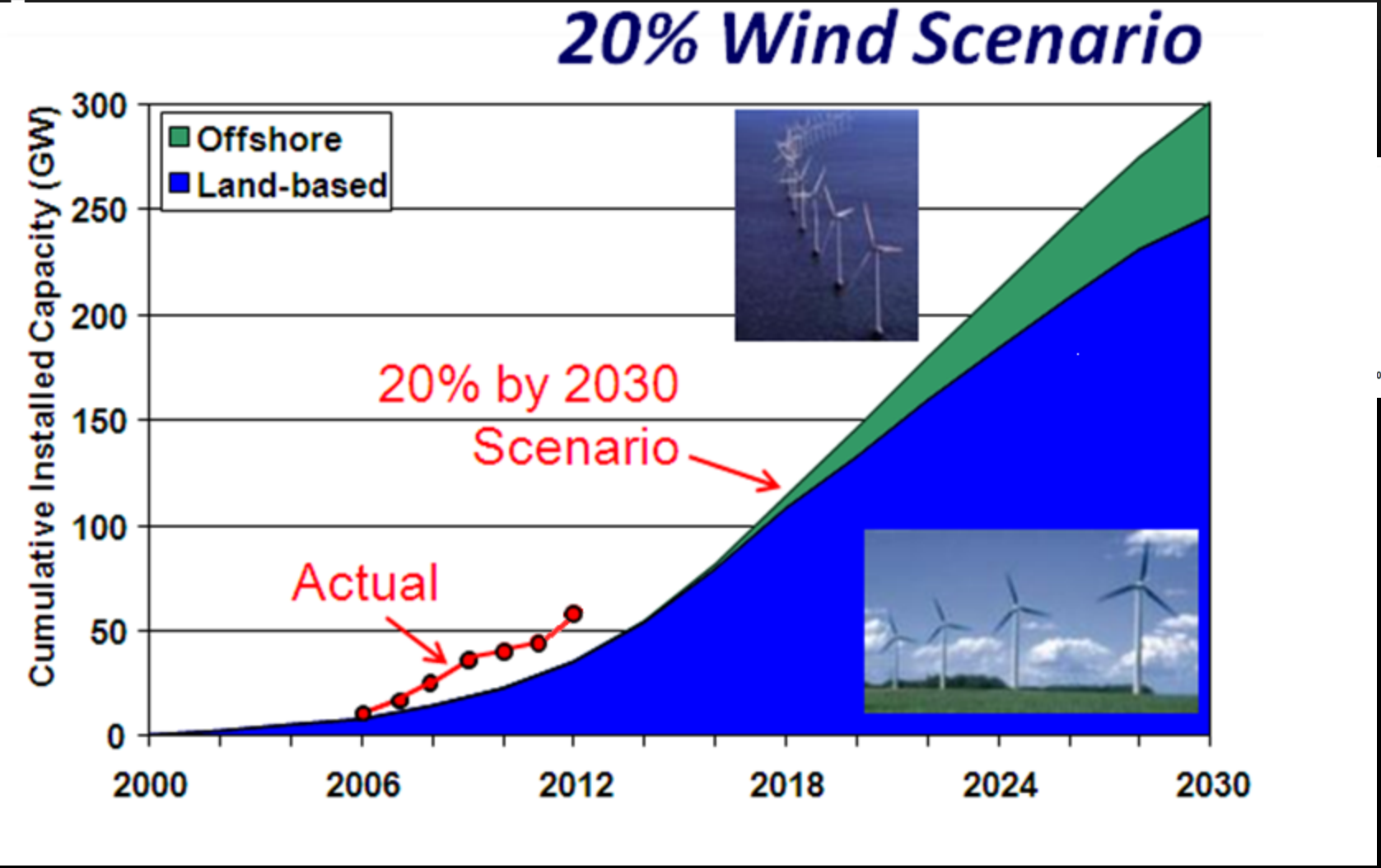
Bloomberg New Energy Finance



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
Cumulative Installed Capacity (GW)
300
250
200
150
100
50
0
Offshore
Land-based
20% by 2030
Scenario
Actual
2000
2006
2012
2018
2024
2030

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

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Eco

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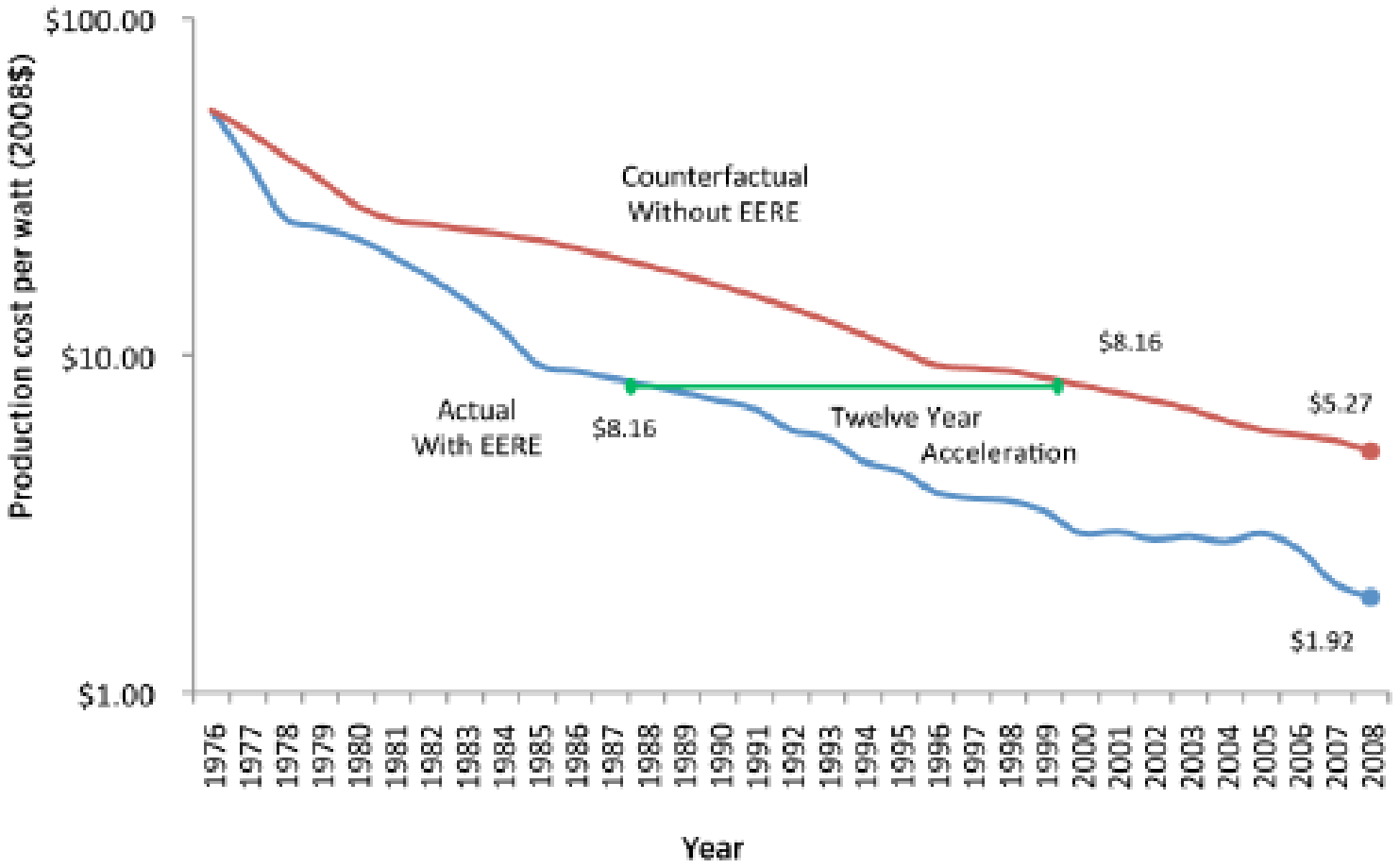
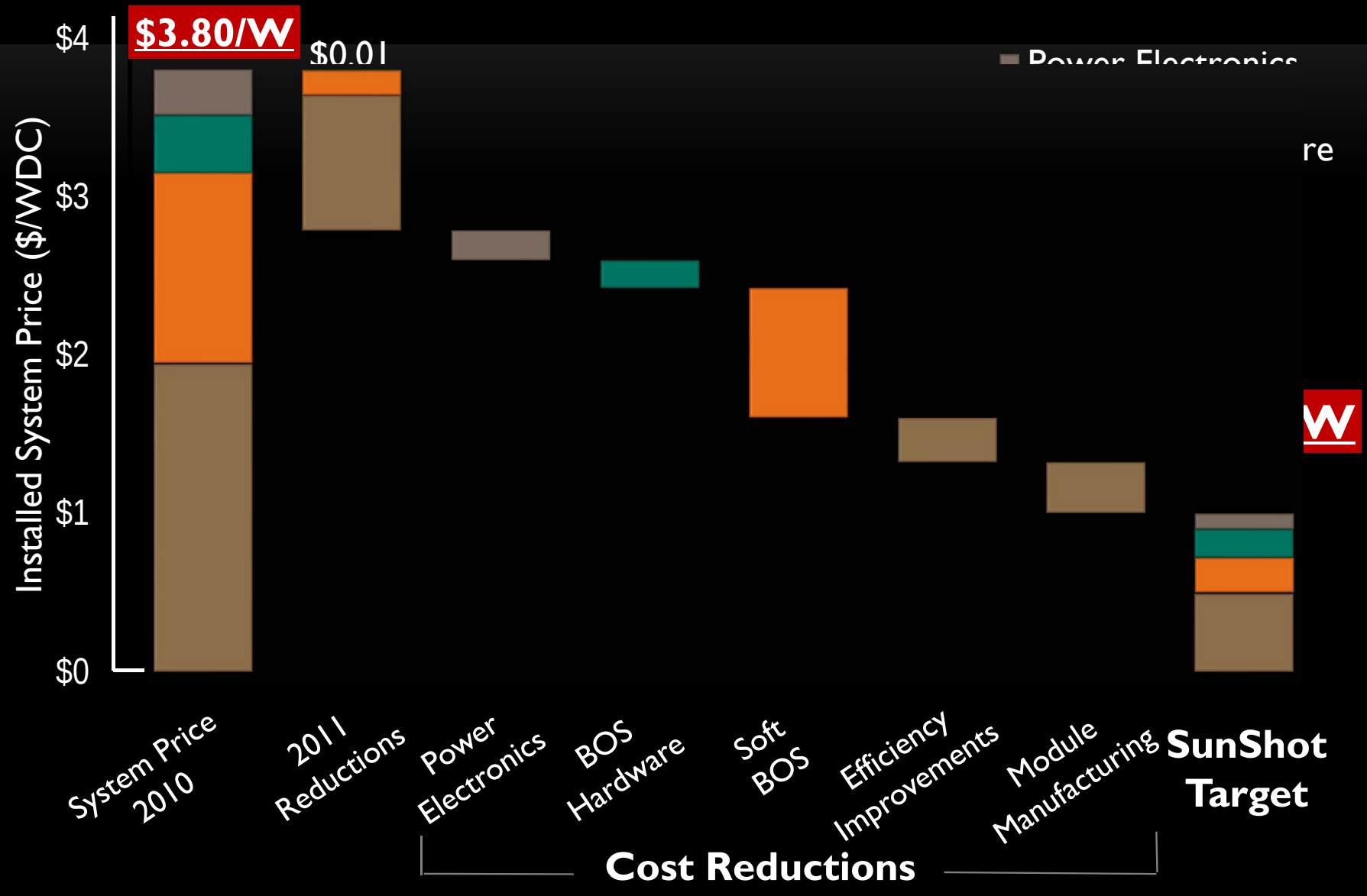


Figure 1: Actual and Counterfactual PV Module Production Cost

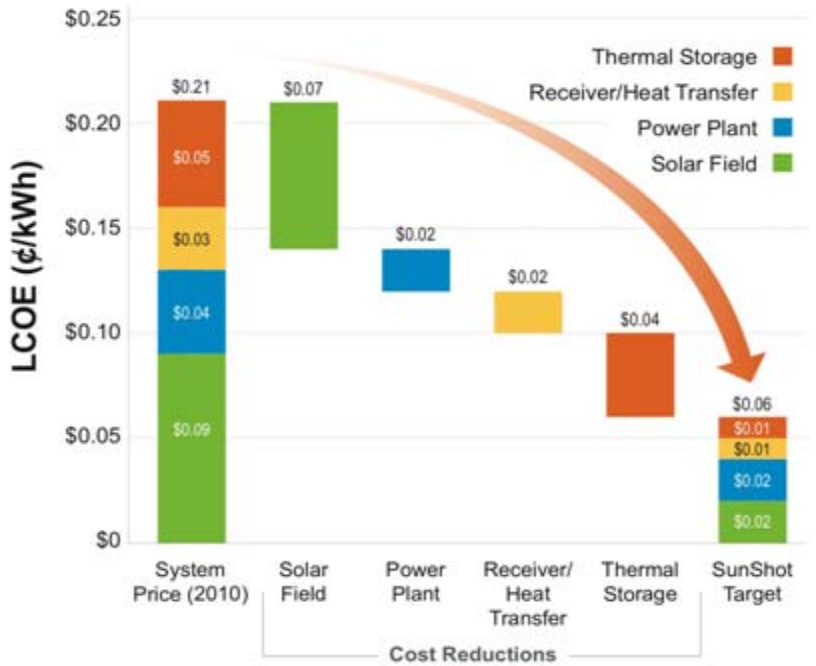
UTILITY PV – SUNSHOT PV ROADMAP



SOLAR CONCENTRATED SOLAR POWER ROADMAP

SunShot Goal

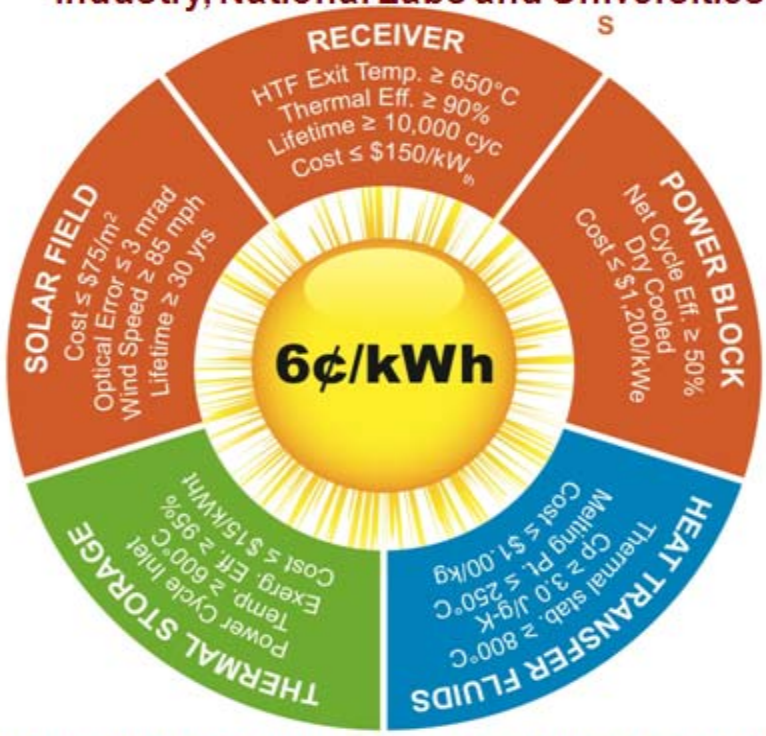
"… The SunShot Initiative is a collaborative national endeavor to make solar energy cost competitive with other forms of energy, without subsidies, by the end of the decade."



Strategy for CSP FOAs:

Deconstructing 6¢/kWh

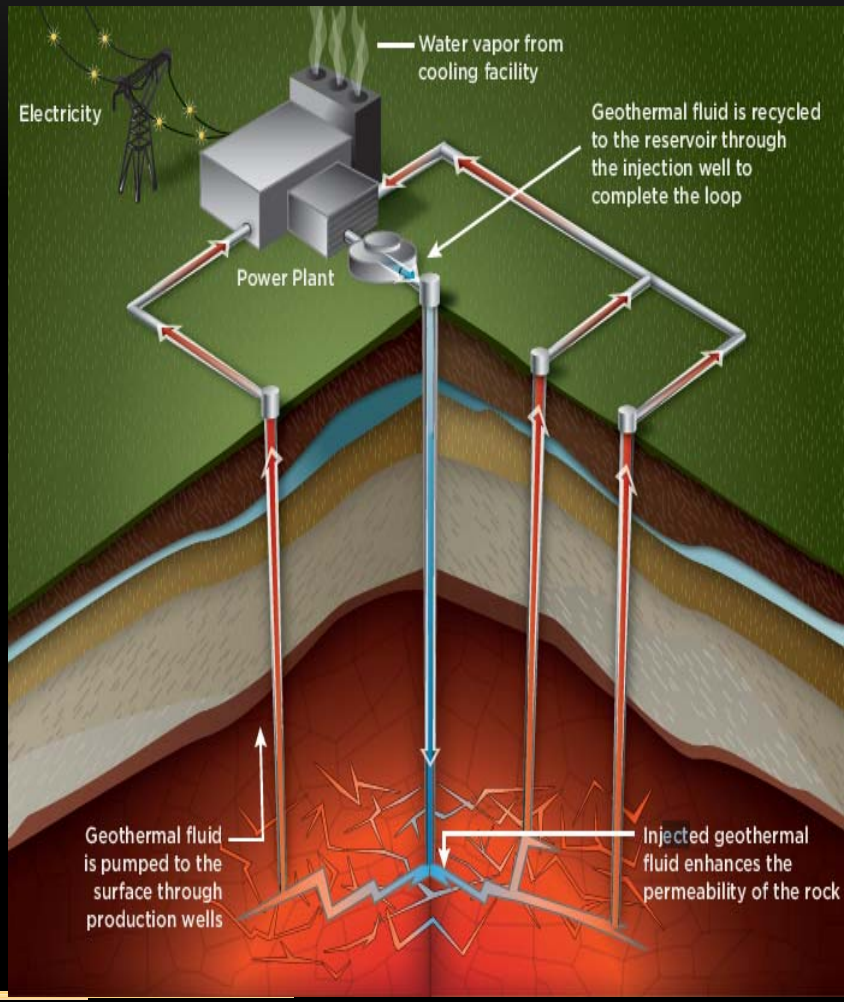
The CSP program competitively funds the Industry, National Labs and Universities



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

GEOTHERMAL

- 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

Ocean Renewable Power Company's
Tidal Energy Project, Maine

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

Successfully completed R&D to produce cellulosic ethanol at $2.65/gal gas equivalent 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

Future Emphasis:

- Focus now on bio-based gasoline, diesel, and jet fuel (Goal = $3/gal (2007 dollars))

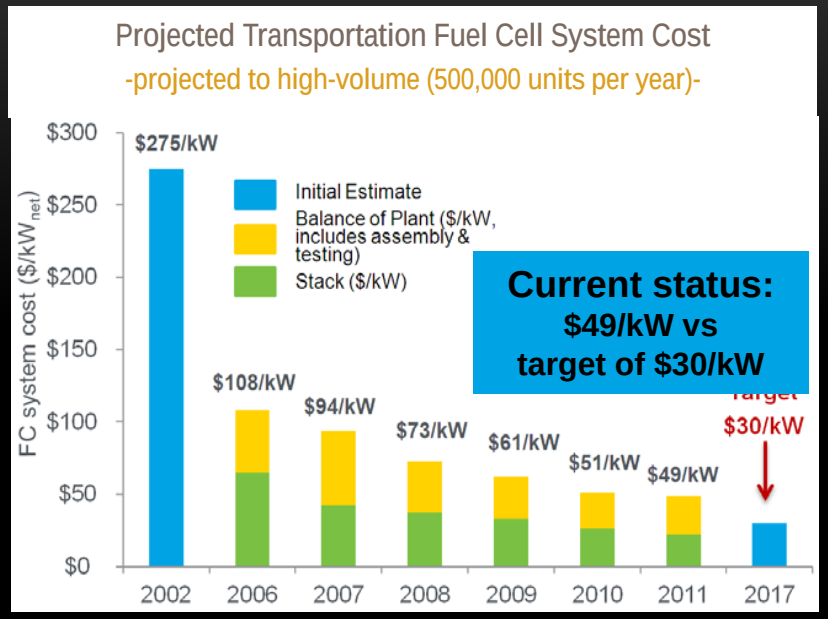
FUEL CELLS

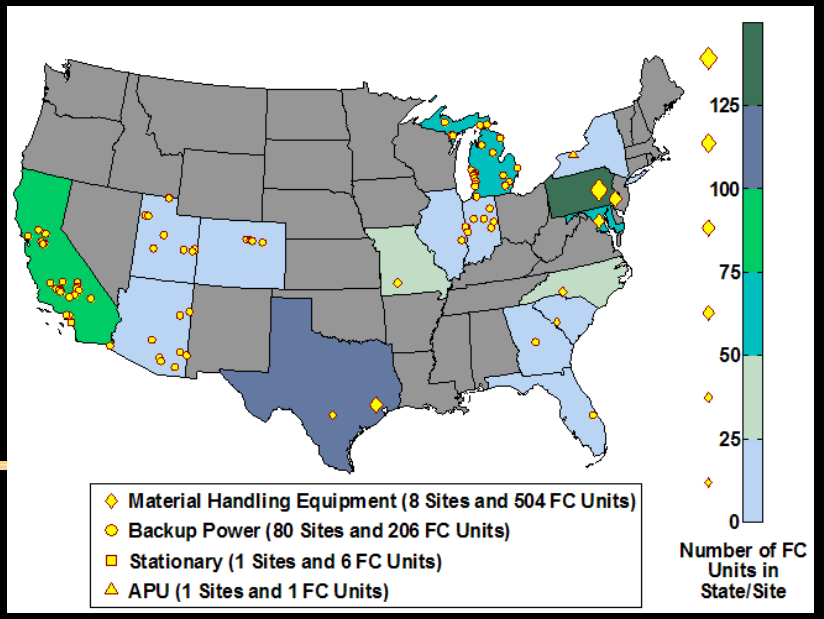
Projected high-volume cost of fuel cells has been reduced to $49/kW (2011)

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

Real world validation marks progress

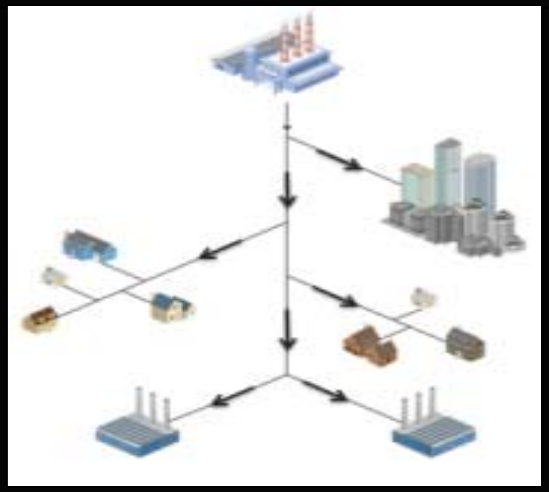
- Vehicles & Infrastructure
  - 155 fuel cell vehicles and 24 hydrogen fueling stations with a fill time of 4 to 6 minutes for 4 kg
  - Demonstrated fuel cell efficiency of up to 59%
  - 2,500 hours (nearly 75K miles) durability
  - Validated over 250 mile vehicle range on one fill (430 miles on one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



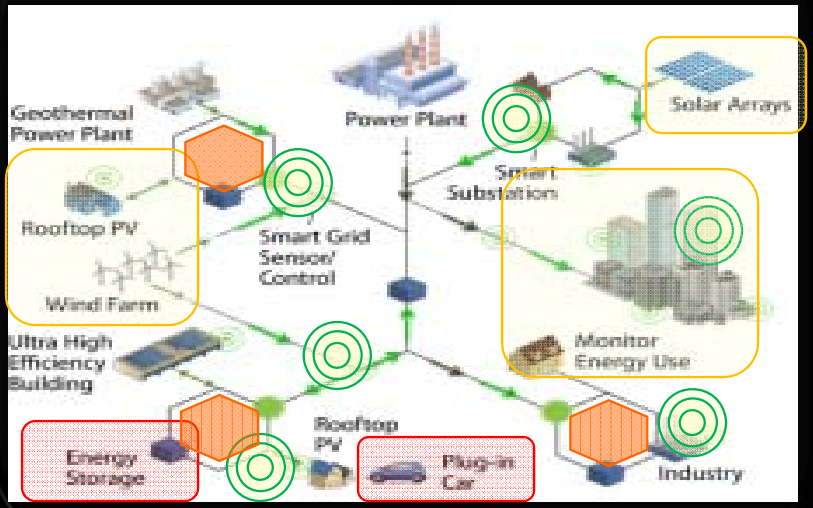


Grid Integration: More resilient, flexible and dynamic grid

Current Energy Systems



Future Energy Systems



Reducing investment risk and optimizing systems in a rapidly changing energy world

- Increasing penetration of variable RE in grid
- Increasing ultra high energy efficiency buildings and controllable loads
- New data, information, communications and controls
- Electrification of transportation
- Integrating energy storage (stationary and mobile) and thermal storage

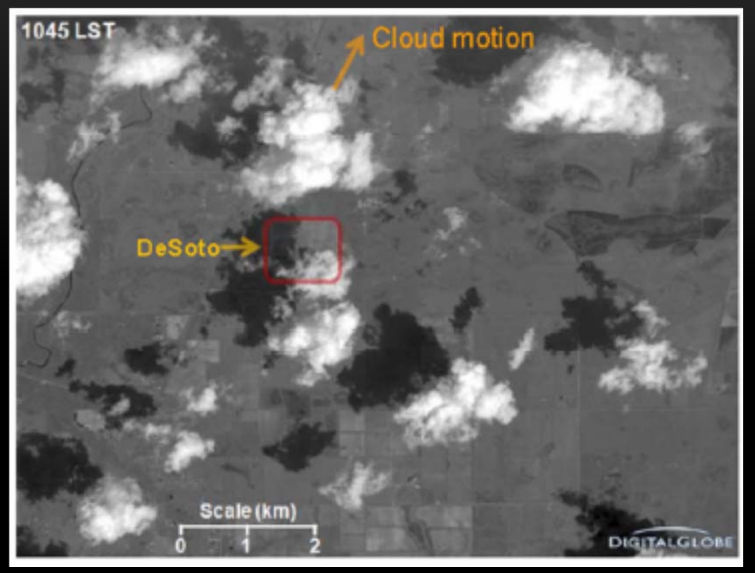
SOLAR RESOURCE FORECASTING

Objectives:

- Improve accuracy of solar resource forecasts
- Enable widespread use of solar forecasts in power system operations

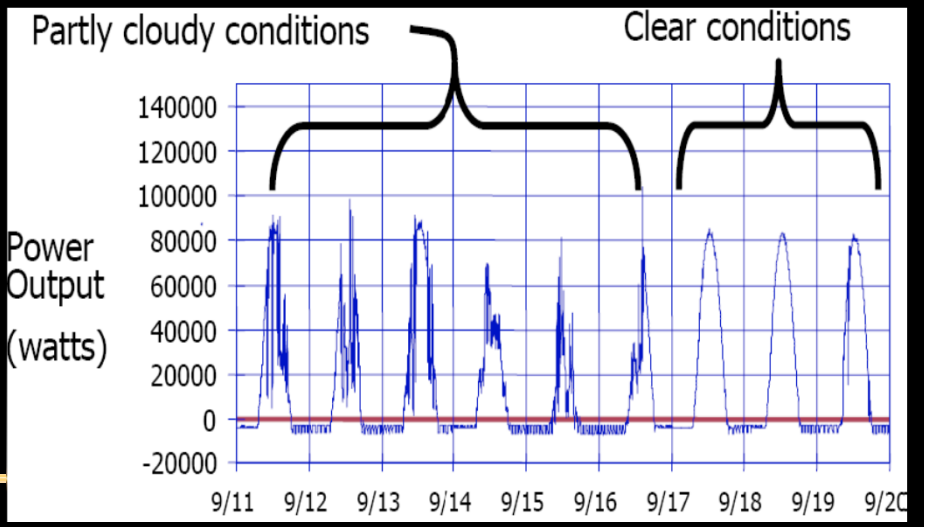
Impacts:

- Increase dependability of power output prediction
- Prepare for impending intermittencies to minimize grid impacts



Focus Areas:

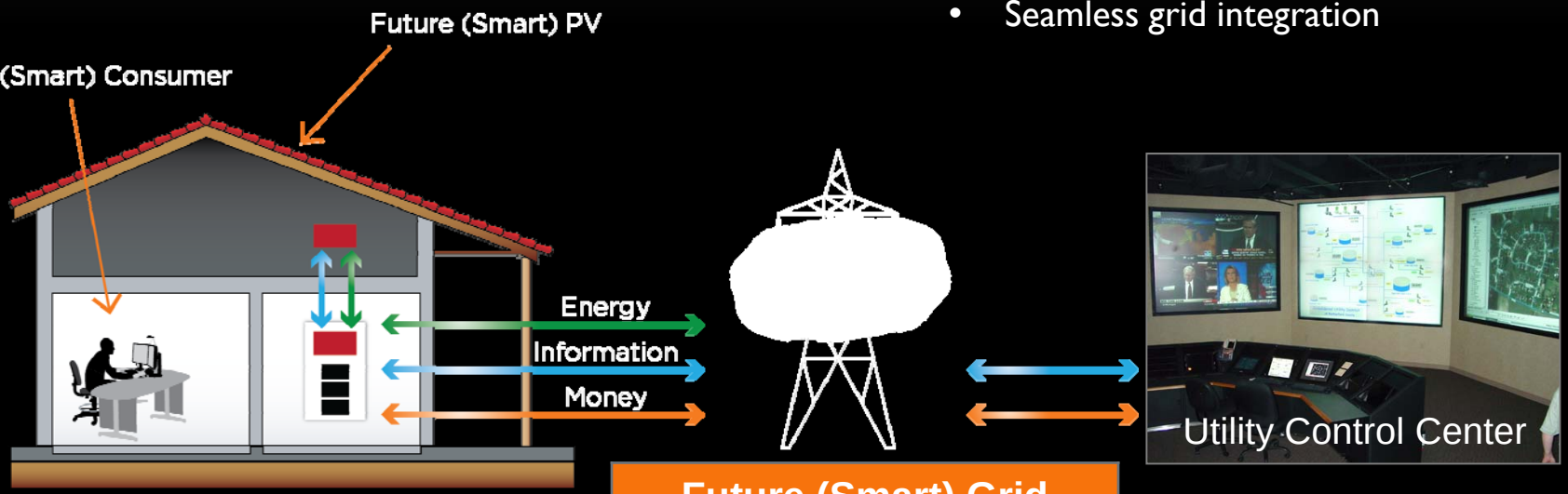
1) Develop Standardized Target Metrics
2) Develop Innovative algorithms and validate
3) Demonstrate value with utilities/system operators
4) workshops



PLUG-AND-PLAY VISION

Vision: PV as an Appliance

- No permitting required
- Easy installation
- Seamless grid integration



Future (Smart) Home

- Smart outlet
- Smart circuit
- Smart breaker panel
- Smart appliances
- Home area network (HAN)

Future (Smart) Grid

- Distributed generation
- Two-way power flow
- Communication and control
- Rich energy information and transactions
- Microgrid

Future (Smart) City

- Integrated grid and city planning

SOLAR UTILITY NETWORKS: REPLICABLE INNOVATION IN SOLAR ENERGY (SUN RISE)

- Encourage Grid Integration of large amounts of solar technologies by enabling
  - Holistic utility strategic planning for high pen PV
  - Power system operators to become familiar with high penetration of renewables
  - Developing PV deployment opportunities
- This funding opportunity will accomplish the above goals by
  - **Topic A-1:** Enable creation of strategic and sustainable long-term plans that identify pathways for utilities to operate reliably and profitably with high penetrations of renewables – especially solar
  - **Topic A-2:** Enabling utility power grid control centers to have capabilities to simulate and analyze impact of high pen solar on the power grid

Max. award duration
2-4 years
Estimated Max. award size
Topic A-1 or A-2: $500,000 Topic B: $4,000,000
Total DOE funding anticipated
$10-12,000,000
Cost-share minimum
Activity A-1 & A-2 50%; Activity B 25%
Application Deadlines
Concept Paper: March 20, 2013 Full Application: May 1, 2013

ADVANCED GRID INTEGRATION: MAKING THE CASE

To achieve the levels of wind energy targeted by DOE, grid planning and operations must be adapted to remove wind integration barriers and accelerate deployment.

Consider:

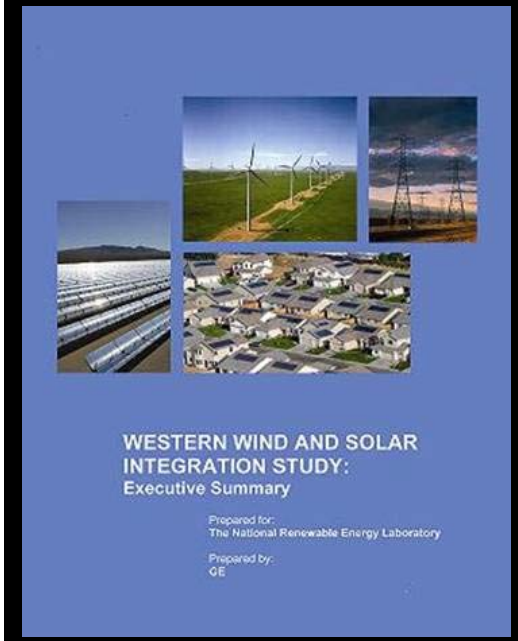
1. Wind integration costs are not fully understood and differ across regions.
   - Example: BPA requested a "wind integration rate" of $12/MWh from FERC, but settled at a rate of $5.70/MWh.
2. The variability and uncertainty of power system planning and operations is increased with addition of wind and other variable energy sources.
   - Xcel Energy has recorded instantaneous penetration levels of over 50% (wind power to load) in Colorado.
3. As more wind energy is integrated into the system, new capabilities will need to be developed to help wind generators operate an economic and reliable system.
4. Lack of sufficient transmission limits wind deployment. Efficient transmission development has diverse regional benefits that need to be quantified. Wind deployment benefits local and state economies even if the deployment does not occur locally.
   - Wind penetration is 3% (52GW) nationally, with 300GW of additional generation in interconnection queues.

WESTERN WIND AND SOLAR INTEGRATION STUDY

Project Summary

The Western Wind and Solar Integration Study analyzes the operational impacts of integrating large penetrations of renewables (wind and solar) on WECC

- Phase 1 examined operating impacts with up to 27% renewables penetration across WECC
- Phase 2 examined cycling impacts on plant O&M costs and emissions due to variable generation
- Phase 3 will examine impacts on system dynamics due to variable generation



Phase 1 Findings

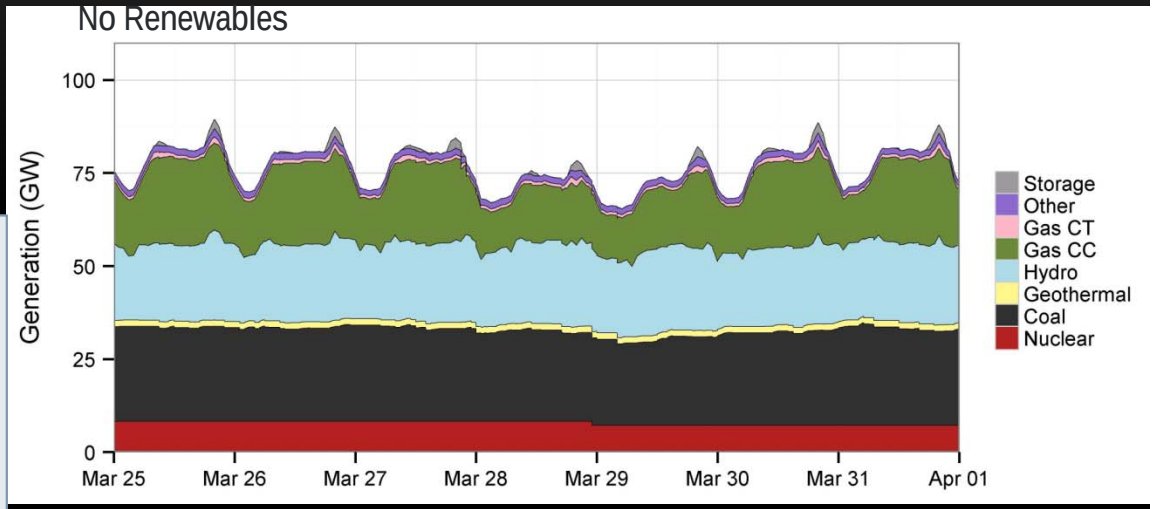
- Increasing geographic diversity of wind and solar resources substantially reduces variability
- Sub-hourly scheduling reduces the need for fast reserves
- Wind and solar forecasting in utility operations reduces operating costs by up to 14%
- Demand response programs can provide the flexibility needed to more easily integrate variable renewables

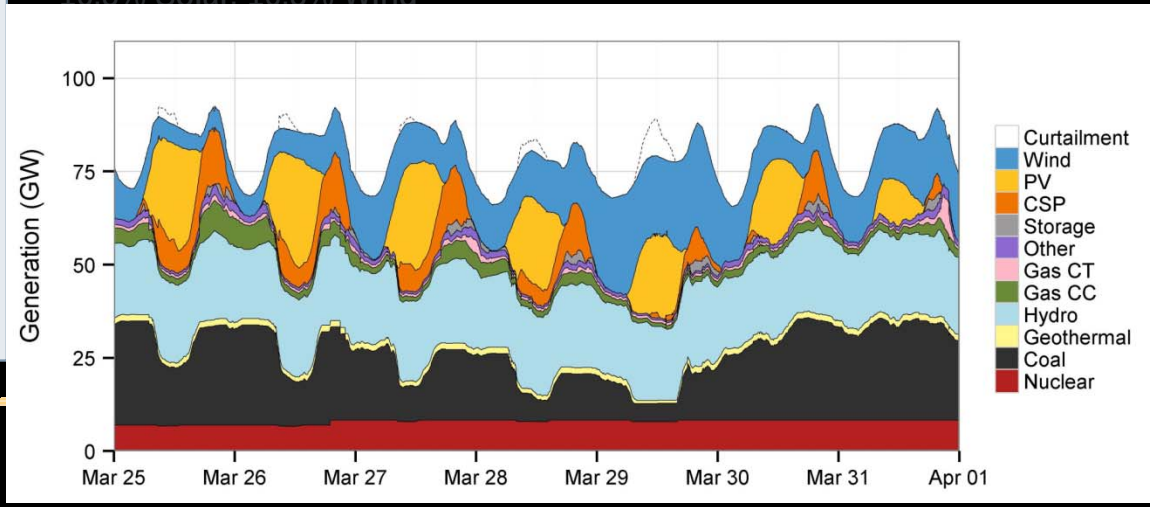
WESTERN WIND AND SOLAR INTEGRATION STUDY

Phase 2 Findings

With 33% wind and solar integrated on WECC:

- Fossil plant cycling costs increased by 13-24%, $0.5-1.3/MWh of O&M
- CO2, NOx, and SO2 are reduced by 29-34%, 16-22% and 14-24% respectively
- Cycling causes a negligible impact on CO2, improves NOx benefit by 1-2%, and lessens SO2 benefit by 2-5%





BUILDINGS --- 70% OF THE LOAD --- OPPORTUNITY

- Buildings have a large role in helping to enhance grid reliability and enabling the rapid integration of Renewable Energy and Storage.

BUT

- Buildings today are limited by existing controls systems that can't easily transact at the speed or scale that is required by the grid
  - High cost to "get it right" with existing technology and economics
  - Components are emerging with greater capabilities of control

- Building solutions must "think across the meter"
  - Energy Efficiency is at the core, but there are additional value streams to/from third party entrepreneurs
  - Better control of loads have other benefits
- Thinking Differently will unlock new value streams…

BUILDINGS OPEN ARCHITECTURE CONTROLS

Success: "Across the meter solution to enable transactions for commoditizing energy related services"

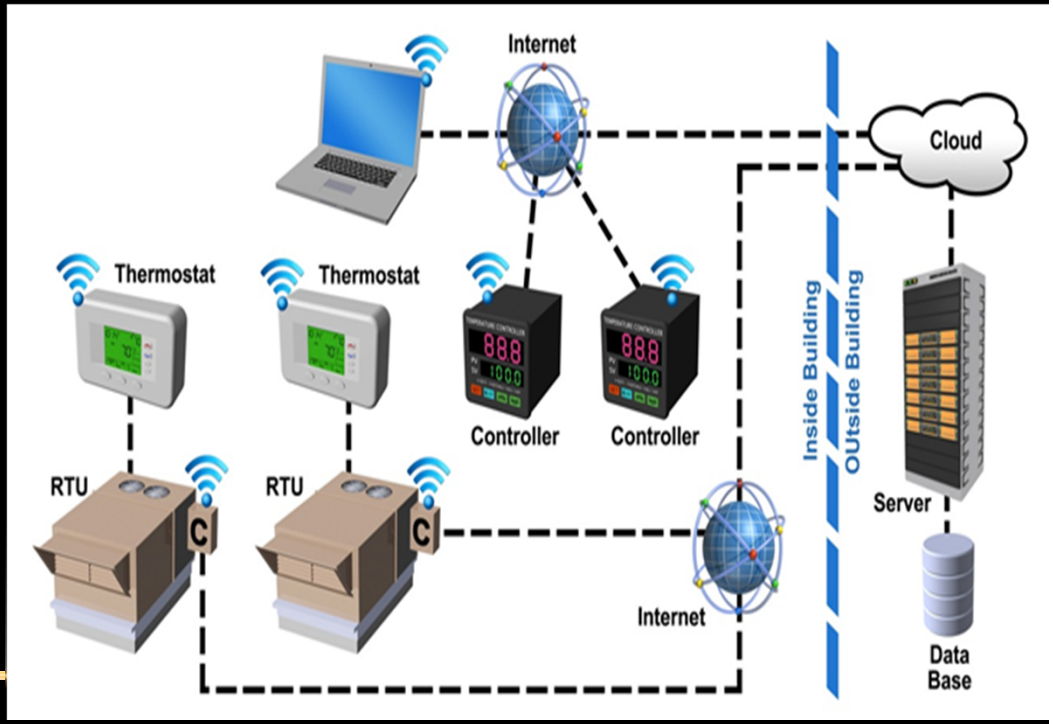
Opportunity: Less than 10% of the buildings in the U.S. use energy saving building automation systems or central controls. Over 90% of the buildings are either small (<5,000 sf) or medium-size (between 5,000 sf and 50,000 sf)

Problem: These buildings currently do not have a cost-effective way to monitor and control their building systems from a central location.

Solution: Development of cost-effective open architecture Building Automation System (BAS) for small and medium-sized.

Solution:

- Transaction-based network that enables interactions among RTUs, the electric power grid, and software applications and data in The Cloud;
- Embedded automated diagnostics and self-correcting controls (SCC) with advanced controls on an RTU controller;
- Automation using Cloud resources in cases where RTU controller resources (i.e processing) are inadequate.



PEV/INFRASTRUCTURE DATA ANALYSIS

VEHICLE TECHNOLOGIES PROGRAM – SLEZAK/ANDERSON

Project Topic, Summary & Goals

In order to understand the potential grid-impacts that result from the large-scale deployment of plug-in electric vehicles, real-world data that reflects consumer usage patterns is invaluable. Through ARRA-funded projects with ECOtality and ChargePoint, EV microclimates have been established and vehicle/infrastructure data is being collected to characterize the following:

- Vehicle and charger performance, efficiency, and utilization
- Drivers' charging patterns and public charging use
- Impact of various rate structures on charging habits
- Impact of electric vehicle charging on the electric grid

Lab/Organization

PI: Jim Francfort / INL

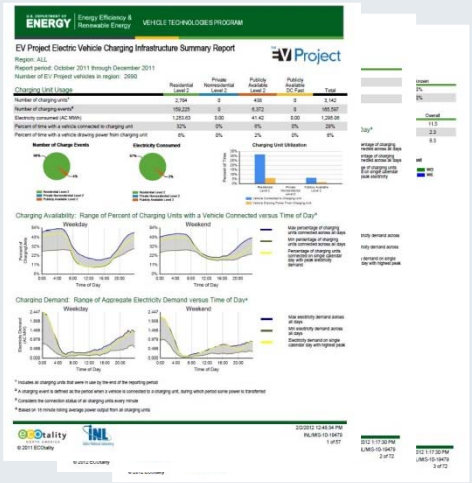
Key Collaborators

ECOtality North America, ChargePoint, General Motors, Nissan

* Infrastructure data collection/analysis primarily funded through ARRA, leveraged through additional activities funded through appropriations as outlined below:

Current Status & Findings

- Currently collecting over 100,000 PHEV/EV test miles and approximately 4,500 charging events each day
- Over 15,000 charging stations deployed (of 20,000 planned) so far
- Over 14,500 MWh of electricity delivered to PEVs
- Summary data disseminated via avt.inl.gov



2012 $360K | 2013 $360K | 2014 $360K

U.S. DRIVE GRID INTERACTION TECH TEAM

VEHICLE TECHNOLOGIES PROGRAM – SLEZAK

Project Topic, Summary & Goals

The Grid Interaction Tech Team (GITT) is part of the DOE/Industry partnership, U.S. DRIVE. The GITT seeks to advance a transition scenario to large scale grid-connected vehicle charging with transformational technology, proof of concept and information dissemination.

Through DOE/Industry collaboration, the GITT addresses connectivity between light duty plug-in vehicles, the charging infrastructure and the electric power grid, focusing on:

- Reduced Cost of Electric Charging Infrastructure
- Harmonization of Global Connectivity Standards
- Enabling Technology Development
- Enhanced Viability of Fast/Consumer-Friendly Charging
- Managed Vehicle Charging Loads Consistent with Smart Grid

Key Collaborators

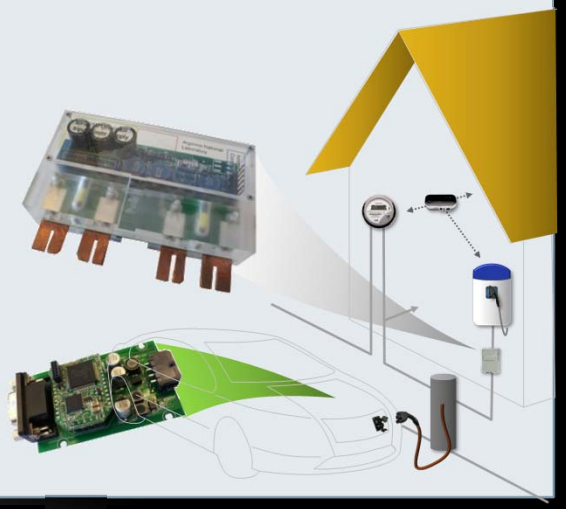
DTE, So. Cal Edison, EPRI
Ford, Chrysler, GM, Tesla

GITT Government Co-Chair: Lee Slezak / DOE
GITT Industry Co-Chairs: DTE, Chrysler

Note: U.S. DRIVE is a non-binding, non-legal, voluntary government-industry partnership focused on advanced automotive and related energy infrastructure R&D. It does not have a budget, and does not conduct or fund its own R&D. Each partner makes its own independent decisions regarding project funding and management.

Current Status & Findings

- Supported SAE grid connectivity, charging and communication standards development
- Developed sub-metering and communications technology and prototype modules
- Demonstrated EV-EVSE-network-grid communication



2011 $650K
2012 $300K
2013 $300K
2014 $300K

CODES & STANDARDS SUPPORT FOR EVS

VEHICLE TECHNOLOGIES PROGRAM – SLEZAK/ANDERSON

Project Topic, Summary & Goals

Support vehicle electrification standards via active participation on a focused group of relevant standards committees and through transformative actions such as creation of proof of concept systems as well as validation of proposed approaches.

- Encourage harmonized worldwide standards approach
- Support standards to improve grid connectivity of electric vehicle charging infrastructure via lower cost, secure, universalized wired and wireless communications technologies
- Validate adopted performance targets in a systems context

Lab/Organization

PI: Ted Bohn / ANL

Krishnan Gowri / PNNL

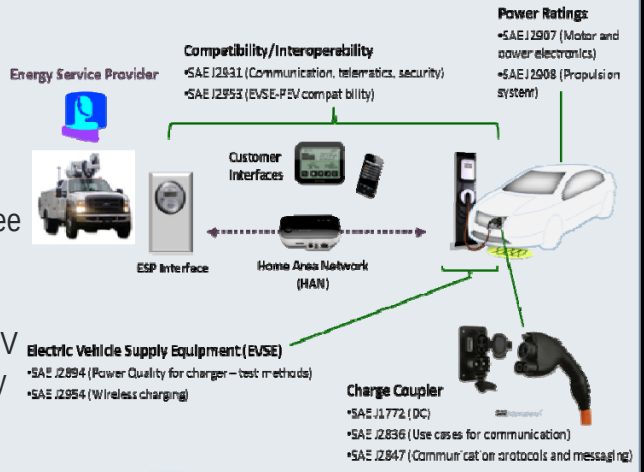
Key Collaborators

EPA, EPRI, NFPA, NHTSA, NIST, REMA USA, SAE, UL

Auto industry and utilities

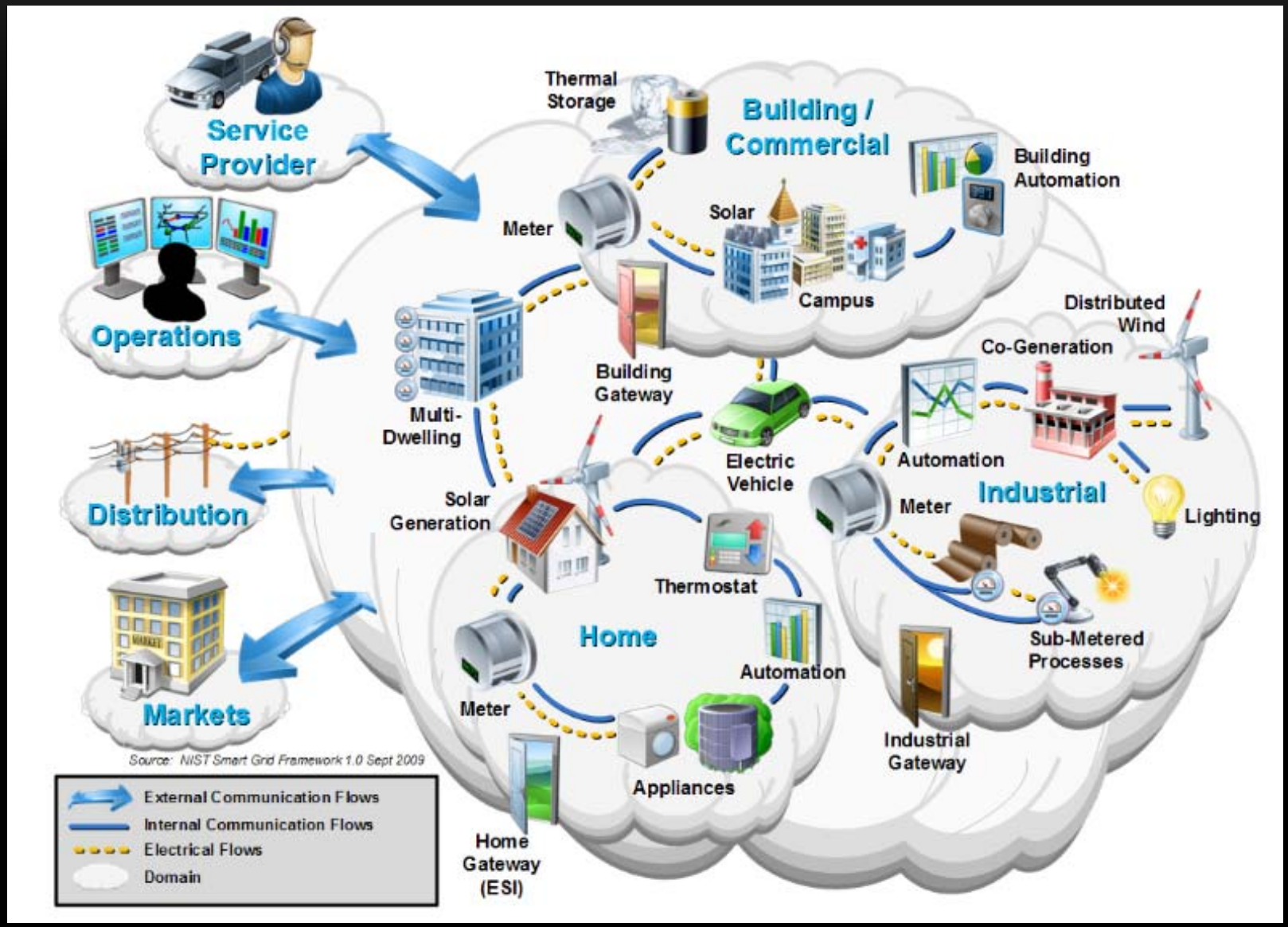
Current Status & Findings

- SAE J1772; Supported UL certification of Combo Coupler
- SAE J2931; Testing Power Line Communication technologies and protocols; Applied Auto-rem G3 module and EUMD (see GITT slide)
- Supported other SAE committees: J2836/J2847 – Communication between PEV and Grid/EVSE/V2G; J2894 – Power Quality Requirements



2011	2012	2013	2014
$775K	$405K	$500K	$400K

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



DOE's Energy Systems Integration Facility (ESIF) at NREL

- NREL's largest R&D facility (182,500 ft^2)
- Space for 200 NREL staff and research partners
- Focus of the ESIF is to conduct R&D of integrated energy systems (Electricity, Fuels, Transportation, and Buildings & Campus systems)

A laboratory for de-risking the challenges of large-scale integration of clean energy technologies into the energy systems infrastructure

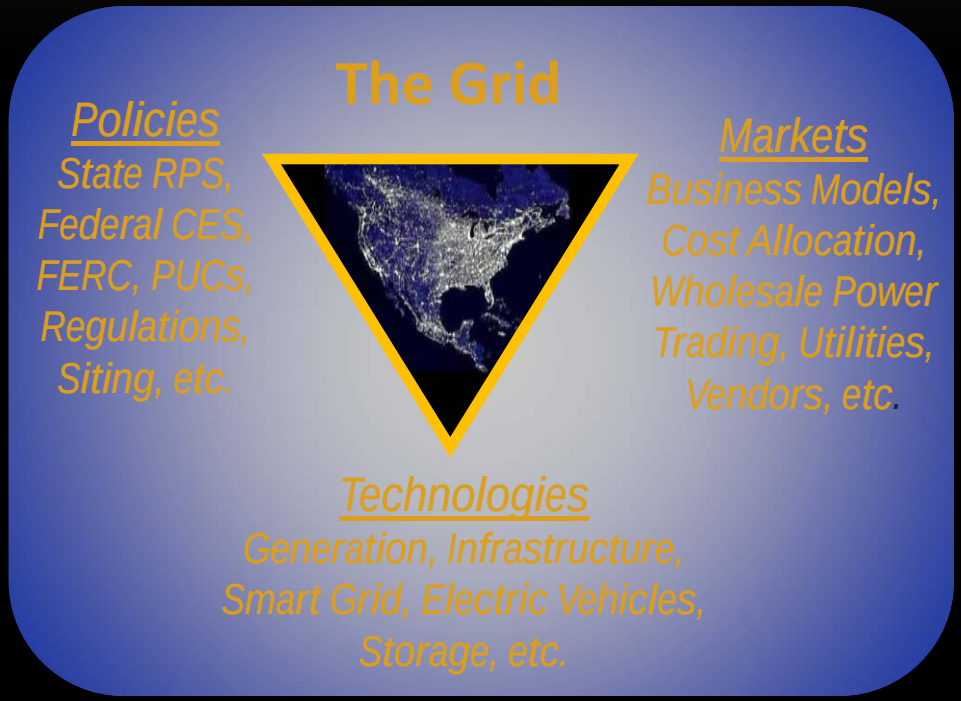
http://www.nrel.gov/eis/facilities_esif.html

DOE GRID TECH TEAM

DOE Vision:

A *seamless*, cost-effective electricity system, from generation to end use, capable of meeting the clean energy demands and capacity requirements of this century, while allowing consumer participation and electricity use as desired.

- Significant scale-up of Clean Energy
- Allows 100% consumer participation and choice
- 100% holistically designed
- Reliable, secure, and resilient



DOE Roadmap - To identify and address the technical, market, and regulatory changes that limit high penetration levels of renewable energy and energy efficiency technologies into the grid, enabling their integration in a safe, reliable, and cost-effective manner. Stakeholder Engagement:

- Distribution Workshop Sept '12
- Transmission Workshop Nov '12

POINTS OF CONTACT

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