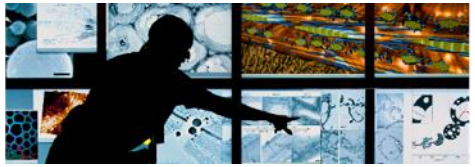
NREL
NATIONAL RENEWABLE ENERGY LABORATORY

U.S. Renewable Energy:
Increasing Capacity- Reducing Costs

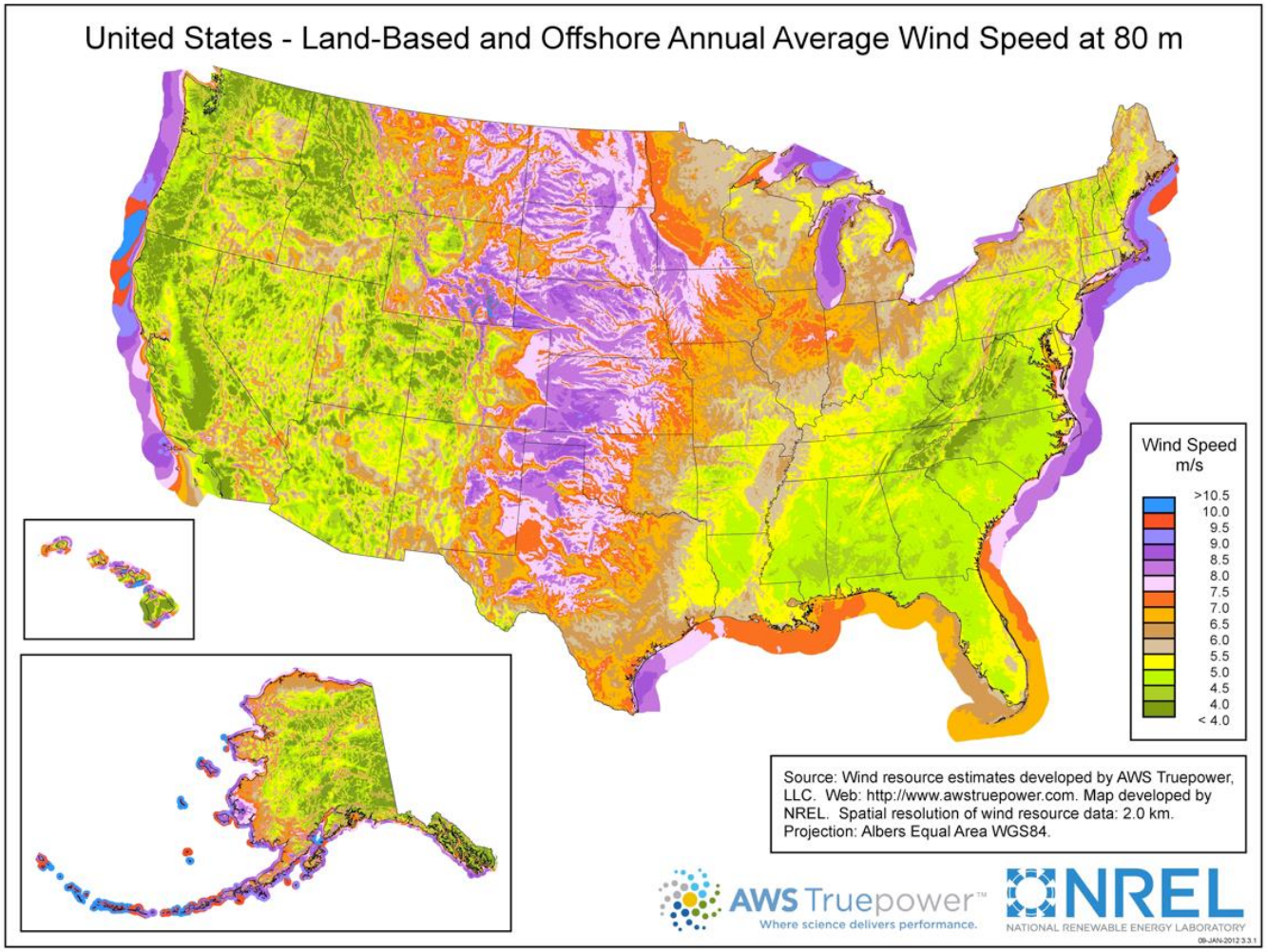



Presentation to the Japan Renewable Energy Foundation

Douglas Arent, Ph.D.

March 2016

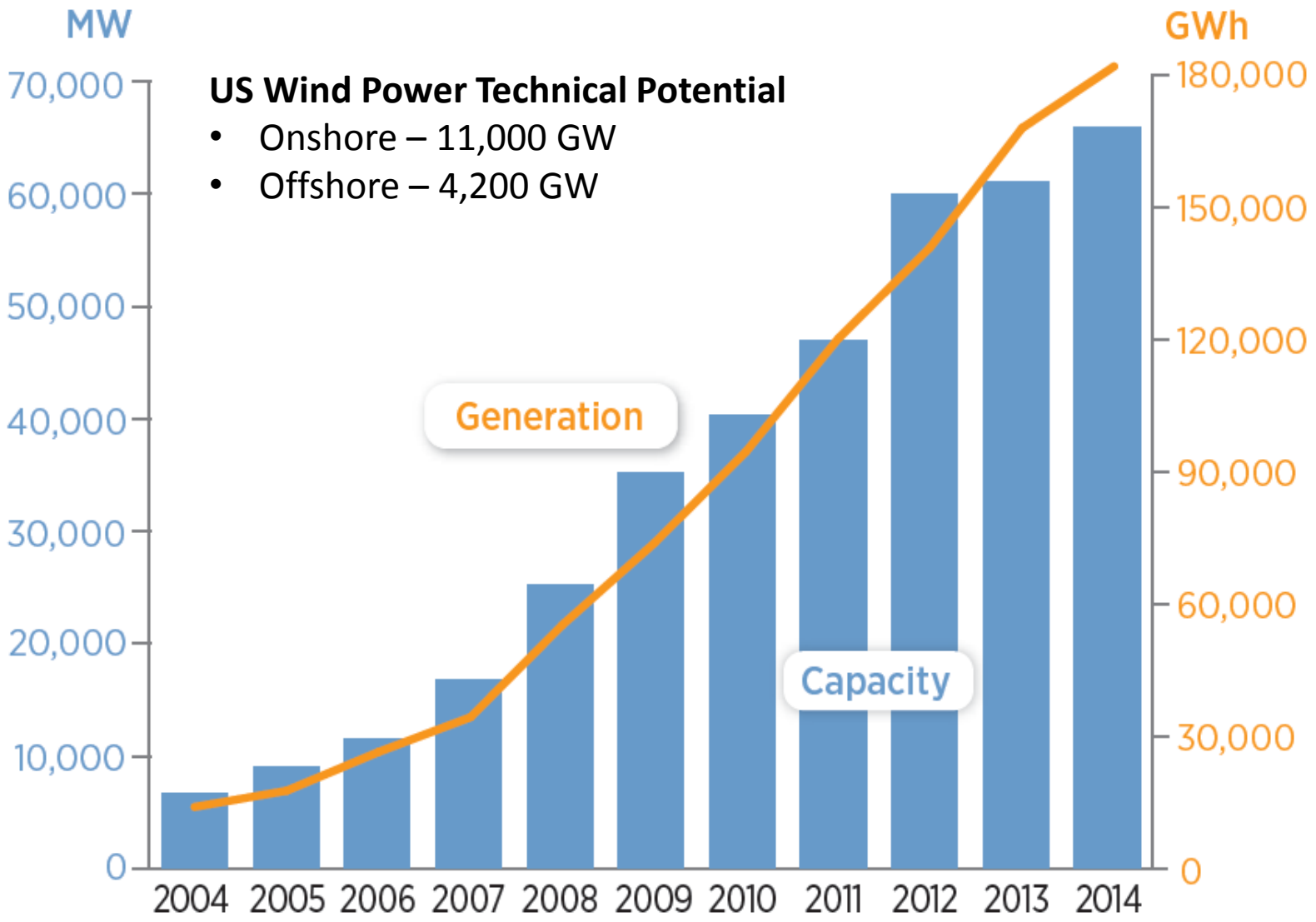
US Wind Resources



US Wind Power Technical Potential

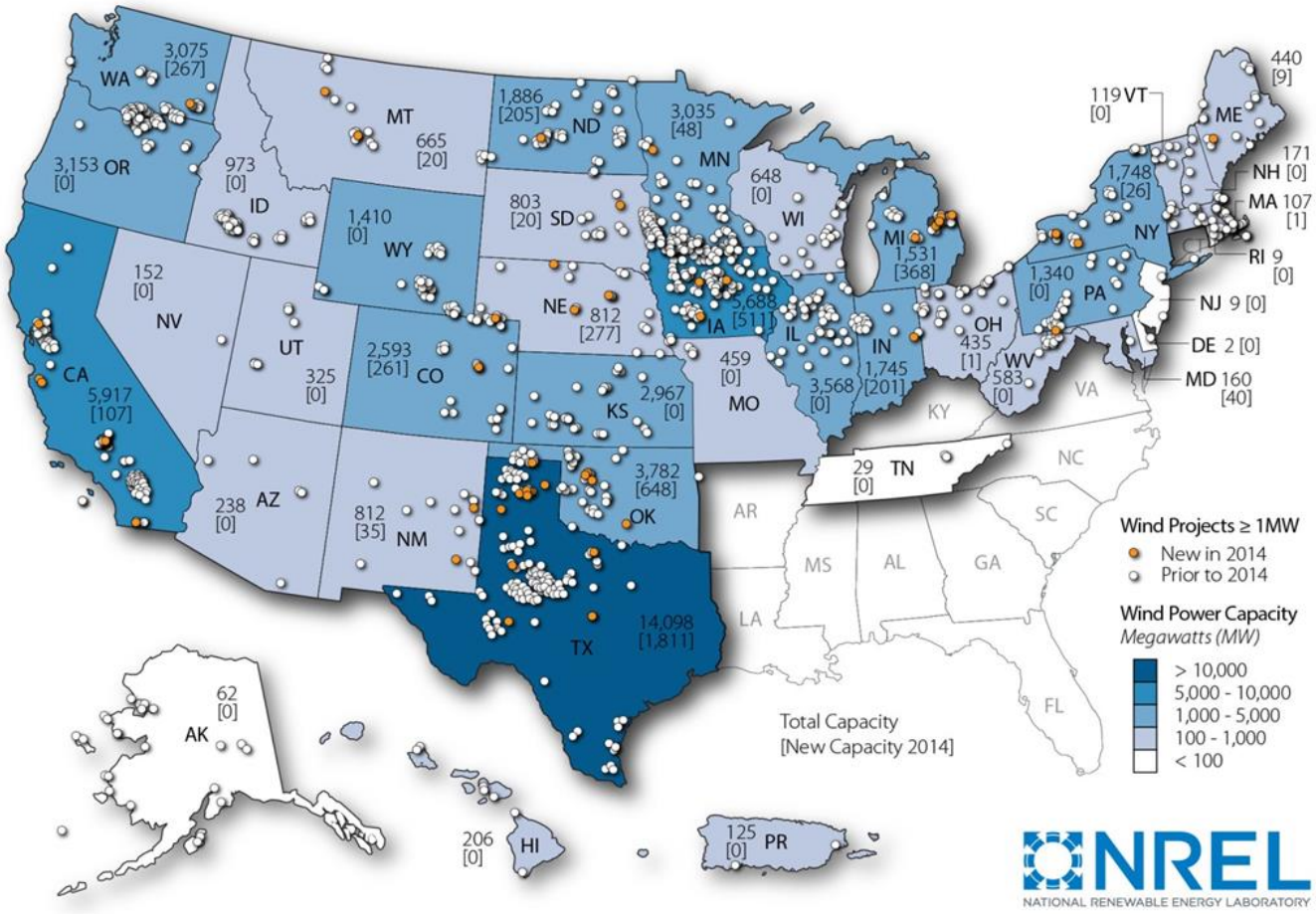
- Onshore – 11,000 GW
- Offshore – 4,200 GW

US Wind Generation Trends



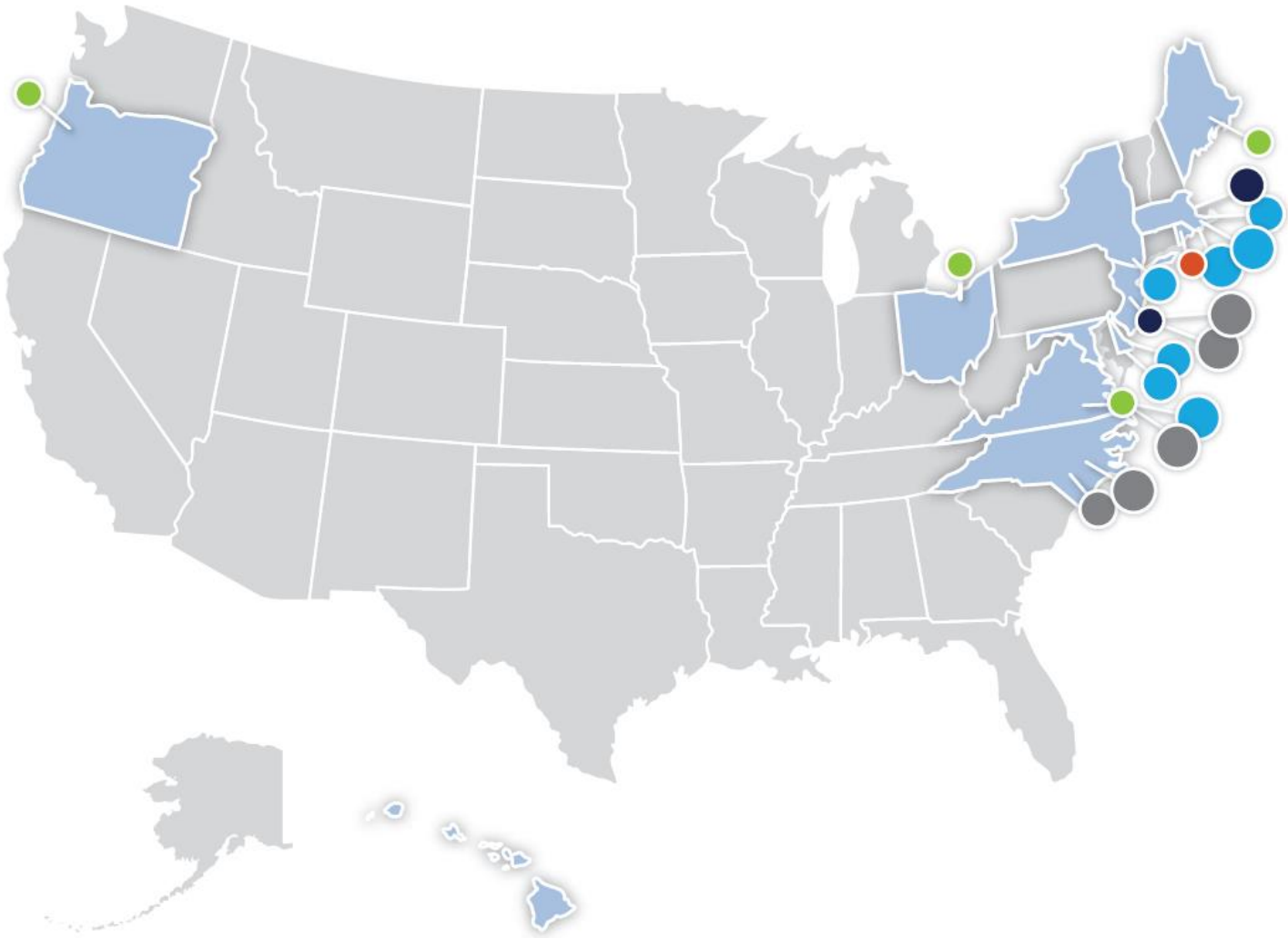
Source: EIA and LBNL

Geographic Spread of Wind Projects in the United States Is Reasonably Broad



Note: Numbers within states represent cumulative installed wind capacity and, in brackets, annual additions in 2014

US Offshore Wind Projects



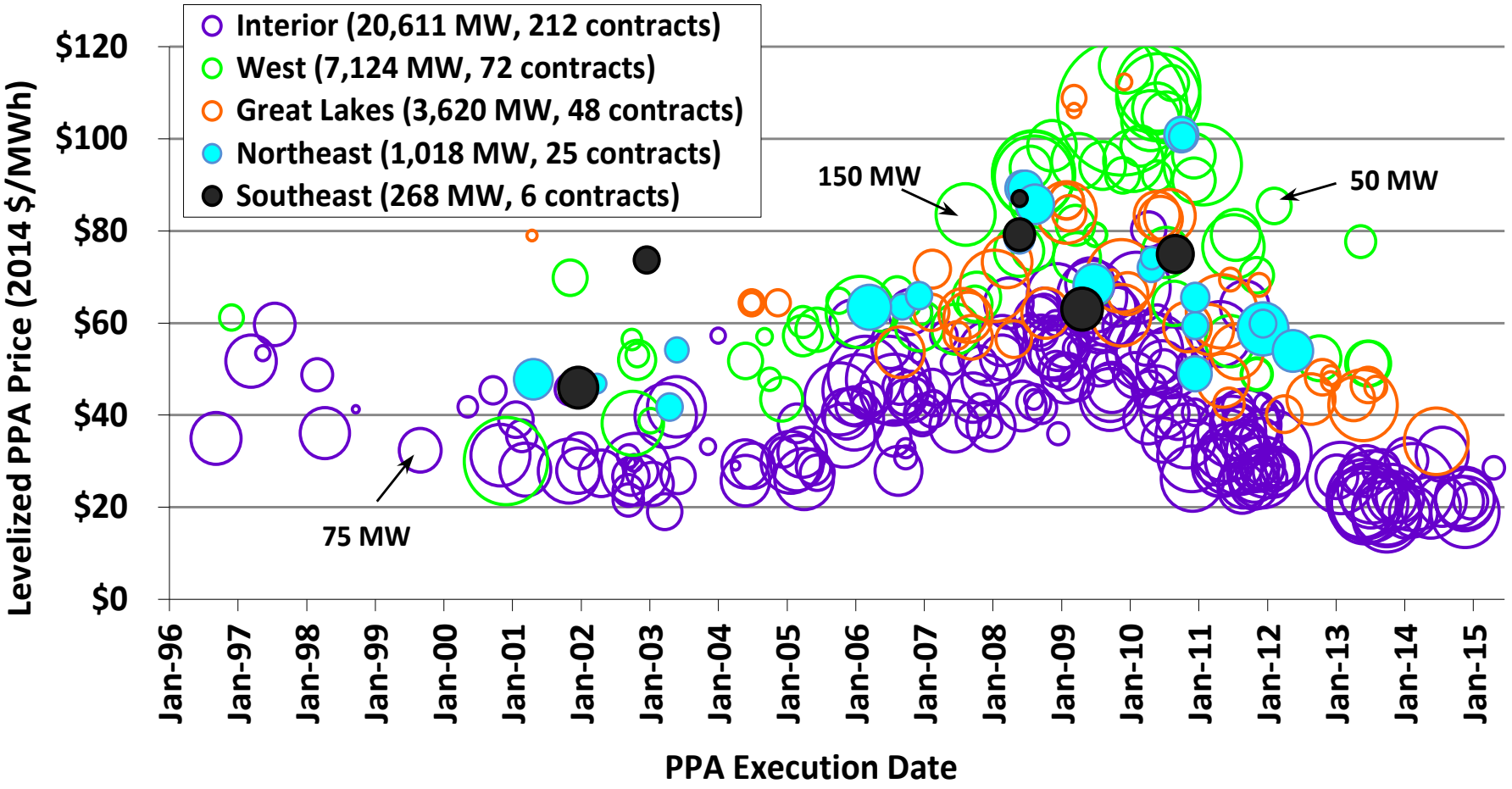
Project Status

- Under Construction
- Approved
- Permitting
- Planning—Site Control
- Planning—Early Stage

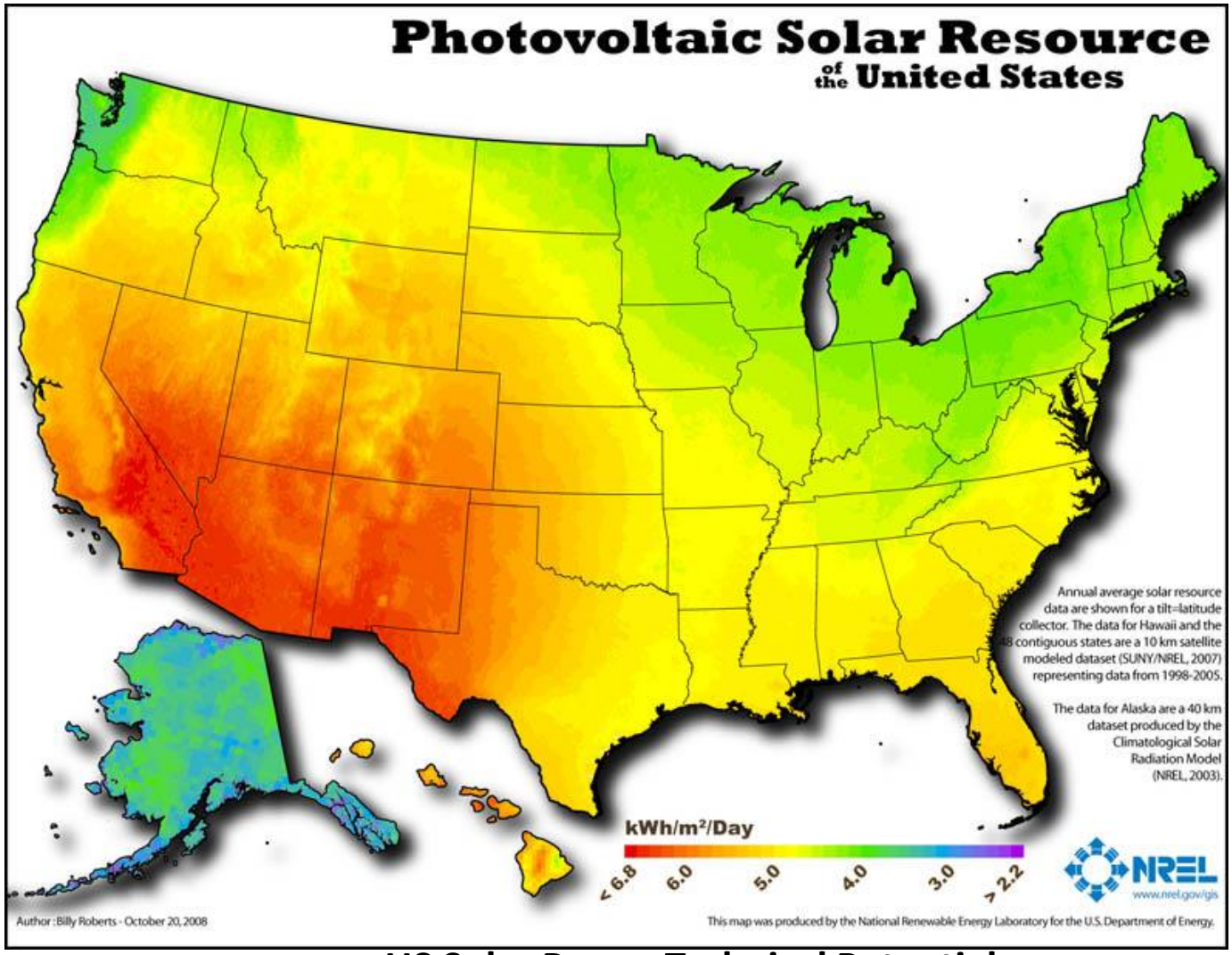
Project Size

- 0–50 MW
- 51–250 MW
- 251–500 MW
- 501–1,000 MW
- >1,001 MW

Wind Power PPA Trends



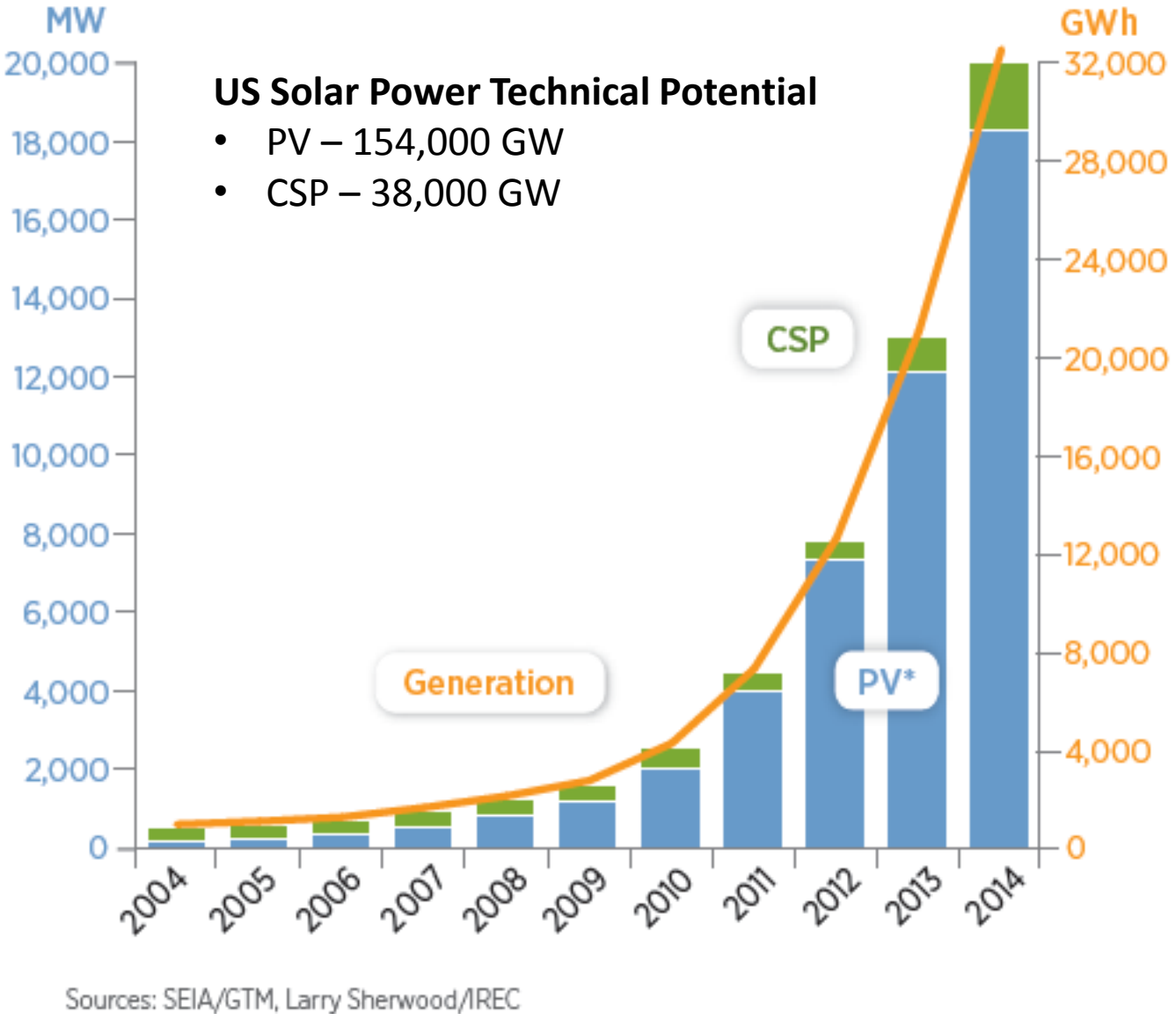
U.S. Solar Energy Resource



US Solar Power Technical Potential

- PV – 154,000 GW
- CSP – 38,000 GW

U.S. Solar Deployment Trends

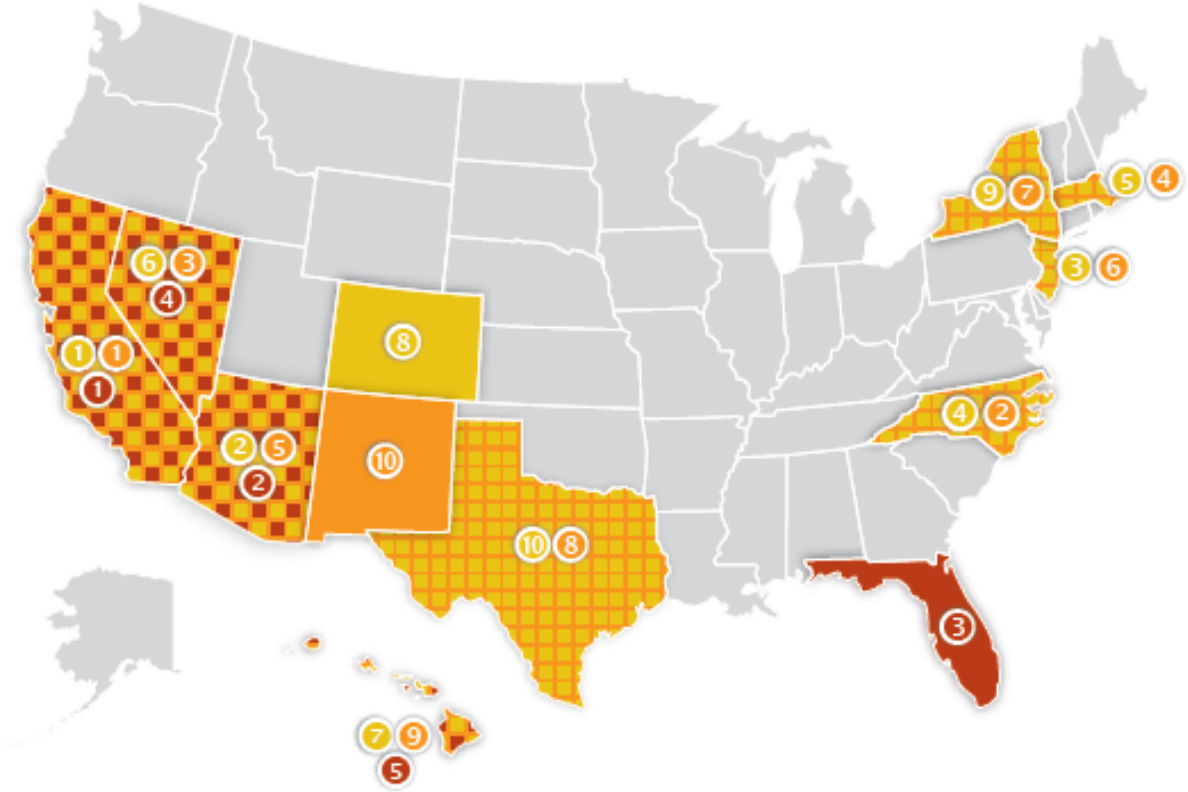


US Solar Power Technical Potential

- PV – 154,000 GW
- CSP – 38,000 GW

Sources: SEIA/GTM, Larry Sherwood/IREC

U.S. Solar Deployment



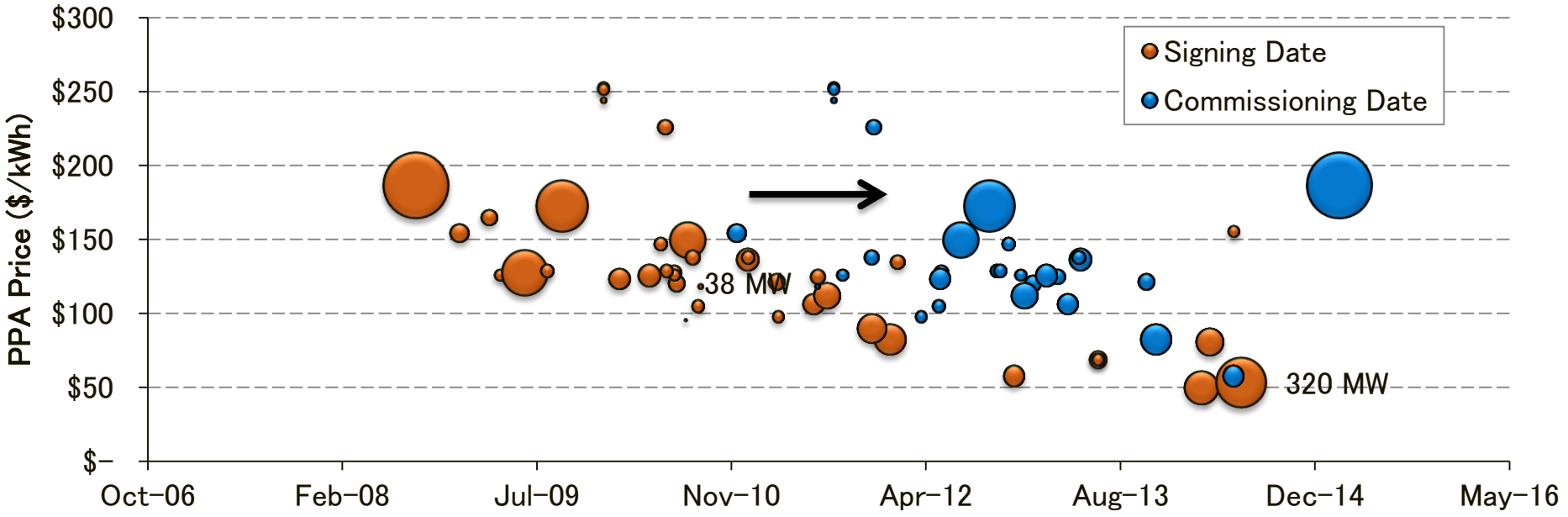
PV Cumulative Capacity (MW)	
1 California	8,720.7
2 Arizona	1,786.0
3 New Jersey	1,451.1
4 North Carolina	953.2
5 Massachusetts	751.2
6 Nevada	725.0
7 Hawaii	440.5
8 Colorado	398.4
9 New York	396.9
10 Texas	330.0

PV Annual Capacity Additions (MW)	
1 California	3,549.0
2 North Carolina	396.6
3 Nevada	339.3
4 Massachusetts	308.2
5 Arizona	246.6
6 New Jersey	239.8
7 New York	147.4
8 Texas	128.9
9 Hawaii	106.9
10 New Mexico	88.2

CSP Cumulative Capacity (MW)	
1 California	1,256.0
2 Arizona	283.0
3 Florida	75.0
4 Nevada	64.0
5 Hawaii	7.0

Sources: GTM/SEIA and IREC

US Solar PPA Price (Utility Projects)



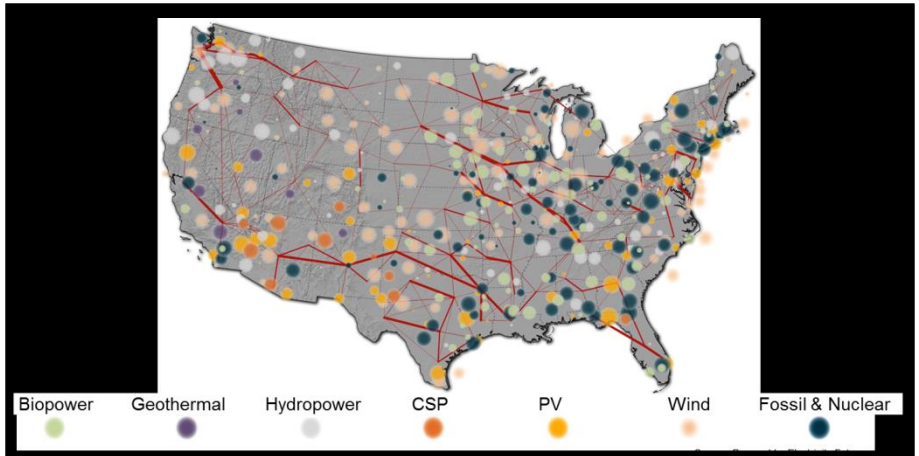
- PPA prices have continued to decline due to intense competition among solar developers
  - Several projects have signed PPA's for approximately $0.05/kWh
- A lag between a project's PPA "signing date" and its "commissioning date" can lead to conflicting information regarding "current" pricing for PV
  - The weighted capacity lag between the above projects averaged over 3 years

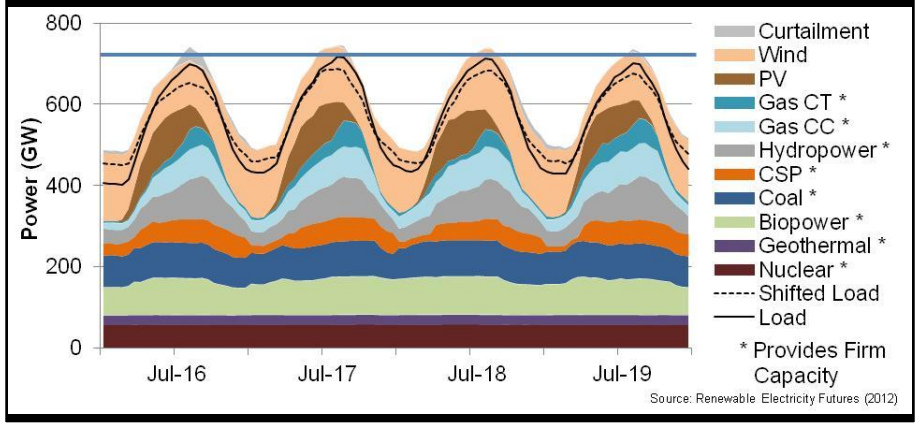
Note: Commissioning date data from NREL internal database.
Source: BNEF H2 2014 PPA Market Outlook. December 12, 2014.

Drivers for Renewable Energy

- **Federal**
  - Investment Tax Credit
  - Production Tax Credit
  - Clean Power Plan (final rule)
  - 1603 Treasury Grant
  - Modified Accelerated Cost Recovery System Depreciation Schedule (MACRS)
  - DOE Loan Program
- **Business**
  - 3rd Party Ownership & Leases
  - Services Platforms
  - Community Renewables
  - Solar Bonds & Individual Investors
- **State**
  - Renewable Portfolio Standards
  - Renewable Energy Certificates (RECs) or Performance Based Incentives
  - Net Metering & VOS
  - Carbon Markets
  - State Tax Credit
  - Property Assessed Clean Energy (PACE) Programs
  - Property Tax Exemptions
  - State Sales Tax Exemptions
  - Grants
  - Clean Energy Financing Program
  - Subsidized Loans
  - On-Bill Financing

Exploring Possibilities: Renewable Electricity Futures Study





National Renewable Energy Laboratory. (2012). Renewable Electricity Futures Study. Hand, M.M.; Baldwin, S.; DeMeo, E.; Reilly J.M.; Mai, T.; Arent, D.; Porro, G.; Meshek, M.; Sandor, D. eds. 4 vols. NREL/TP-6A20-52409. Golden, CO.

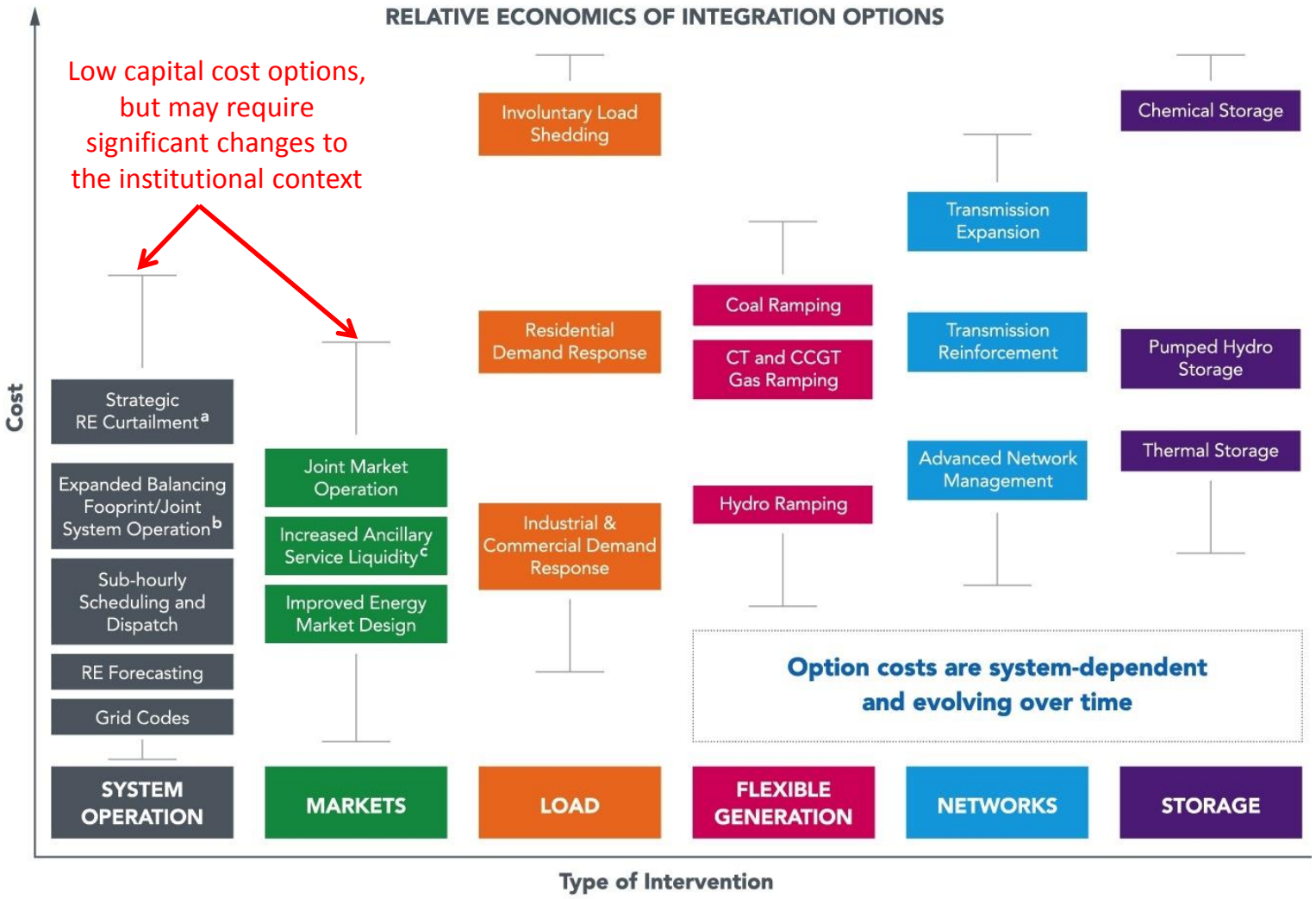
www.nrel.gov/analysis/re_futures

Methodology: ReEDS and SolarDS capacity expansion models used to develop high RE scenarios in the U.S. (and estimate associated cost/benefits); GridView production cost model used to evaluate hourly operability of 80%-by-2050 scenarios.

Key Findings:

- 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 impactful lever for reducing this incremental cost.

Transforming Power Systems: Enabling Flexibility



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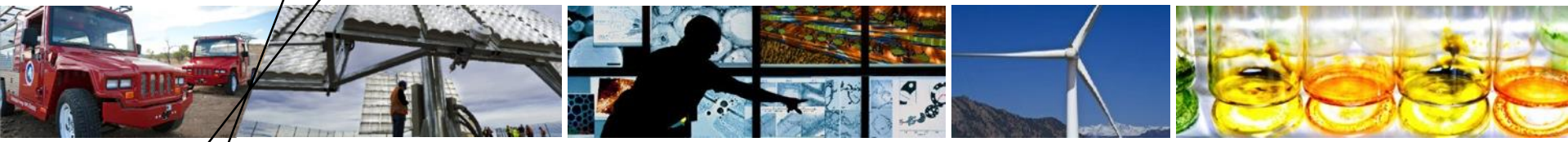

Thank You.

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