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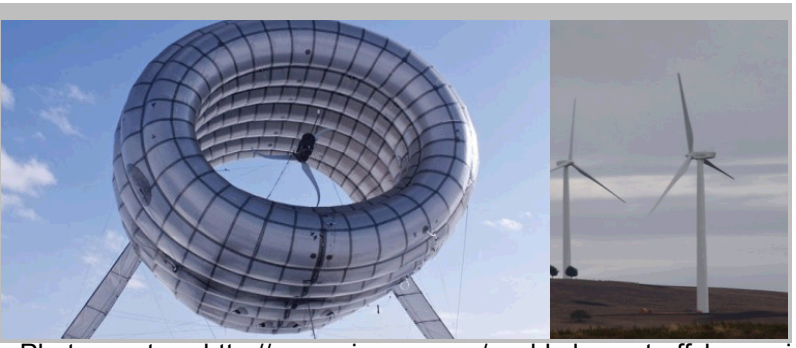

Photo courtesy http://www.gizmag.com/worlds-largest-offshore-wind-farm/9329/

Photo courtesy U.S. Department of Energy

ENG 505 -Feasibility Study of Alternative Energy Sources across US

Haoran Deng (6921), Biliana Paskaleva (6923), Janis Schubert (6923)

U.S. DEPARTMENT OF ENERGY | NNSA

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Alternative Energy Sources

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- Many choices of alternative energy sources both renewable and non-renewable
- Focusing primarily on renewable sources, which energy sources would be preferable for development in each state?
- What energy sources are possible in each state?
- How much energy can each source produce?
- Can we rank the possible sources based on factors such as potential production, cost, incentives, etc.?

Data Sources

- Study at NREL modeled technical potential for 5 types of renewable energy: solar, wind, biopower, geothermal and hydroelectric – generated capacity by state for these 5 types of energy and 10 subtypes
  - Lopez, A. et al. (2012). "U.S. Renewable Energy Technical Potentials: A GIS-Based Analysis." NREL/TP-6A20-51946. Golden, CO: National Renewable Energy Laboratory.
- State Energy Data System (SEDS) – state energy statistics
  - U.S. Energy Information Administration (EIA) State Energy Data System (SEDS) – http://www.eia.gov/state/seds/
- Database of State Incentives for Renewables & Efficiency (DSIRE) – incentives and subsidies
  - http://www.dsireusa.org/incentives/
- Oak Ridge Siting Analysis for power Generation Expansion (OR-SAGE) – nuclear plant potential siting
  - http://nuclearstreet.com/nuclear_power_industry_news/b/nuclear_power_news/archive/2012/02/28/oak-ridge-maps-every-potential-nuclear-plant-site-in-country-022802.asp

Analysis Approach

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- Considered 3 variables (factors) for the 6 alternative sources of energy:
  1. Technical potential (in BTU) per energy source; varies from state-to-state
  2. Cost of energy per energy source; same for all states
  3. Number of state initiatives and subsidies per energy source; varies from state-to-state; data available for 5 energy sources
- Ranked individually each factor within a state: 1-best, 6-worst
- Combined the ranking of the 3 variables to determine total rank or feasibility of energy source per state

Variables

- Technical Potential
  - Technical potential represents the achievable energy generation of a particular technology given system performance, topographic limitations, environmental, and land-use constraints.
- Cost
  - Levelized cost represents the present value of the total cost of building and operating a generating plant over an assumed financial life and duty cycle, converted to equal annual payments and expressed in terms of real dollars to remove the impact of inflation
  - Reflects overnight capital cost, fuel cost, fixed and variable O&M cost, financing costs, and an assumed utilization rate for each plant type
  - Costs are expressed in terms of net AC power available to the grid for the installed capacity.
  - Cost does not include targeted tax credits: could significantly affect the leveled cost estimate

Examples of Variables 1 and 2 Data and Analysis

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State Code	AllSolB	AllWinB	AllBioB	AllGeoB	NucllB	HydroB	R1Sol	R1Wind	R1Bio	R1Geo	R1Nucll	R1Hydro
AL	12823391.81	966	43425	1827166	711449	13999	1	6	4	2	3	5
AK	28263254.39	4686349	1963	52674	0	80784	1	2	5	4	6	3
AZ	83788787.22	88840	6569	4256569	454819	4447	1	4	5	2	3	6
AR	17142034.45	78112	52699	2144946	571700	20792	1	4	5	2	3	6
CA	60392356.59	9391721	95264	5033252	508178	102445	1	2	6	3	4	5

Plant type	Capacity factor (%)	Levelized capital cost	Fixed O&M	Variable O&M (including fuel)	Transmission investment	Total system levelized cost
Dispatchable Technologies						
Conventional Coal	85	65.7	4.1	29.2	1.2	100.1
Advanced Coal	85	84.4	6.8	30.7	1.2	123
Advanced Coal with CCS	85	88.4	8.8	37.2	1.2	135.5
Natural Gas-fired						
Conventional Combined Cycle	87	15.8	1.7	48.4	1.2	67.1
Advanced Combined Cycle	87	17.4	2	45	1.2	65.6
Advanced CC with CCS	87	34	4.1	54.1	1.2	93.4
Conventional Combustion Turbine	30	44.2	2.7	80	3.4	130.3
Advanced Combustion Turbine	30	30.4	2.6	68.2	3.4	104.6
Advanced Nuclear	90	83.4	11.6	12.3	1.1	108.4
Geothermal	92	76.2	12	0	1.4	89.6
Biomass	83	53.2	14.3	42.3	1.2	111

http://www.eia.gov/forecasts/aeo/electricity_generation.cfm

Variable 3: Financial Incentives for Renewable Energy

http://www.dsireusa.org/glossary/

- **Corporate Tax Incentives:** includes tax credits, deductions and exemptions.
- **Grant Programs:** encourage the use and development of renewables and energy efficiency
- **Green Building Incentives;** designed and constructed using practices and materials that minimize the impacts of the building on the environment and human health;
- **Industry Recruitment/Support:** to promote economic development and the creation of jobs,
- **Loan Programs:** provide financing for the purchase of renewable energy or energy efficiency systems or equipment.
- **Property-Assessed Clean Energy (PACE)** allows property owners to borrow money for renewable energy and/or energy-efficiency improvements.
- **Performance-Based Incentives Performance-based incentives (PBIs)** provide cash payments based on the number of kilowatt-hours (kWh) or BTUs generated by a renewable energy system.
- **Personal Tax Incentives** include income tax credits and deductions. Eligible technologies vary widely by state.
- **Property Tax Incentives** include exemptions, exclusions, abatements and credits. Most property tax incentives provide that the added value of a renewable energy system is excluded from the valuation of the property for taxation purposes.
- **Rebate Programs** to promote the installation of renewable energy and energy efficiency projects
- **Sales Tax Incentives:** provide an exemption from, or refund of, the state sales tax (or sales and use tax) for the purchase of a renewable energy system or energy-efficiency measures.

Financial Incentives for Renewable Energy, example

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http://www.dsireusa.org/summarytables/finre.cfm

State	Personal Tax	Corporate Tax	Sales Tax	Property Tax	Rebates	Grants	Loans	Industry Support	Bonds	Performance Based Initiatives
Federal	3	4	0	0	0	4	6	1	0	0
Arizona	4	2	1	1	10 1		1	1		
Arkansas					1		1 1	1		
California			1	1	7 46 2		3 1 7	1		1 2 1
Colorado			2 1	3	20 2	1	2 1 2			2
Florida		1	1		21 1		1 6 3	1		2
Hawaii	1	1		1	1 1		3 1 2			1
Illinois			1	2	2 14	4 1 1	2	1	1	1 1
Iowa	3	3	1	3	24		3 2			1
Louisiana	1	1		1	1		2 1			
Minnesota			2	1	76	2	6 2			1
New York	2	1	3 1	3 1	8 6		3			2 1
New Mexico	6	5	4	1	1		2	1	1	3
Texas		1		1 1	26 2		2 1 1	1		1
Utah	2	2	1		4		1	1	1	
Vermont		1	1	2	1		1			1 2
Washington			1		13	1	9 1	1		1 3
Wisconsin	1	1	1	1	3 7	1	1 2			2
Total	45	42	46	77	554	53	204	40	4	75

State Utility Local Nonprofit Federal

Current Energy Usage

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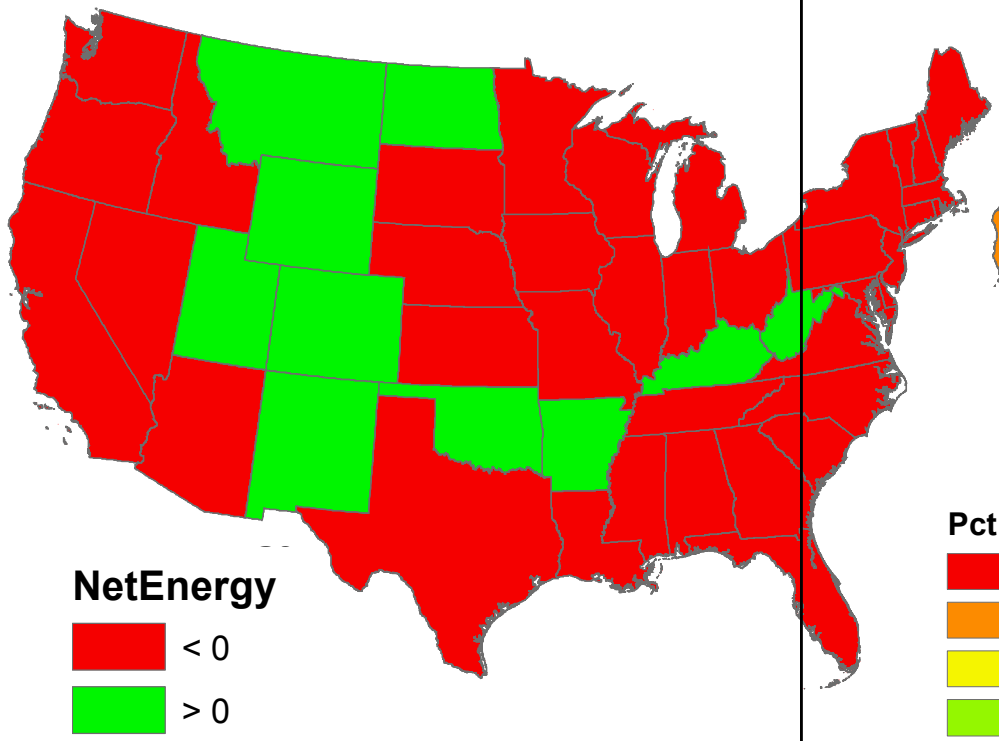
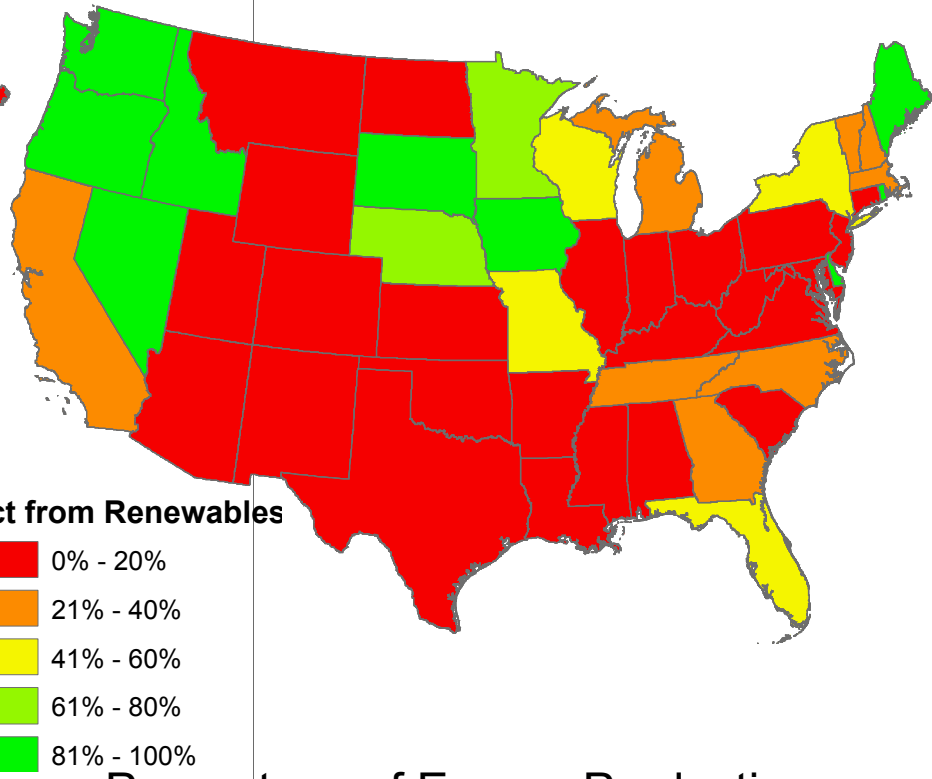


Net Energy Usage
(Total Production – Total Consumption)



Percentage of Energy Production from Renewable Sources
(Total Renewable Production / Total Production)

U.S. Renewable Resources

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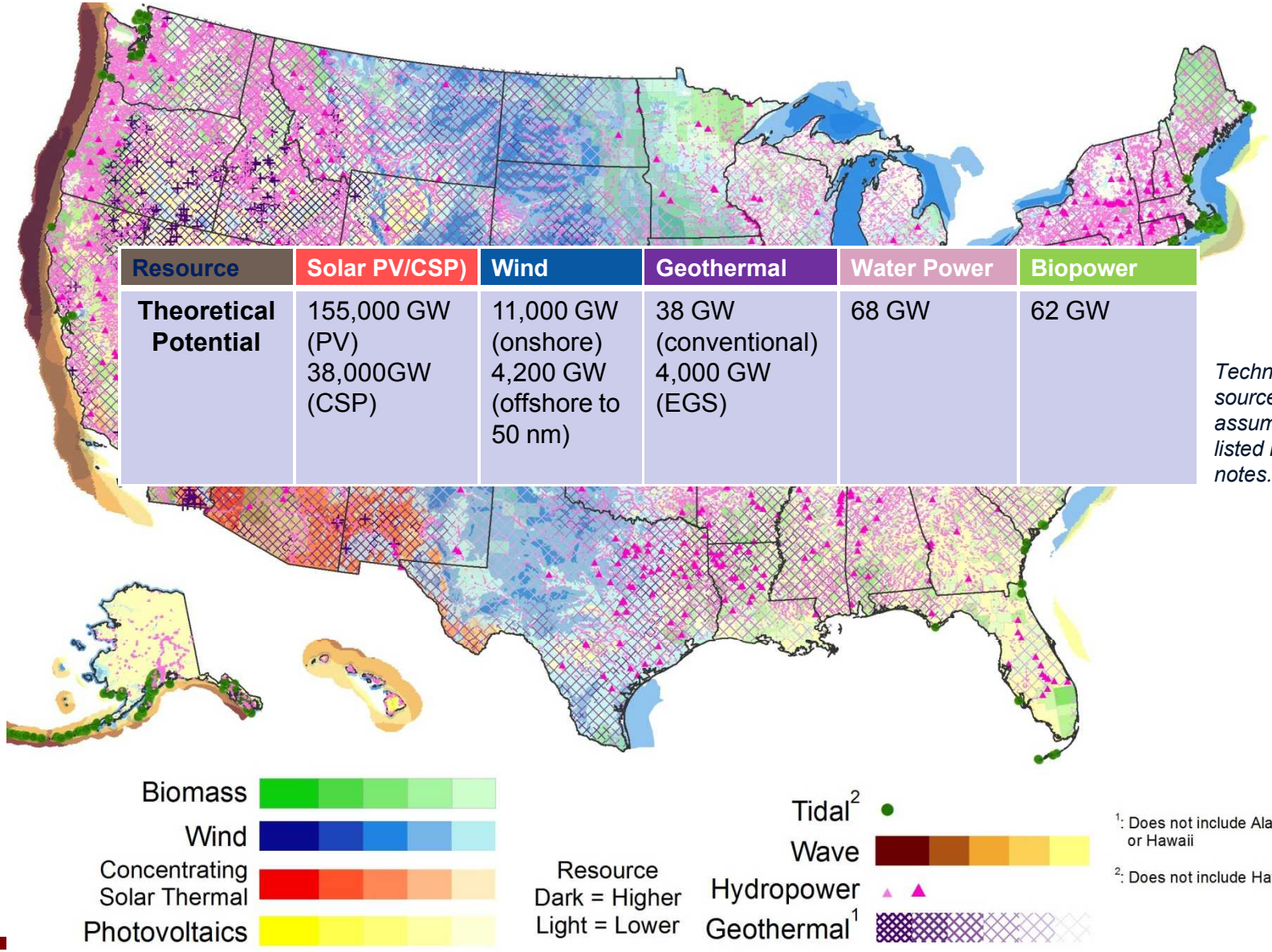
Resource	Solar PV/CSP)	Wind	Geothermal	Water Power	Biopower
Theoretical Potential	155,000 GW (PV) 38,000GW (CSP)	11,000 GW (onshore) 4,200 GW (offshore to 50 nm)	38 GW (conventional) 4,000 GW (EGS)	68 GW	62 GW

Technical potential sources and assumptions are listed in the slide notes.



Lopez, A. et al. (2012). "U.S. Renewable Energy Technical Potentials: A GIS-Based Analysis." NREL/TP-6A20-51946. Golden, CO: National Renewable Energy Laboratory.

Potential Nuclear Plant Sites in the Contiguous US

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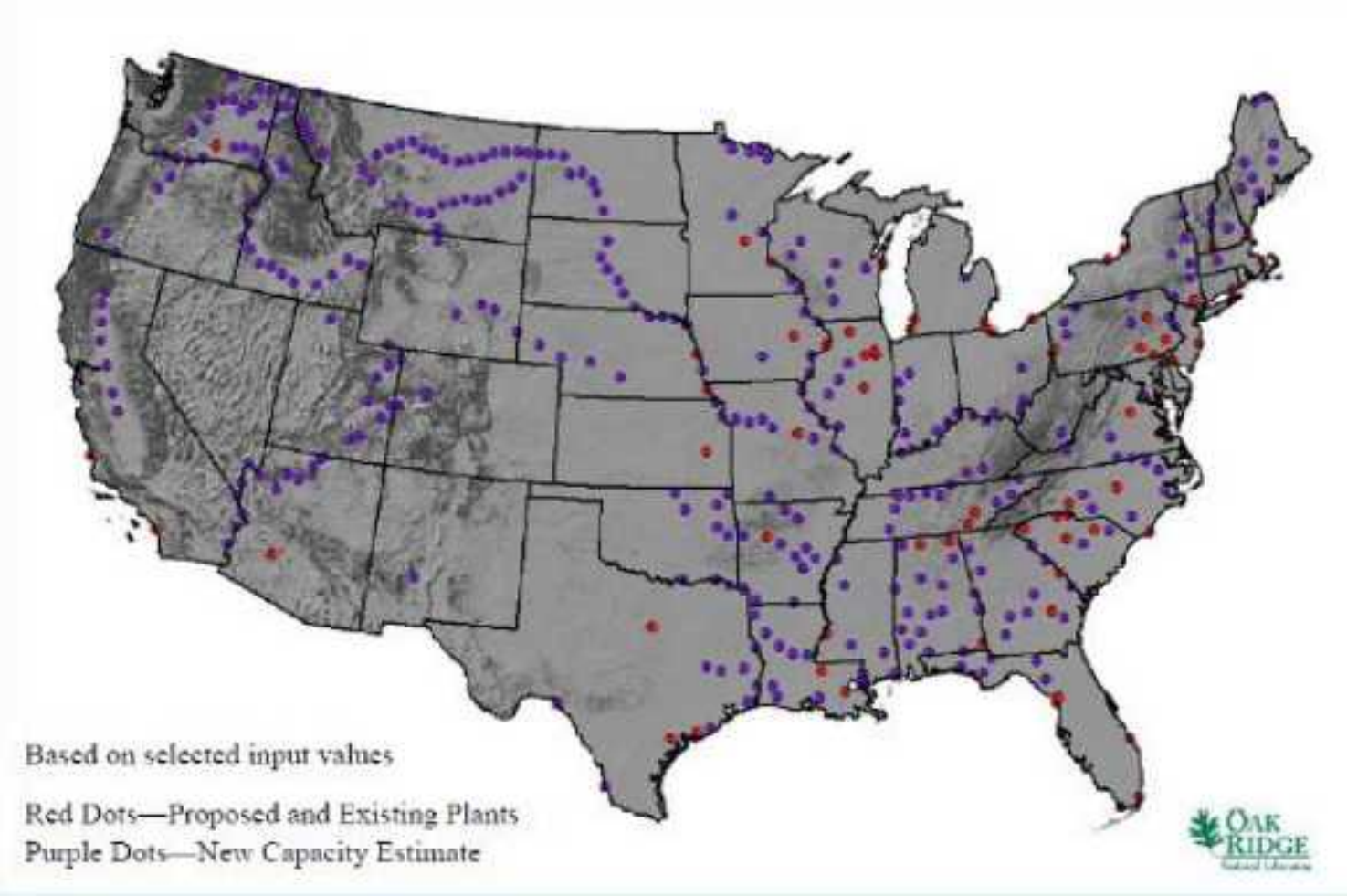

http://nuclearstreet.com/nuclear_power_industry_news/b/nuclear_power_news/archive/2012/02/28/oak-ridge-maps-every-potential-nuclear-plant-site-in-country-022802.aspx

Solar Technical Potential

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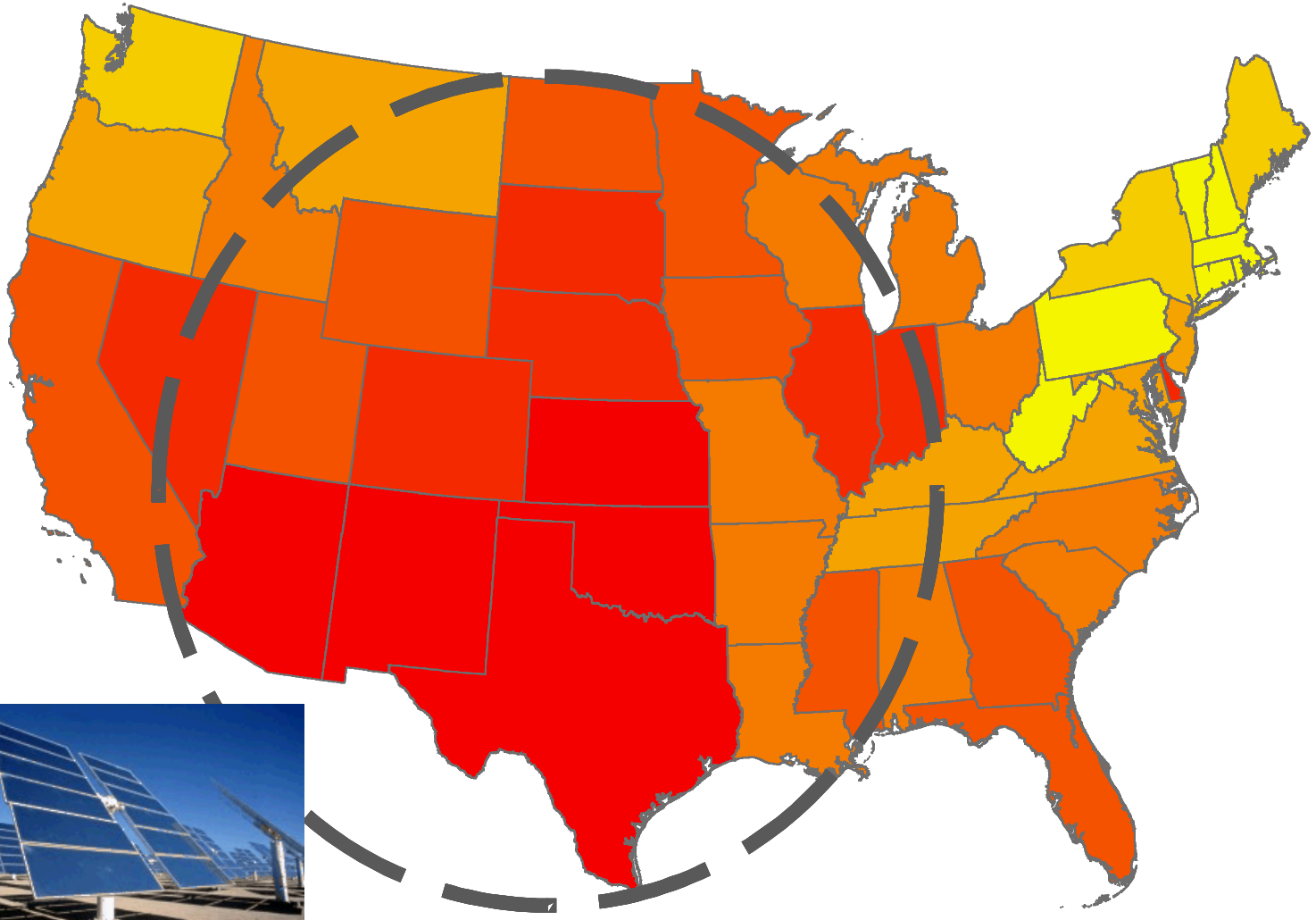

http://www.conserve-energy-future.com/SolarEnergy.php

Wind Technical Potential

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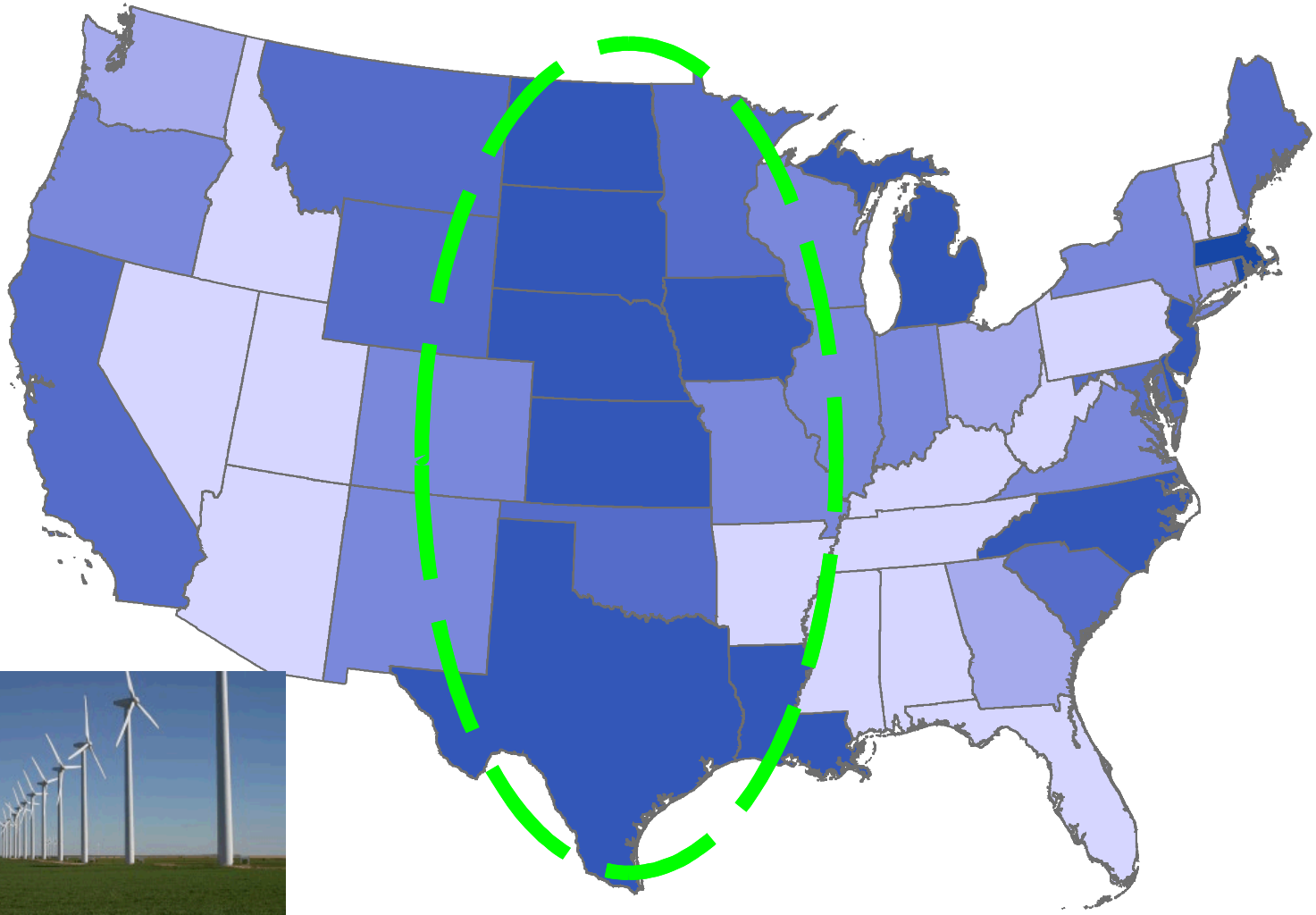
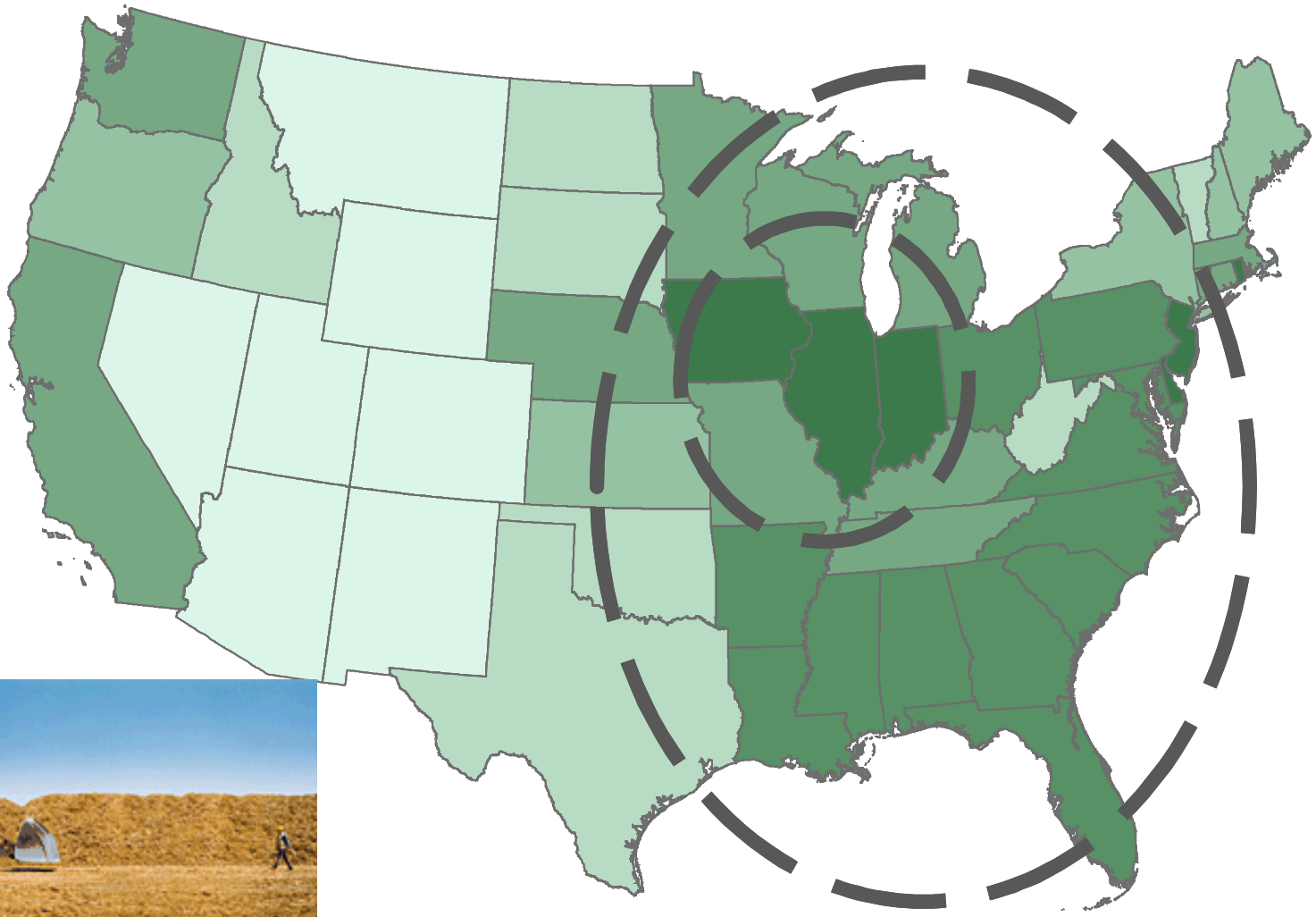


http://blogs.scientificamerican.com/plugged-in/2012/08/16/tax-credits-the-wind-in-wind-energy/

Biopower Technical Potential



http://www.energy.siemens.com/us/en/renewable-energy/?stc=usccc025486

Geothermal Technical Potential

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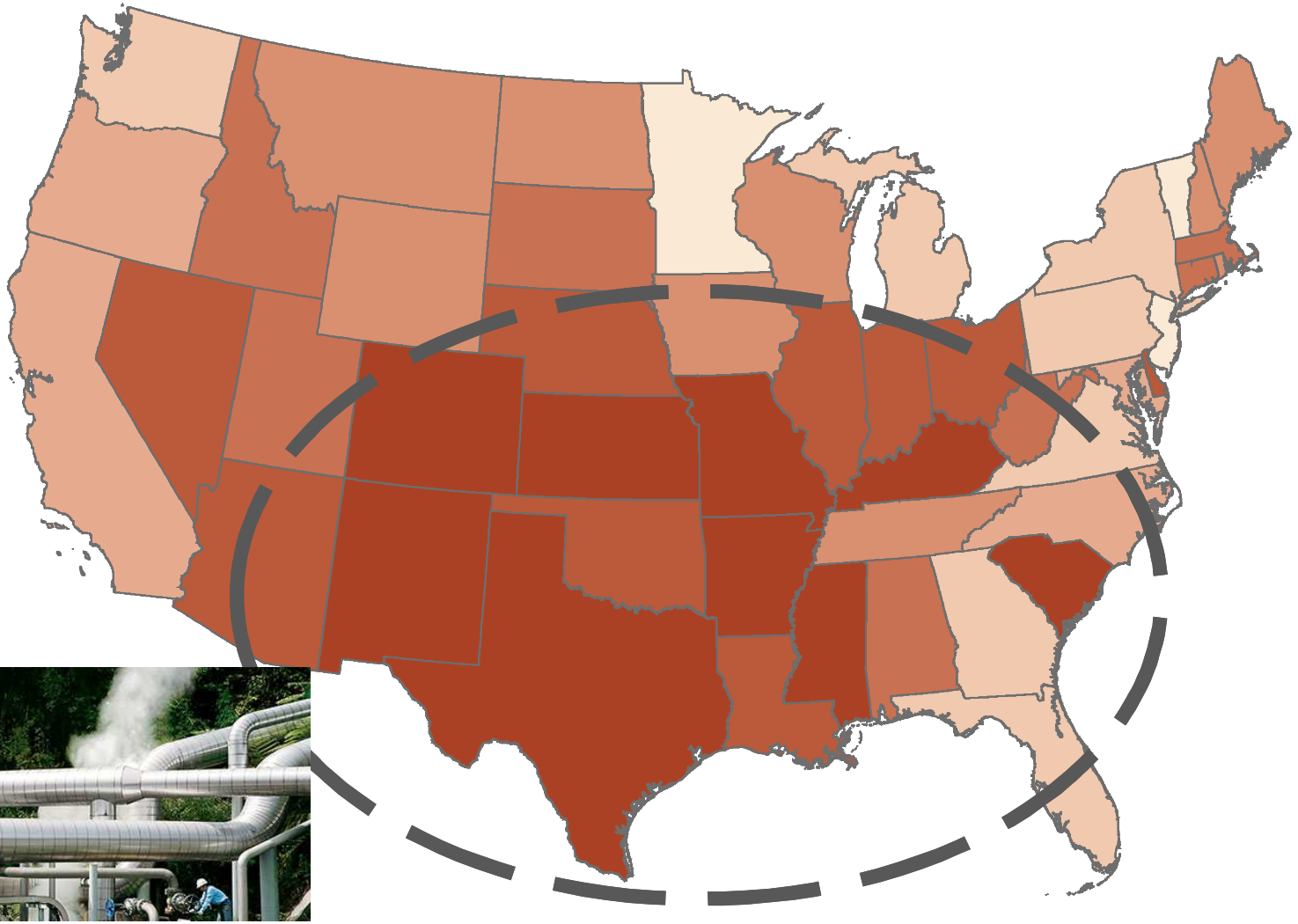

http://www.chevron.com/deliveringenergy/geothermal

Hydroelectric Technical Potential

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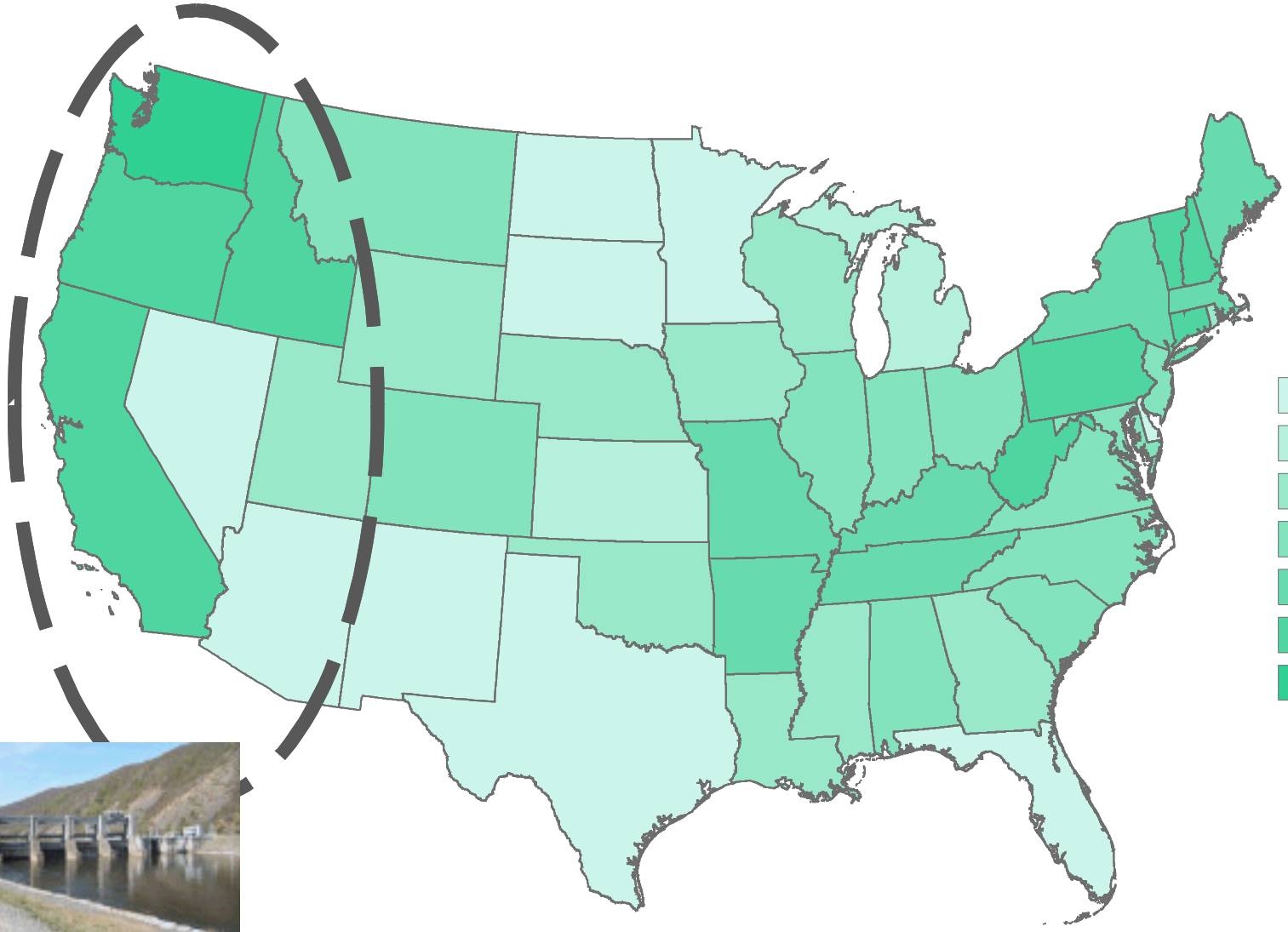

http://www.energy.siemens.com/us/en/renewable-energy/?stc=usccc025486

Nuclear Potential

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http://images.yourdictionary.com/nuclear-energy

Ranking by Technical Potential

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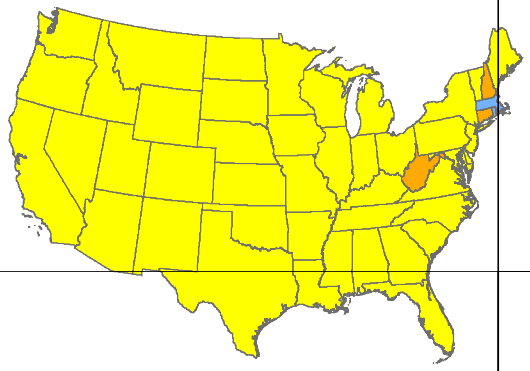
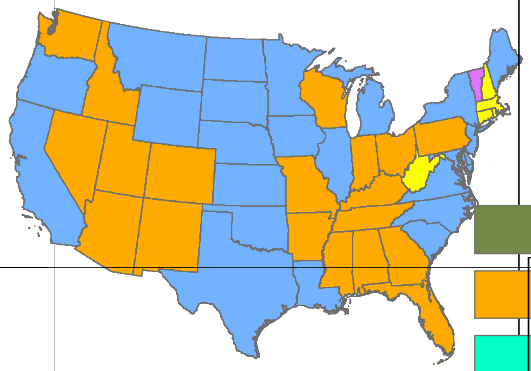
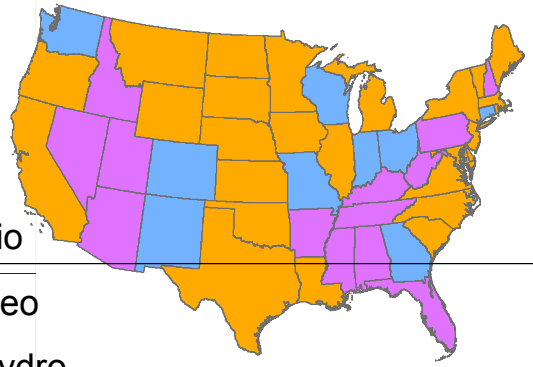
Rank #1



Rank #2

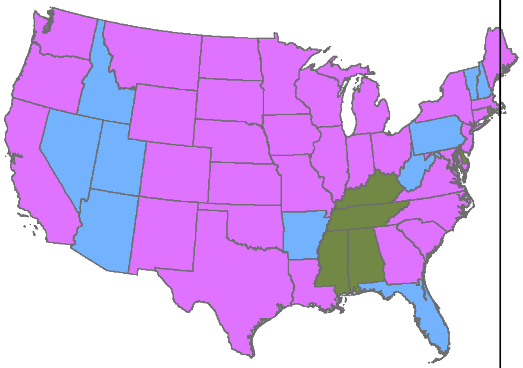


Rank #3

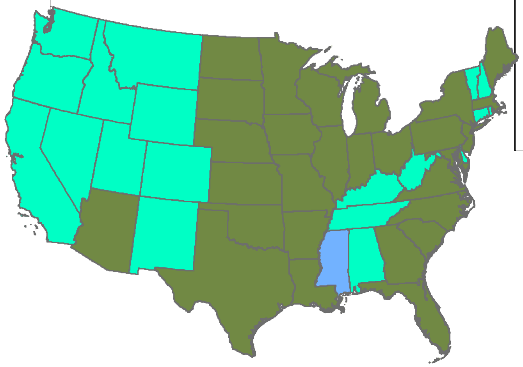


Bio
Geo
Hydro
Nuclear
Solar
Wind

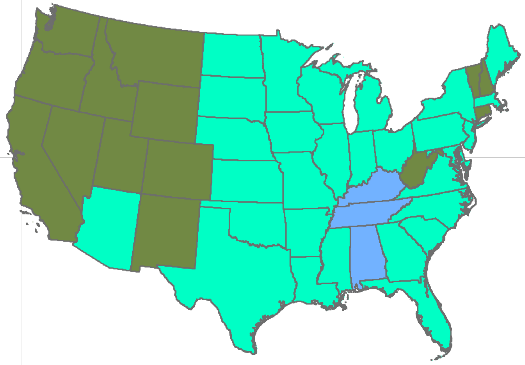
Rank #4



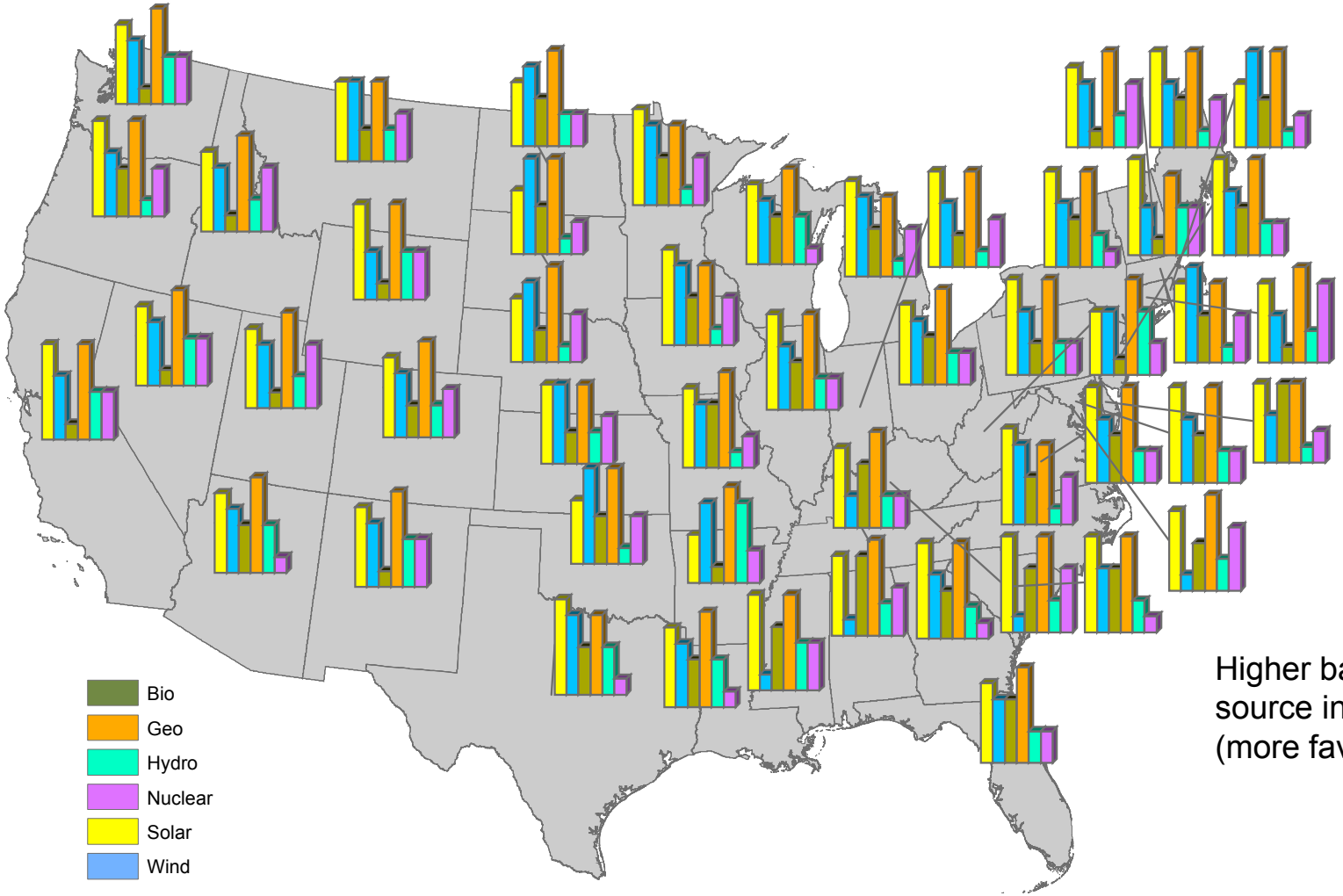
Rank #5



Rank #6



Ranking by Potential, Cost, and Incentives



Higher bars for an energy source indicate a higher (more favorable) ranking.

Conclusions

- Solar has highest potential to provide renewable energy in nearly every state
- Solar has the higher number of state and federal incentives; however, comes at the highest price
- Nuclear with lower than solar potential can be also developed in nearly every state
- Alternatives other than solar have regional potential and more dependent factors such as land availability, water availability, terrain conditions, cost, etc.
- Hydro and bio energy have potentials with complimentary spatial locations across US (~50-50%, West to East)

Conclusions

- Consideration of cost and incentives in addition to potential for energy production can result in significant changes in ranking of energy sources across sates
  - When technical potential and number of inceptives considered, solar continue to be the lead
  - Including cost in the equation, the solar shares the 1st place with geo and others