

Renewable Energy Update



Message from the President

“... I will not walk away from the promise of clean energy. I will not walk away from workers ... I will not cede the wind or solar or battery industry ... It's time ... to double down on a clean energy industry that has never been more promising.”

- President Obama, State of the Union, 24 January 2012



EERE Goals

Clean Electricity: 80 percent by 2035

- Renewable electricity competitive with conventional sources without subsidies in:
 - Solar (SunShot initiative).
 - Wind - Offshore and Land Utility wind to contribute 20 percent by 2030 (300GW).
 - Water - Cost-competitive conventional hydropower and marine and hydrokinetic water power.
 - Geothermal.

Buildings

- Improve building energy efficiency 50 percent, in a cost-effective manner, by 2030.
- 1 million homes weatherized by 2013.

Federal Sustainability

- Reduce federal energy demand by 30 percent by 2015 (2003 base).
- Reduce federal GHG emissions by 28 percent by 2020 (2008 base).

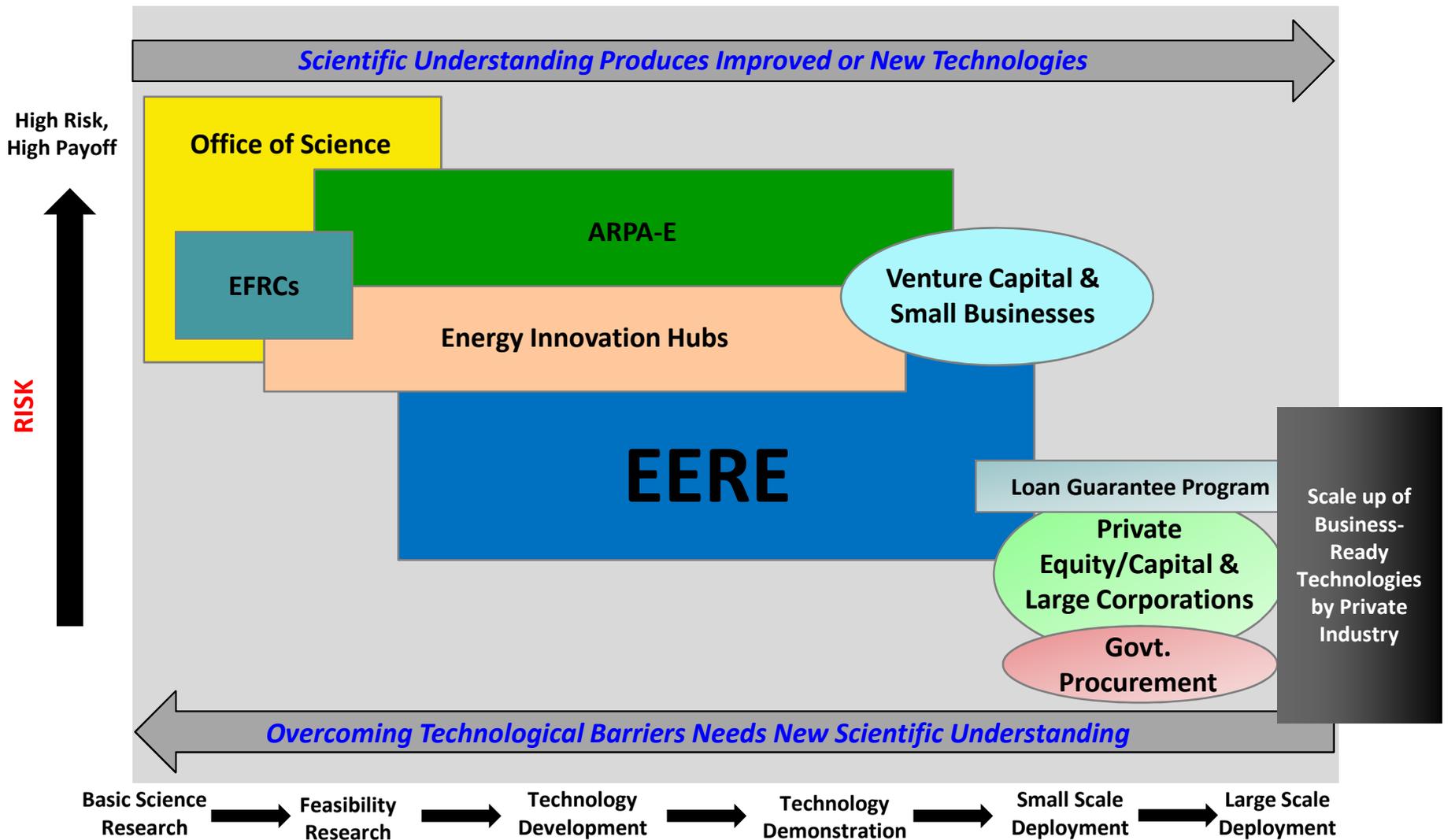
Transportation

- Reduce oil imports 1/3rd by 2025 and diversify fuel mix:
 - Biomass – Less than \$3/gallon (GGE) for drop-in fuels such as renewable gasoline, diesel, and jet fuel.
 - Cars able to achieve fuel economy >60mpg by 2025.
 - Batteries 1/2 today's price in 2015, 1/4 today's price in 2020.
 - Fuel cells for vehicles \$30/kW; 5000 hour duration.

Industry

- Reduce energy consumption of manufactured goods across targeted product life-cycles by 50 percent or more.

EERE Guiding Principles: Leveraging Technology Investments



EERE Impact



Solar: Innovations contributing to 10x PV cost reduction up to 2010.



Wind: Nearly 47 GW of installed capacity in the U.S.; wind energy installations represent over 35 percent of all new installed capacity over the last 4 years.



Biofuels: Cellulosic (non-food) biofuels are becoming close to cost-competitive with other fuels.



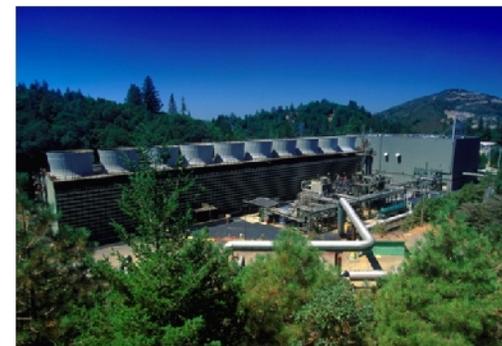
Geothermal: First demo-scale facility to extract high-quality and cost-competitive battery materials from geothermal brines; potential to produce enough lithium for hundreds of thousands of vehicle batteries per year.



Fuel Cells: R&D contributing to more than 80 percent estimated cost reduction of automotive fuel cell technologies since 2002.



Water: Developed a fish-friendly water turbine with a 98 percent survival rate and no decrease in energy conversion performance.



Solar Energy

Program Overview

The Solar Energy Technologies Program supports the SunShot Initiative's mission to develop solar energy technologies through a collaborative national push to make solar photovoltaic (PV) and concentrated solar power (CSP) energy technologies cost-competitive with fossil fuel-based energy by reducing the cost of solar energy systems by 50 to 75 percent before 2020.

Budget Request

Activity	Dollars in Thousands	
	FY 2012 Enacted	FY 2013 Request
Innovations	79,606	70,045
Emerging Technologies	126,446	117,055
Systems Integration	68,090	93,400
Market Barriers	10,551	25,589
SBIR/STTR	4,258	3,911
TOTAL	288,951	310,000

Technology and Focus Areas

- **PV Module** will continue to focus on innovation through R&D efforts, which remain a key focus of the program's activities. Increasing cell efficiency, improving reliability, and experimenting with new forms for novel applications are critical to the program's goals. The program has re-focused its efficiency goals for all conversion technologies. Each conversion technology has a 2-3 year R&D focus to track progress against long-term goals. For example, in FY 2013 CdTe R&D has an ambitious 23 percent goal.
- **Innovations in Manufacturing R&D** will focus on development of manufacturing processes which increase efficiency and reduce costs to improve competitiveness of U.S. companies. Two of the program's critical competitively awarded activities, PVM1 and SUNPATH, focus on retaining intellectual property, stimulating domestic manufacturing of PV and its supply chain components, and increasing U.S. global competitiveness.
- **CSP Systems** will focus on the R&D to enable CSP to be competitive as a firm capacity power source. In order to achieve this, activities are focused on lowering costs and improving performance and reliability of heliostats and thermal storage, as well as other critical components. Work on higher temperature components will enable higher performance of CSP systems.
- **Power Electronics & Systems** will focus on developing technologies in power electronics that reduce overall system costs, enabling higher penetration of solar technologies onto the grid and enhancing the performance of the system.
- **BOS** will focus on streamlining permitting and inspection costs, identifying innovative new approaches to deploying solar energy, and reductions in hardware costs to drive down the overall BOS cost at the residential, commercial and utility scale.

Wind Energy

Program Overview

The Wind Energy Program conducts research, development, demonstration and deployment activities (RDD&D) in partnership with industry, academia and the National Laboratories for land-based utility-scale, offshore and small and midsize wind, to reduce wind cost of energy, improve wind integrated plant and turbine performance, and facilitate wind energy's rapid market deployment via reduction of market barriers including streamlining siting and permitting, addressing environmental concerns, and improving wind integration into the electric transmission system. The program's goals are for wind energy to compete, unsubsidized, with lowest cost fossil fuel - Natural Gas, projected as \$.06/kWh and achieve 20 percent of U.S. electricity generation by 2030 (300 GW).

Budget Request

Activity	Dollars in Thousands	
	FY 2012 Enacted	FY 2013 Request
Innovations	27,279	35,480
Emerging Technologies	29,317	22,321
Systems Integration	24,186	24,280
Market Barriers	10,446	10,786
SBIR/STTR	2,026	2,133
TOTAL	93,254	95,000

Technology and Focus Areas

For all Wind market areas (Land-based Utility, Offshore Wind, and Small and Midsize Wind):

- **Innovation Concepts and Emerging Technologies** detail designs to reduce the cost of wind to compete unsubsidized with fossil-based alternatives (projected as \$.06/kWh). Technology focus to lower wind turbine capital costs with lighter components, higher reliability and lower maintenance. Improve overall plant and turbine performance with higher capacity and lower plant losses.
- **System Integration** via testing and demonstrations to foster market development and private investment of Land and Offshore wind systems, including DOE Offshore wind demonstration project, and innovative land-based testing facilities for independent, industry-wide information.
- **Market Barriers** reductions needed to achieve 300 GW target, via strong intra-agency coordination and advanced, independent siting, radar and environmental studies, and optimized transmission integration. Market barriers will additionally provide annual market data and analysis of emergent policy, economic issues and proactive planning and siting practices.

Geothermal Technology

Program Overview

The Geothermal Technologies Program goal is to establish geothermal as a major baseload contributor to the U.S. energy mix. The Program will implement a balanced portfolio of investments in innovative emerging technologies, systems demonstrations, and activities to address market barriers. By 2020, the Program seeks to demonstrate that Enhanced Geothermal Systems are technically feasible by advancing critical technologies in reservoir creation, reservoir monitoring, and sustainability of sub-surface geothermal reservoirs. The Program focus is establishing EGS field sites, user test facilities, and developing game-changing reservoir creation and management technologies to expand the geothermal capacity more than 10 times from the current geothermal installed capacity of 3 GWe. The program will also aim to pursue technological innovation in finding, accessing, and developing “blind” geothermal resources.

Technology and Focus Areas

- **Enhanced Geothermal Systems (EGS)** activities will support the resource characterization of up to three geologically unique test sites; demonstrate high temperature and pressure drilling technology that could increase the rate of penetration (3x) and allow a high degree of control for monitoring and navigating drilling operations; and publish a scientific and engineering model of EGS.
- **Hydrothermal and Resource Confirmation (HRC)** activities will focus on developing and validating exploration technologies to effectively and efficiently find and access “blind” geothermal resources; continue funding low-temperature power generation projects; address geothermal high cost drilling systems; and develop in-situ logging tools for high temperature and pressure resources.
- **Resource Assessment** activities will release an EGS resource potential map for all 50 states.

Budget Request

Activity	Dollars in Thousands	
	FY 2012 Enacted	FY 2013 Request
Innovations	18,925	27,146
Emerging Technologies	10,056	26,661
Systems Integration	3,882	5,332
Market Barriers	4,000	4,000
SBIR/STTR	999	1,861
TOTAL	37,862	65,000

Water Power

Program Overview

The Water Power Program supports technology advancement of both emerging marine and hydrokinetic (MHK) technologies and novel conventional hydropower systems that present a pathway to be competitive with fossil fuel-based energy. Cost parity will be rapidly achieved through innovation, critical design improvements and demonstrations that will be accelerated through testing at marine centers of excellence, and through cost-effective demonstrations at our nation's existing hydropower infrastructure. These efforts will help re-establish American technological and market leadership in water power technologies by leveraging key research institutions, and our shipbuilding and naval marine industries; catalyzing economic development through enhanced utilization of our water power resources.

Budget Request

Activity	\$ in thousands	
	FY 2012 Enacted	FY 2013 Request
Innovations	5,170	3,080
Emerging Technologies	23,000	6,783
Systems Integration	24,330	7,068
Market Barriers	4,546	2,459
SBIR/STTR	1,741	610
TOTAL	58,787	20,000

Technology and Focus Areas

- **Marine and Hydrokinetics (MHK) Technology** will focus on developing innovative technologies capable of tapping the vast and predictable energy of waves, tides, and currents. Through cost-shared technology development and demonstration grants, DOE assists this emerging industry with the design, manufacture, testing, and evaluation of leading concepts and designs to prove technical and economic performance. DOE is also concurrently addressing environmental and permitting challenges, and is developing a marine testing infrastructure to accelerate design improvements at a reduced cost to developers.
- **Conventional Hydropower Technology** will continue R&D to support innovation and optimization on small hydropower, pumped storage, and expanding existing hydropower capacity.
 - **Small Hydropower** will support the research, development and demonstration of innovative systems that can capture and convert the energy of water at existing non-powered dams and other conduits/water conveyance systems.
 - **Environmental Mitigation Technologies** will focus on enhancing environmental performance while increasing electricity generation, mitigating fish and habitat impacts, and enhancing downstream water quality.
 - **Pumped Storage Hydropower** will support the development of a world-class PSH system that can cost-effectively provide balancing, reserves and grid stability, to ease the greater integration of variable renewables.

Hydrogen and Fuel Cell Technologies

Program Overview

The Hydrogen and Fuel Cells Technology Program develops technologies to enable fuel cells to be cost-competitive in diverse applications, including light-duty vehicles (at \$30/kW) and stationary power (at less than \$1,500/kW), and to enable renewable hydrogen (from diverse resources) to be cost-competitive with gasoline (\$2 – 4/gge, delivered and dispensed).

Budget Request

Activity	Dollars in Thousands	
	FY 2012 Enacted	FY 2013 Request
Innovations	64,021	52,441
Emerging Technologies	19,465	15,909
Systems Integration	11,421	6,980
Market Barriers	6,180	2,520
SBIR/STTR	2,537	2,150
TOTAL	103,624	80,000

Hydrogen and Fuel Cell Technologies leverages other EERE program activities (e.g., Advanced Manufacturing and Vehicle Technologies in key areas such as carbon fiber cost reduction).

Technology and Focus Areas

- **Fuel Cell R&D** will improve the durability, reduce costs, and improve the performance of fuel cell systems, through advances in fuel cell stack materials and components, and in balance of plant components and subsystems. Goal:
 - Reduce costs by increasing PEM fuel cell power output per gram of platinum-group catalyst from 2.8 kW/g (in 2008) to 5.9 kW/g in 2013 and 8.0 kW/g by 2017.
- **Hydrogen Fuel R&D** will focus on production from renewable resources, delivery, and storage R&D to achieve a near-term 10 percent reduction in the delivered, untaxed hydrogen cost from the baseline of \$8/gge, and develop hydrogen storage technologies to reduce costs by 10 percent in the near term from \$17/kWh.
- **Safety, Codes and Standards** will develop and validate fast-fill models to optimize fueling protocols for SAE J2601.
- **Manufacturing R&D** will develop and demonstrate advanced manufacturing technologies and processes that will reduce the cost of fuel cell systems and hydrogen technologies. Goal:
 - Reduce cost of manufacturing membrane electrode assemblies (MEAs) by 25 percent, relative to 2008 baseline of \$63/kW at 1000 units/year by 2013.
- **Systems Analysis** will determine technology gaps, economic potential, infrastructure cost reduction opportunities for early market penetration of fuel cells, crosscutting fuel cell applications and integration for EERE technology portfolio and technology advancement in 2013.

Biomass

Program Overview

The Biomass & Biorefinery Program fund research, development, and demonstration projects to advance biofuels and to validate and assist in the commercialization of integrated biorefinery technologies and the development of biomass conversion technologies. Additionally, the program works to produce a variety of biofuels, bioproducts, biopower and evaluate environmentally sustainable feedstocks.

Budget Request

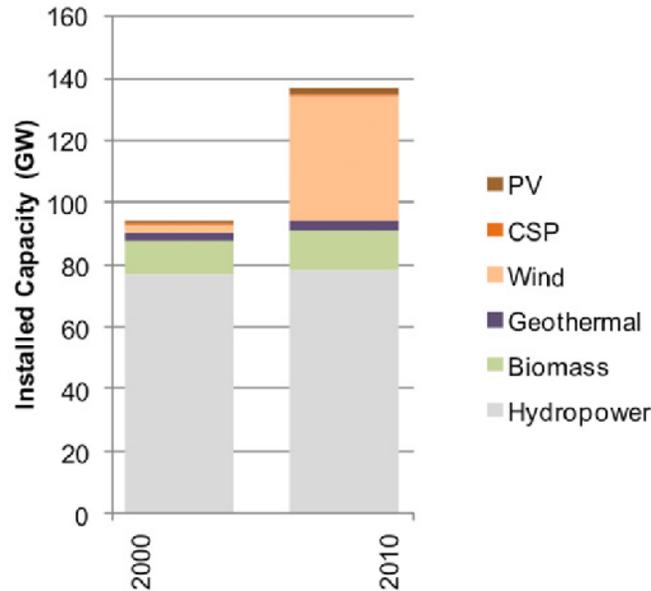
Activity	Dollars in Thousands	
	FY 2012 Enacted	FY 2013 Request
Innovations	89,453	75,344
Emerging Technologies	57,709	84,629
Systems Integration	2,079	62,987
Market Barriers	44,135	42,283
SBR/STTR	5,900	4,757
TOTAL	199,276	270,000

Technology and Focus Areas

- **Integrated Biorefineries** activities will continue to support the President's commitment to help entrepreneurs break ground for four next-generation biorefineries – supporting small scale innovative pilots through to larger scale commercial facilities.
- **Biochemical** activities will continue to focus on process integration including pretreatment, clean sugar production and fermentation and/or catalysis to hydrocarbon fuel intermediates and bio-based chemicals. A design case will be developed to target research toward the goal of <\$3.00 gal fuel by 2017.
- **Thermochemical** pathway efforts will continue to focus on laboratory scale integration of bio-oil production and upgrading to hydrocarbon fuels. The design cases for fast pyrolysis to biofuels will be re-examined to ensure the optimal cost, carbon and energy-efficient process is chosen.
- **Algae** work include selection of three innovative algae production strains with the necessary traits to produce biofuels, as well as continuation of development of low energy intensity technologies for dewatering algal biomass.
- **Feedstock Logistics** will include the demonstration of using uniform-format densified solid feedstocks and its seamless interface with conversion technology.
- **Biopower** will continue to conduct RD&D on developing more efficient cookstoves with reduced emissions.

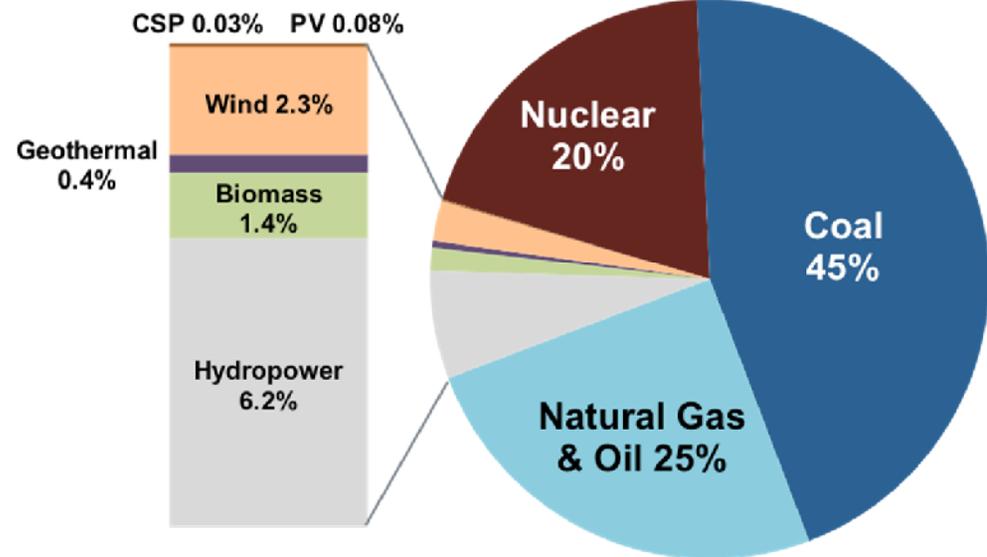
Renewable Electricity Futures Motivation

RE Capacity Growth 2000-2010



Source: RE Data Book (DOE 2011)

2010 Electricity Generation Mix



Source: Renewable Electricity Futures (2012)

- **RE is a low carbon, low air pollutant, low fuel use, low water use, domestic, sustainable electricity source.**
- **To what extent can renewable energy technologies commercially available today meet the U.S. electricity demand over the next several decades?**

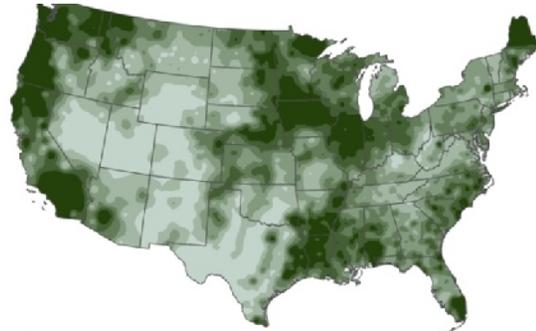
Renewable Electricity Futures Introduction

RE Futures does....	RE Futures does not...
Identify commercially available RE generation technology combinations that meet up to 80% or more of projected 2050 electricity demand in every hour of the year	Consider policies, new operating procedures, evolved business models, or market rules that could facilitate high levels of RE generation
Identify electric sector characteristics associated with high levels of RE generation	Fully evaluate power system reliability
Explore a variety of high renewable electricity generation scenarios	Forecast or predict the evolution of the electric sector
Estimate associated US electric sector carbon emissions reductions	Assess optimal pathways to achieve a low-carbon electricity system
Explore a select number of economic, environmental and social impacts	Conduct comprehensive cost-benefit analysis
Illustrate a RE-specific pathway to a clean electricity future to inform the development of integrated portfolio scenarios that include consideration of all technology pathways and their implications	Provide a definitive assessment of high RE generation, but does identify areas for deeper investigation

Abundant Renewable Energy Resources

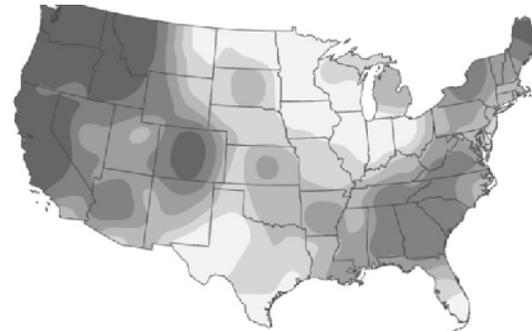
Biopower ~100 GW

- Stand-alone
- Cofired with coal



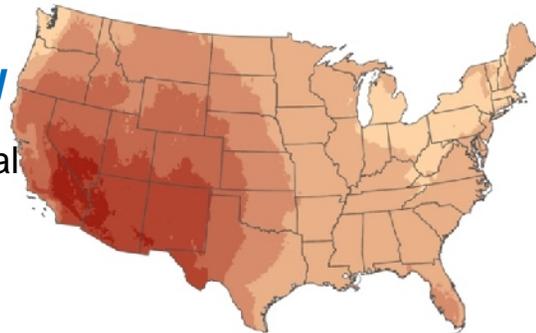
Hydropower ~200 GW

- Run-of-river



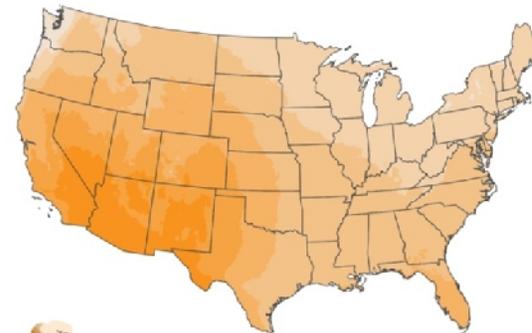
Solar CSP ~37,000 GW

- Trough
 - Tower
- With thermal storage



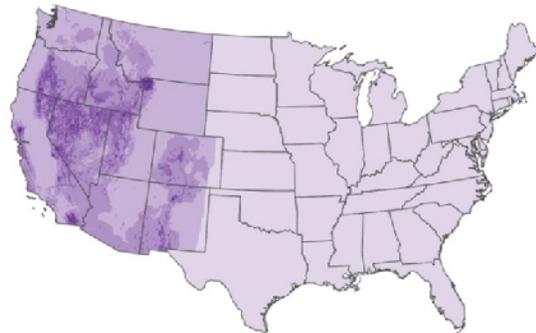
Solar PV ~80,000 GW (rooftop PV ~700 GW)

- Residential
- Commercial
- Utility-scale



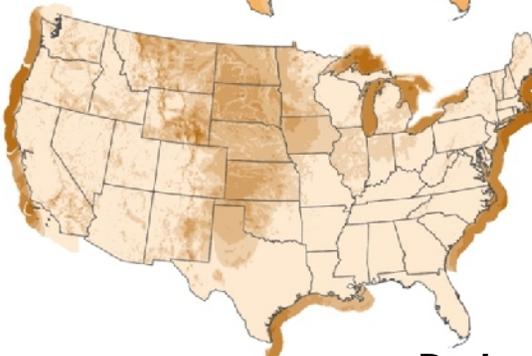
Geothermal ~36 GW

- Hydrothermal



Wind ~10,000 GW

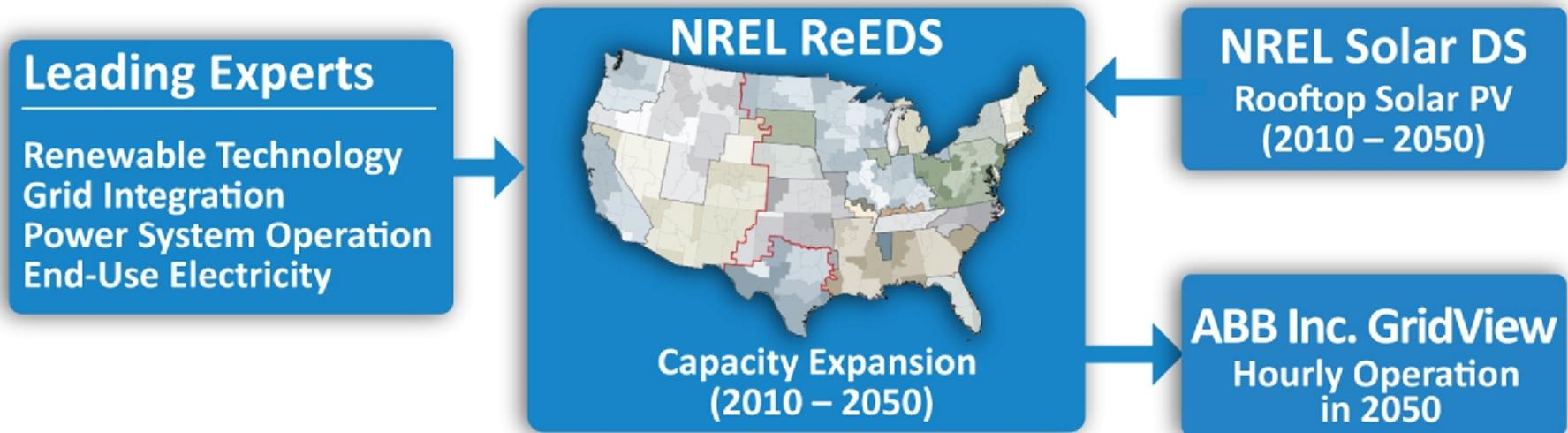
- Onshore
- Offshore fixed-bottom



Darker Colors = Higher Resource

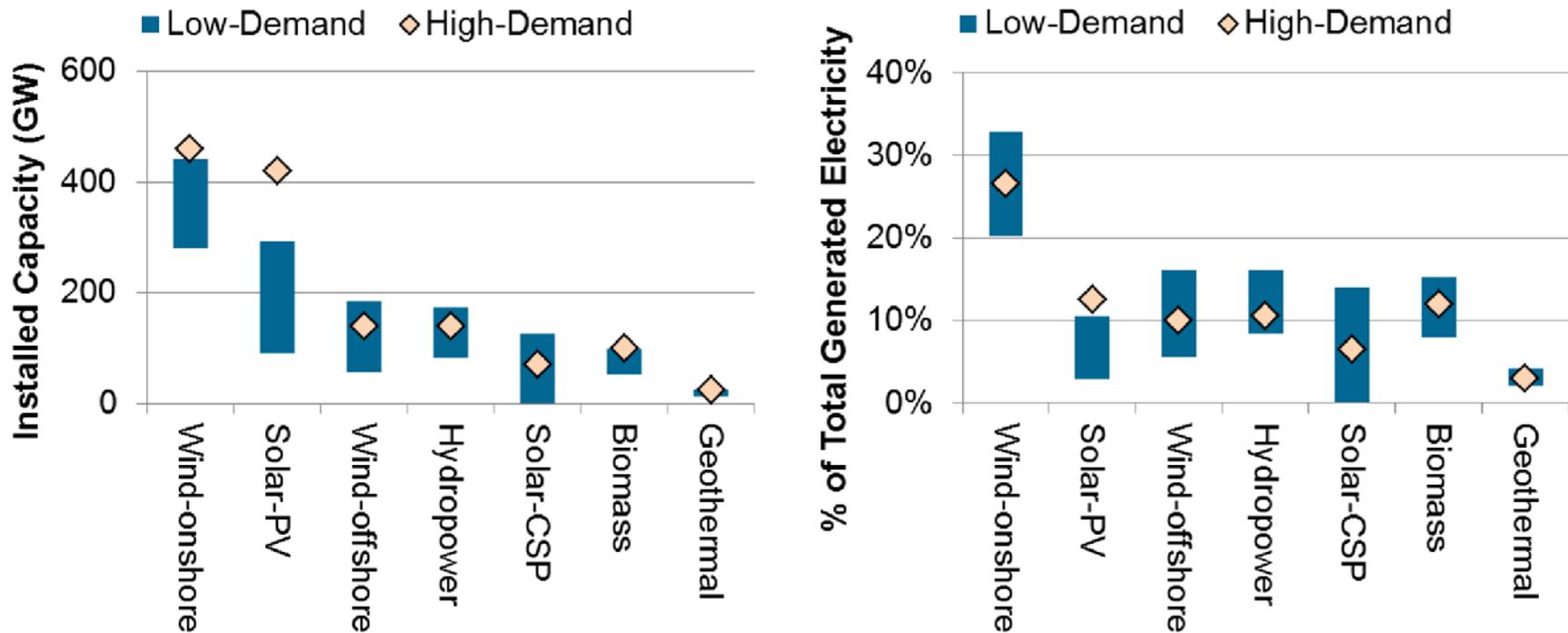
Geographic location, technical resource potential, and output characteristics are unique to each RE generation technology.

State of the Art Electric System Models



- **Unprecedented geographic and time resolution for the contiguous United States**
- **Over two dozen scenarios of U.S. electric sector focused on 2050**

Multiple Technology Pathways to 80% RE

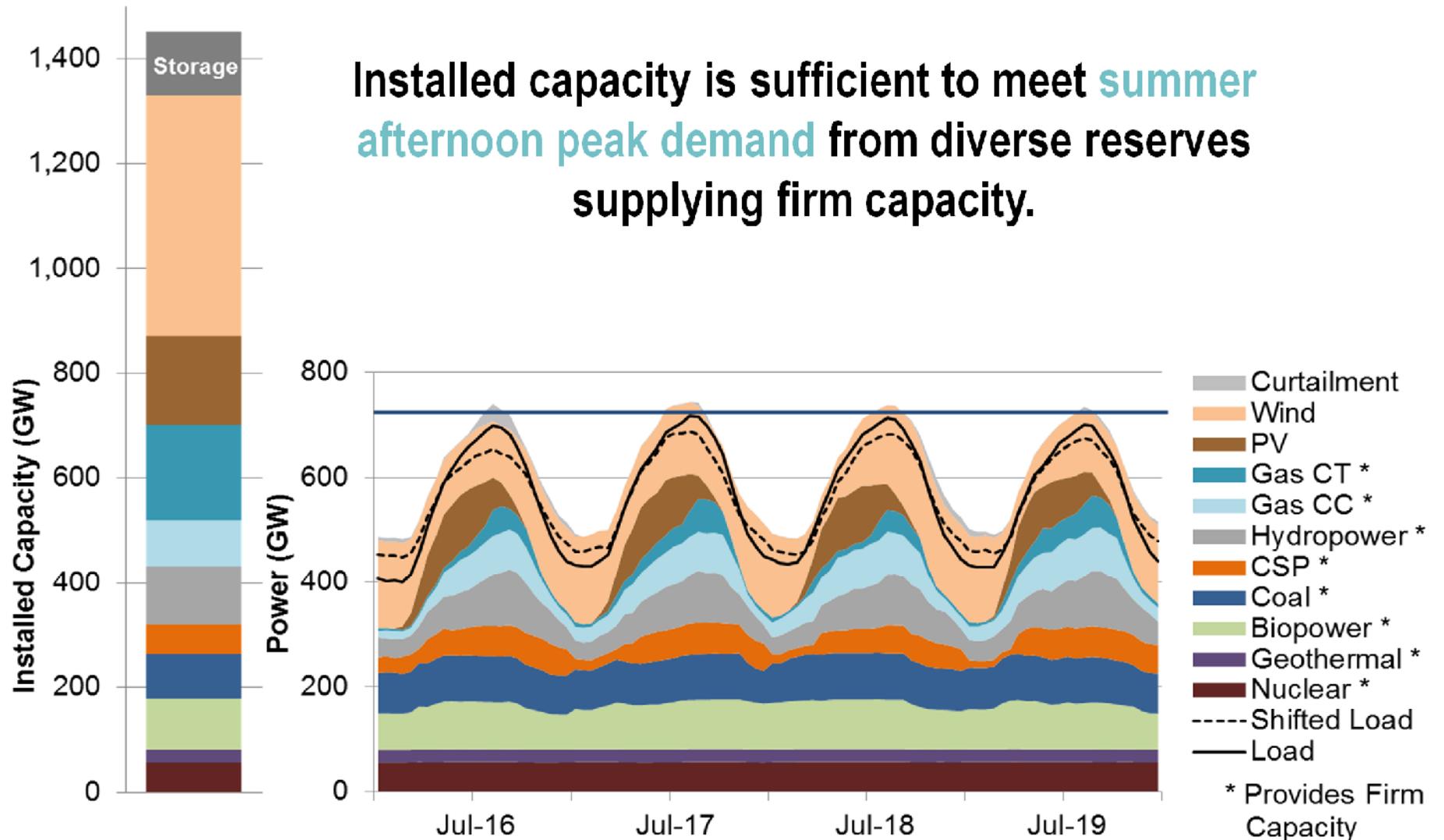


Source: Renewable Electricity Futures (2012)

The capacity of RE generation technologies “built” in 2050 depends on

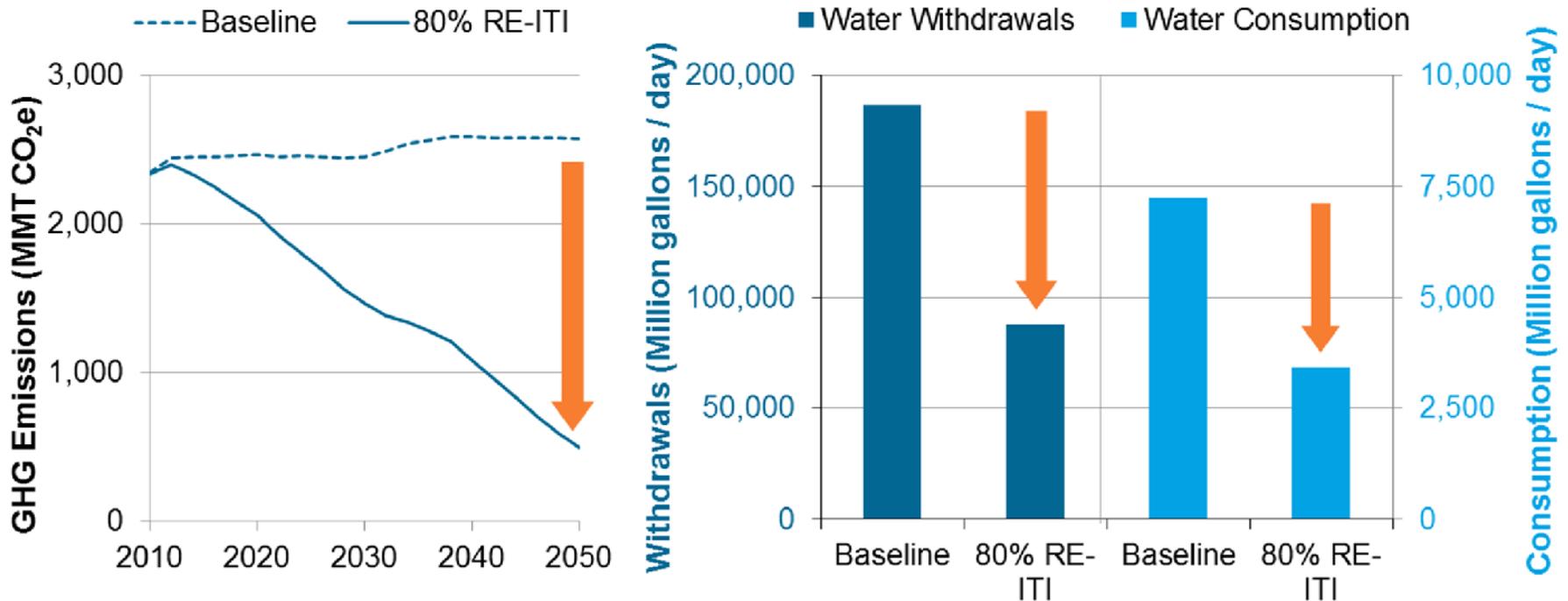
- Future RE technology cost and performance
- Electricity demand growth
- Presence of constraints that limit new transmission infrastructure, grid flexibility, or the accessibility of renewable resources

Supply and Demand Balanced Every Hour of the Year



Source: Renewable Electricity Futures (2012)

High RE Reduces Emissions and Water Use



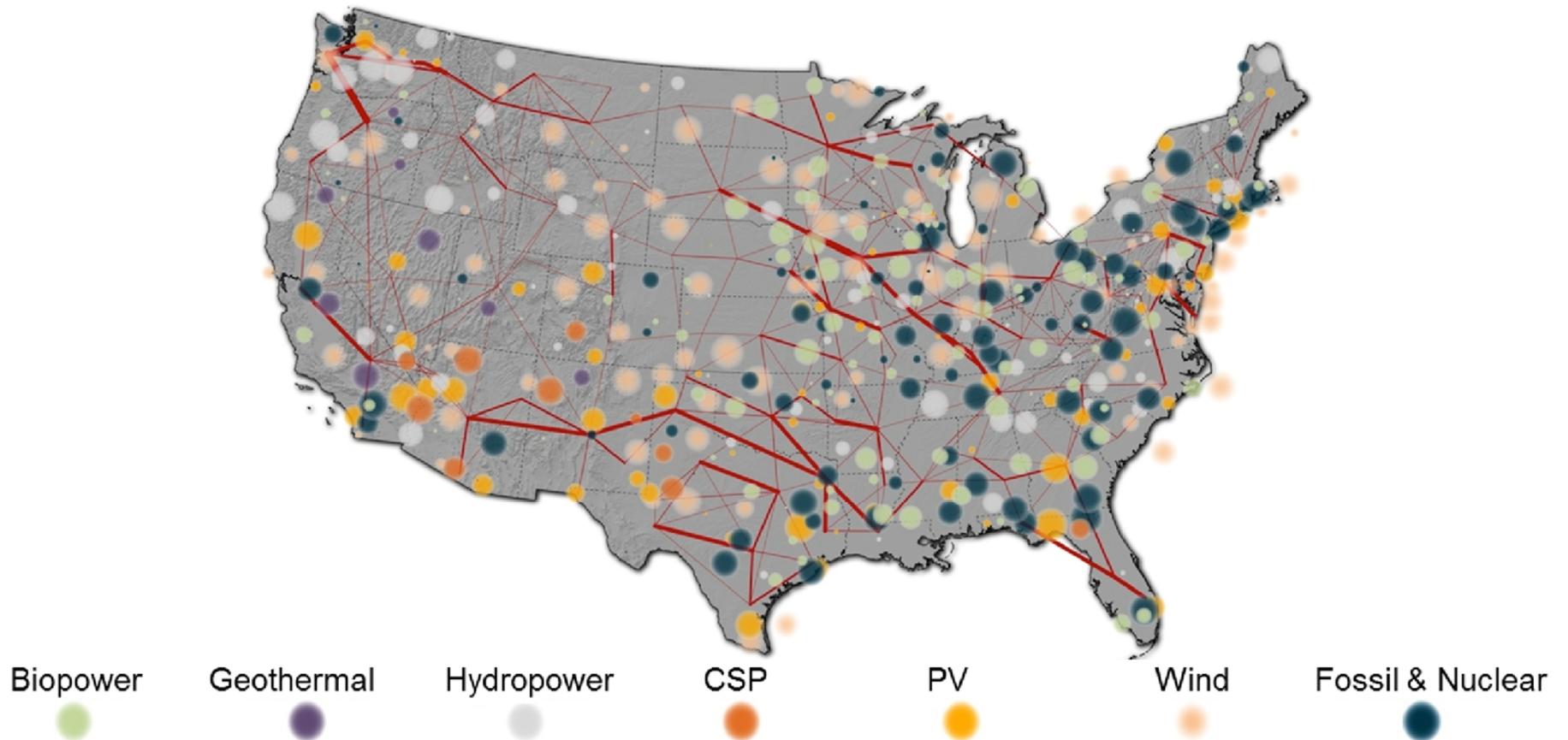
Source: Renewable Electricity Futures (2012)

80% renewable electricity in 2050 could lead to:

- ~ 80% reduction in GHG emissions (combustion-only and full life-cycle)
- ~ 50% reduction in electric sector water use (withdrawals and consumption)

Key Results

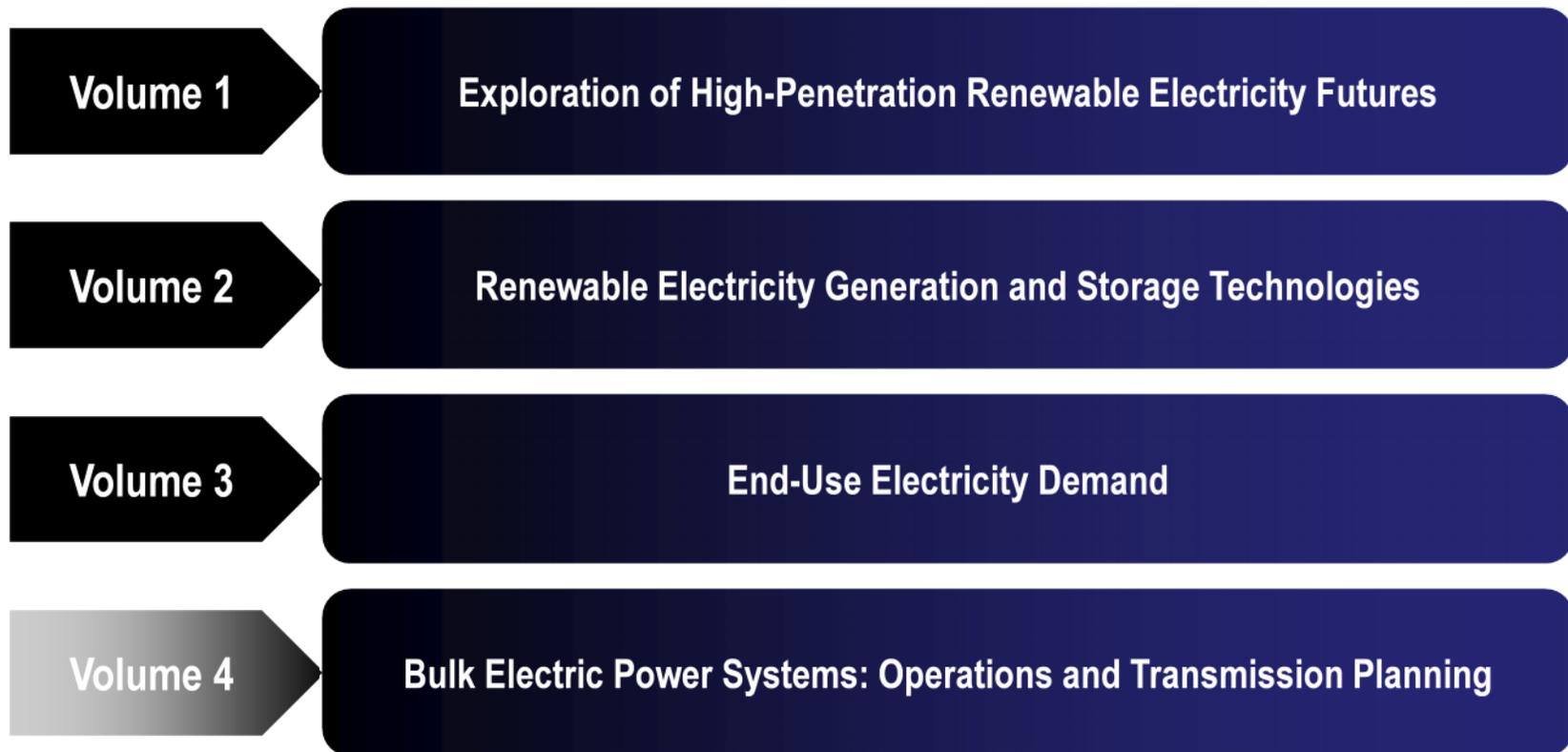
- Renewable electricity generation from technologies that are commercially available today, in combination with a more flexible electric system, is more than adequate to supply 80% of total U.S. electricity generation in 2050 while meeting electricity demand on an hourly basis in every region of the country.
- Increased electric system flexibility, needed to enable electricity supply-demand balance with high levels of renewable generation, can come from a portfolio of supply- and demand-side options, including flexible conventional generation, grid storage, new transmission, more responsive loads, and changes in power system operations.
- The abundance and diversity of U.S. renewable energy resources can support multiple combinations of renewable technologies that result in deep reductions in electric sector greenhouse gas emissions and water use.
- The direct incremental cost associated with high renewable generation is comparable to published cost estimates of other clean energy scenarios. Improvement in the cost and performance of renewable technologies is the most important factor in reducing incremental cost.



Source: Renewable Electricity Futures (2012)

A future U.S. electricity system that is largely powered by renewable sources is possible, and further work is warranted to investigate this clean generation pathway.
www.nrel.gov/re_futures

Renewable Electricity Futures Report



U.S. DOE-sponsored collaboration with more than 110 contributors from 35 organizations including national laboratories, industry, universities, and non-governmental organizations.