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ELEVEN STATES AND 116 MILLION AMERICANS AT HIGH RISK FOR ELECTRIC GRID OUTAGE; SENATE VOTES WEDNESDAY ON KEY PRESIDENTIAL APPOINTEES CHARGED WITH GRID RELIABILITY

NASHUA, NH—States that import electricity over interstate transmission lines and rely on overburdened natural gas pipelines for local electricity generation are at high risk of electric grid outage, according to a quantitative analysis by the Foundation for Resilient Societies, a non-profit research organization. Eleven high-risk states for electric grid outage have population of 116 million, more than a third of all Americans. Unless physical security, cyber-security, and pipeline reliability standards are enacted, increased dependence on natural gas for generation will expose states to electricity shortages and blackouts.

A Senate committee vote on confirmation of Norman Bay and Cheryl LaFleur as Commissioners of the Federal Energy Regulatory Commission (FERC) is expected on Wednesday, June 18. FERC is the lead federal agency charged with electric grid reliability and gas-electric coordination. Will the President's nominees advocate measures to assure that natural gas pipelines supplying just-in-time fuel for the electric grid continue to function during regional electricity blackouts?

Using data from the U.S. Energy Information Administration (EIA), Resilient Societies developed an Electric Reliability Risk Index (ERRI) for each of the fifty states and Washington D.C. The Electric Reliability Risk Index is the percent of electric power reliant on interstate transmission plus the percent of electric power generated by interstate natural gas. Eleven states depend on imported electricity and natural gas for half or more of their electricity consumption and therefore are at high risk for electricity shortages and long-term blackout. States and associated regions that are at high risk for electric grid outages include California and Nevada; Mississippi; Florida; the Mid-Atlantic region of Virginia, Maryland, Washington D.C., Delaware, New Jersey, and New York; and the New England states of Massachusetts and Rhode Island. (See page 4 for an analysis of all 50 states.)

EIA data shows that California, New York, and other populous states already rely on long-distance electricity transmission prone to cascading outage. EIA projects that if natural gas prices stay low, gas will soon become the No. 1 energy source for electricity generation. Gas purchased for electric generation is often without firm delivery contracts. The risks of non-delivery of natural gas to electric utilities are elevated by the present void of reliability standards for interstate gas pipelines.

Of the eleven high-risk states, only one—Nevada—has a senator on the U.S. Senate Energy and Natural Resources Committee, the committee charged with oversight responsibility for FERC. FERC regulates permits and tariffs for interstate natural gas pipelines, but pipeline reliability is largely unregulated; U.S. Department of Transportation principally regulates safety, not pipeline reliability.

Cheryl LaFleur, nominee for Commissioner, testified to the Senate Energy Committee, "The rapid increase in the use of natural gas for electricity generation will continue to require significant work by the industry, State commissions and FERC to ensure that reliability is maintained."

Norman Bay, nominee for FERC Chairman, testified, "The prospect of 'overreliance' on natural gas for power generation is an issue that requires careful consideration."

Electric power carried on long-distance transmission lines is vulnerable to disruption by deliberate attack and weather-related events. A 2013 analysis prepared by the FERC and reported by the *Wall Street Journal* estimated that damage to as few as nine transformer substations could collapse the United States electric grid for over a year. A 2010 report by the Oak Ridge National Laboratory concluded that a severe solar storm could damage high voltage transformers, interrupting long-distance transmission of power for 1-2 years for up to 130 million Americans.

The North American Electric Reliability Corporation (NERC) is a private corporation charged with setting grid reliability standards. In 2013, FERC ordered that NERC set a standard to protect against solar storms. In 2014, FERC ordered a standard for physical security of critical grid facilities. Both standards approved by NERC exempt generation plants. FERC Acting Chair LaFleur has testified that physical attack on a single generation plant could cause cascading grid outage.

As the length and complexity of energy delivery systems increase, potential points of failure also increase. Interstate pipeline compressors and electric transmission substations are commonly managed by computerized controls that are susceptible to cyber-attack and electromagnetic pulse attack. In September 2007, a leaked test video from the Idaho National Laboratory revealed vulnerability of grid substations to "Aurora" cyber-attacks, but seven years later grid reliability standards still do not require protection against this threat.

Natural gas is commonly transported in pipelines hundreds of miles long that use compressor stations every 50-100 miles to maintain pressure. Compressor stations were once self-powered using natural gas from pipelines, but now motors using commercial grid electricity are being installed for economic and environmental reasons. A 2011 report by NERC found that an electricity brown-out because of a severe weather event could reduce power to electric compressors for pipelines. This, in turn, could cause gas-fired electric generators to trip off, creating a "downward spiral." Natural gas pipelines do not have the mandatory equivalent of electric grid "reliability coordinators," but gas delivery interruptions nonetheless affect reliable electricity generation.

Like transformer substations for the electric grid, compressor stations for gas pipelines are often unmanned, in remote locations, and vulnerable to physical attack. Both large gas pipeline compressors and high voltage transformers have replacement lead times of 1-2 years. Stocking of spare transformers is minimal. Since disclosure of physical attack risks in the *Wall Street Journal*, the Virginia State Police have been guarding critical electric grid substations south of Washington D.C.

Gas-electric interdependency, hard-to-replace equipment, and inadequate reliability standards could impede restoration and cause long-term outage after an electric grid collapse—resulting in cascading impacts to critical infrastructure such as telecommunications and the Internet; water and sanitation; food production and distribution; transportation; banking and finance; among others. Because the U.S. electric grid is organized into only three wide-area interconnections, gas-electric interdependency in a single state can ripple through large regions of the country.

"The rapid and unplanned increase in infrastructure interdependencies poses extreme risks to life-sustaining services. Our most critical infrastructures, electric power and communication, are also the most vulnerable to simultaneous multi-state failure from sabotage, cyber-attack, electromagnetic

pulse, and natural disasters such as hurricanes, floods, and solar storms," commented Dr. George Baker, Professor Emeritus of Infrastructure Studies at James Madison University and a director of Resilient Societies. "When there are cost-effective ways to reduce infrastructure interdependencies—such as providing long-term back-up power for life-essential infrastructures, for example equipping gas pipeline compressors with redundant gas and electric powered motors—federal and state governments should set and enforce mandatory standards."

Geological factors prevent significant underground natural gas storage in about 40% of states. Pipeline capacities in regions such as New England are already overburdened. For other regions, pipeline capacities are likely to become constricted due to increased use of natural gas for electric generation. Permitting delays and related safety concerns in local communities put just-in-time delivery of natural gas via pipeline at increased risk. States using imported natural gas for generation and having no underground storage include Nevada, Arizona, Wisconsin, Florida, Georgia, South Carolina, North Carolina, Delaware, New Jersey, and all of the New England states except Vermont. In contrast, coal-fired generation plants typically store two months of fuel on-site and nuclear plants have several years of fuel on-site. Renewable generation can also be fuel-resilient, especially hydroelectric and geothermal plants.

In February 2011, cold weather and related natural gas shortages caused blackouts for 4.4 million electricity customers in Texas, Arizona, and New Mexico. In September 2011, a transmission failure in Arizona caused a blackout for 1.5 million people in southern California. In February 2013, the New England states narrowly missed rolling blackouts when residents using natural gas for heating caused shortages for electricity generation plants. In February 2014, Californians were asked to conserve electricity after a cold snap constricted supplies of natural gas in southern California. In the winter of 2014, the Polar Vortex in the Midwest caused a surge in natural gas demand for the heating of buildings, with resulting shortages of natural gas for electricity generation, application of "demand response" programs to reduce electricity consumption, and extraordinary spikes in rates for electricity consumers.

"The warning signs for an electric grid outage lasting weeks, months, or years are clearly evident," said Thomas Popik, chairman of Resilient Societies. "It is folly for states to blindly depend on distant generation plants and any single imported energy source for the majority of their electricity—instead, local electricity generation should use a diversity of fuel sources. Moreover, regulated utilities should be required to implement cost-effective electric reliability improvements such as armed guards for the most critical gas pipeline and electric grid facilities, current blockers for transformer protection during solar storms, hardware protection against Aurora cyber-attack, and gas pipeline compressors with redundant gas and electric drives."

Foundation for Resilient Societies is a Nashua, New Hampshire non-profit group that performs scientific research on critical infrastructure protection. For further information about the Electric Reliability Risk Index™ (ERRI™) and our work, see our website at www.resilientsocieties.org. To arrange interviews, contact William Harris at williamh@resilientsocieties.org, phone 978-255-2203.

Electric Reliability Risk Index™

Electric Reliability Risk Index = (Percent Net Electricity Imports) + (Percent Generation Using Imported Natural Gas)

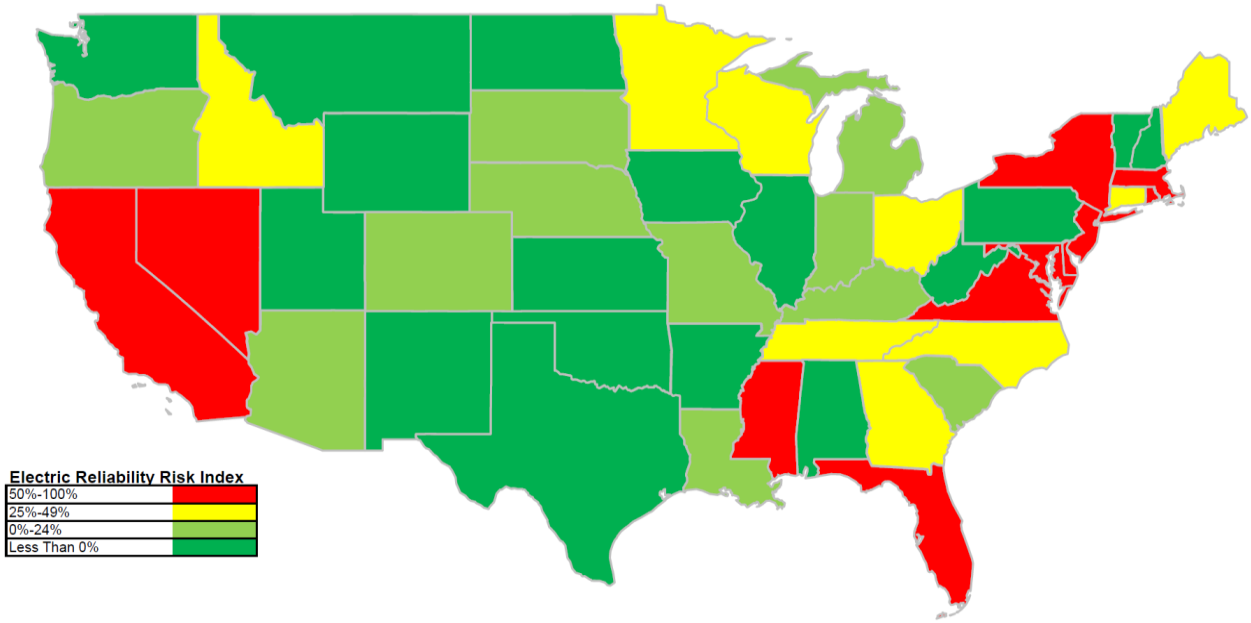
			Electricity Energy Sources & Imports (Exports) Total to 100%							Imported Gas Risk Factors		
Risk Rank	State	Electricity Consumed in 2012 (GW Hour)	Coal	Nuclear	Hydroelectric & Geothermal	Wind & Solar	Natural Gas	All Other Energy Sources	Net Electricity Imports (Exports)	Percent of Natural Gas Imported	Electricity Generation Using Imported Natural Gas	Electric Reliability Risk Index (ERRI)
1	Washington DC	12,056	0%	0%	0%	0%	1%	0%	99%	100%	1%	100%
2	Rhode Island	8,311	0%	0%	0%	0%	98%	1%	0%	100%	98%	99%
3	Delaware	13,069	11%	0%	0%	0%	52%	3%	34%	100%	52%	86%
4	Massachusetts	60,970	4%	10%	1%	0%	40%	4%	41%	100%	40%	81%
5	Nevada	37,753	11%	0%	13%	2%	68%	0%	7%	100%	68%	75%
6	Florida	241,551	18%	7%	0%	0%	62%	4%	8%	99%	61%	70%
7	California	288,660	0%	6%	14%	4%	41%	3%	31%	90%	37%	68%
8	Mississippi	53,694	13%	14%	0%	0%	72%	3%	(2%)	87%	62%	60%
9	New Jersey	81,548	2%	41%	0%	0%	35%	2%	20%	100%	35%	55%
10	Virginia	117,507	12%	24%	1%	0%	21%	1%	40%	64%	14%	54%
11	Maryland	66,897	24%	20%	2%	1%	7%	2%	43%	100%	7%	51%
12	New York	154,993	3%	26%	16%	2%	38%	2%	12%	98%	38%	50%
13	Idaho	25,982	0%	0%	42%	7%	7%	2%	40%	100%	7%	48%
14	Georgia	145,206	28%	23%	2%	0%	29%	2%	16%	100%	29%	45%
15	Maine	15,235	0%	0%	25%	6%	40%	24%	5%	100%	40%	45%
16	Connecticut	32,367	2%	53%	1%	0%	51%	5%	(12%)	100%	51%	40%
17	Minnesota	73,826	31%	16%	1%	10%	10%	3%	29%	100%	10%	39%
18	Tennessee	105,669	34%	24%	8%	0%	8%	1%	26%	98%	7%	34%
19	Ohio	164,703	52%	10%	0%	1%	14%	2%	21%	90%	12%	34%
20	Wisconsin	75,898	43%	19%	2%	2%	15%	3%	16%	100%	15%	31%
21	North Carolina	139,314	37%	28%	3%	0%	14%	2%	16%	100%	14%	30%
22	Michigan	114,607	46%	24%	1%	1%	19%	3%	6%	84%	16%	21%
23	Indiana	120,963	76%	0%	0%	3%	12%	3%	5%	99%	12%	17%
24	Colorado	57,537	60%	0%	3%	11%	18%	0%	9%	0%	0%	9%
25	Kentucky	95,623	87%	0%	2%	0%	3%	2%	6%	53%	2%	8%
26	Louisiana	111,402	19%	14%	1%	0%	53%	6%	7%	0%	0%	7%
27	South Dakota	12,565	23%	0%	48%	23%	2%	0%	4%	79%	1%	6%
28	South Carolina	85,594	33%	60%	2%	0%	17%	2%	(13%)	100%	17%	4%
29	Missouri	88,500	82%	12%	1%	1%	7%	0%	(4%)	100%	7%	3%
30	Oregon	50,627	5%	0%	78%	13%	23%	2%	(20%)	100%	23%	3%
31	Arizona	80,717	50%	40%	8%	2%	38%	0%	(37%)	100%	38%	0%
32	Alaska	6,948	10%	0%	23%	1%	52%	15%	0%	0%	0%	0%
33	Hawaii	10,469	15%	0%	4%	4%	0%	78%	0%	100%	0%	0%
34	Nebraska	33,452	75%	17%	4%	4%	2%	0%	(2%)	99%	2%	0%
35	Texas	425,292	32%	9%	0%	8%	50%	2%	(1%)	0%	0%	-1%
36	Kansas	43,213	65%	19%	0%	12%	7%	0%	(3%)	0%	0%	-3%
37	New Hampshire	11,735	11%	70%	11%	2%	60%	11%	(64%)	100%	60%	-4%
38	Iowa	51,476	69%	8%	1%	27%	4%	1%	(10%)	100%	4%	-6%
39	Vermont	5,905	0%	84%	19%	2%	0%	6%	(11%)	100%	0%	-11%
40	Washington	99,691	4%	9%	90%	7%	5%	2%	(17%)	100%	5%	-12%
41	Alabama	97,570	47%	42%	8%	0%	57%	3%	(57%)	68%	39%	-18%
42	Illinois	157,343	51%	61%	0%	5%	7%	1%	(26%)	100%	7%	-18%
43	Utah	32,946	93%	0%	3%	2%	20%	1%	(20%)	0%	0%	-20%
44	Oklahoma	64,430	45%	0%	2%	13%	61%	0%	(21%)	0%	0%	-21%
45	Arkansas	52,156	55%	30%	4%	0%	33%	3%	(25%)	0%	0%	-25%
46	Pennsylvania	158,651	55%	47%	1%	1%	33%	2%	(41%)	0%	0%	-41%
47	New Mexico	24,949	100%	0%	1%	10%	35%	0%	(47%)	0%	0%	-47%
48	Montana	14,854	94%	0%	76%	8%	3%	5%	(87%)	9%	0%	-87%
49	West Virginia	33,494	210%	0%	4%	4%	1%	1%	(119%)	0%	0%	-119%
50	North Dakota	15,925	177%	0%	16%	33%	0%	1%	(127%)	0%	0%	-127%
51	Wyoming	19,455	223%	0%	5%	22%	3%	2%	(155%)	0%	0%	-155%

Sources: U.S. Energy Information Adminstration 2012 State Electricity Profiles & Natural Gas Annual; Foundation for Resilient Societies Analysis

Notes:

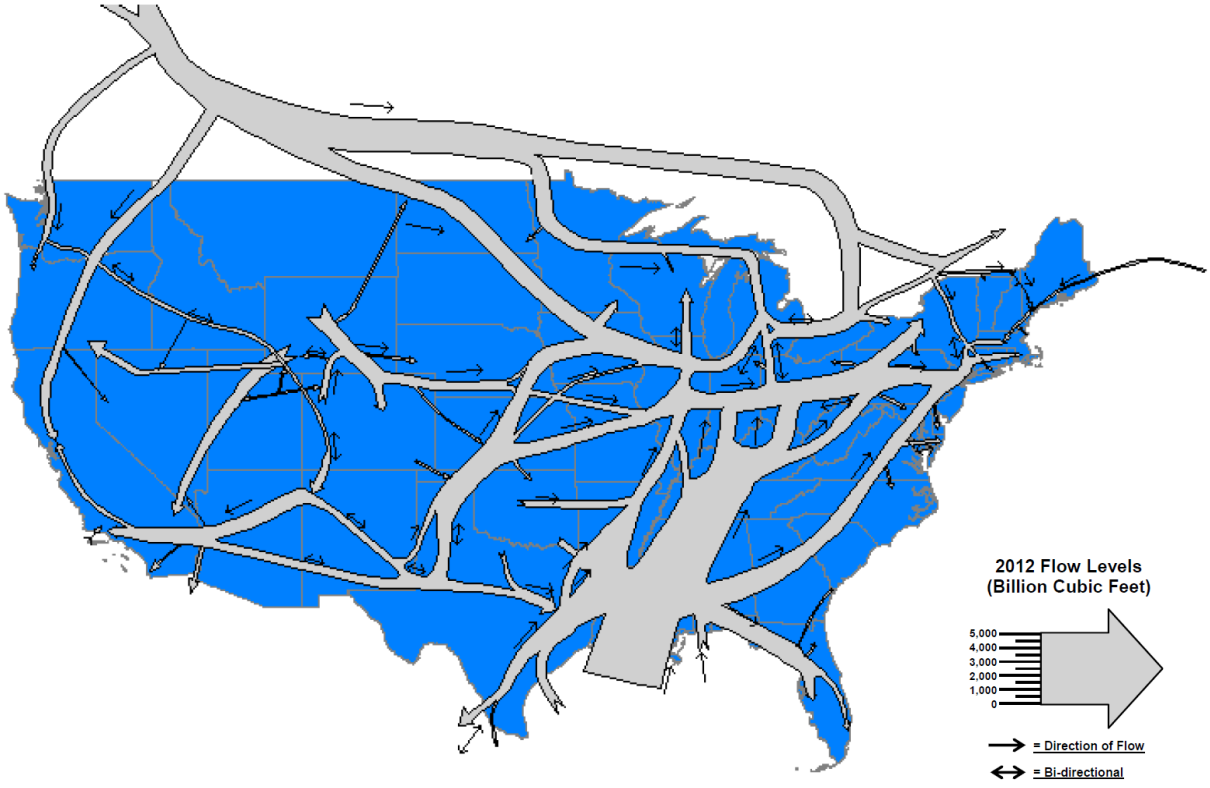
1. "Electricity Consumed" = EIA "Net Generation" plus (International Imports-International Exports) minus EIA "Net Interstate Transfers"
2. Electricity Energy Sources & Imports (Exports) for individual states total to 100%.
3. "All Other Energy Sources" includes petroleum for Hawaii and Alaska and wood for Maine.
4. "Percent of Natural Gas Imported" = EIA "Consumption" minus EIA "Marketed Prod." divided by "Consumption," up to a maximum of 100%.
5. "Generation Using Imported Natural Gas" = "Natural Gas" times "Percent of Natural Gas Imported."
6. ERRI is rounded to the nearest percent.

Electric Reliability Risks Are Concentrated in East and West Coast Population Centers



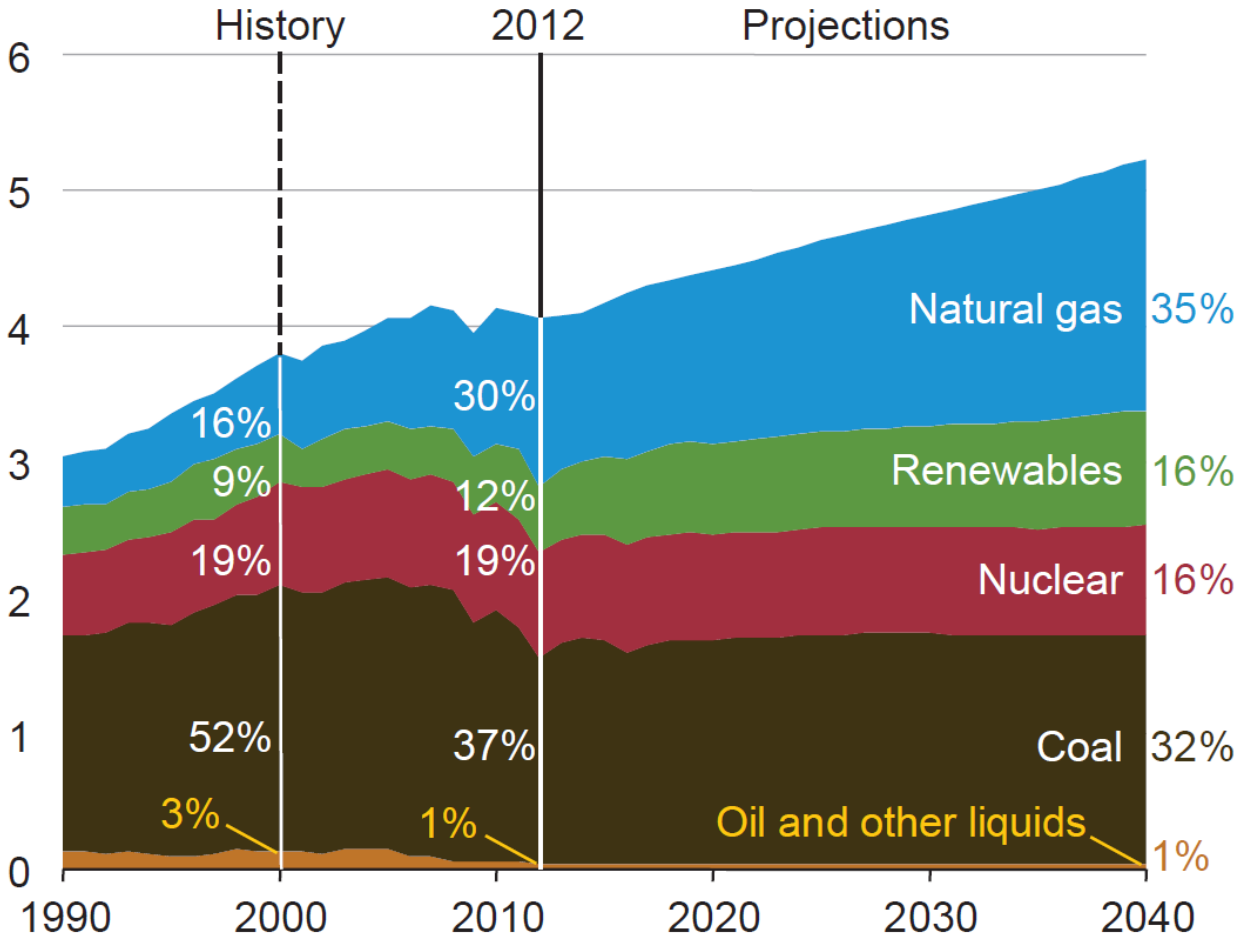
Source: Foundation for Resilient Societies

California, Florida, and New England Are At Narrow Ends of Long Natural Gas Corridors



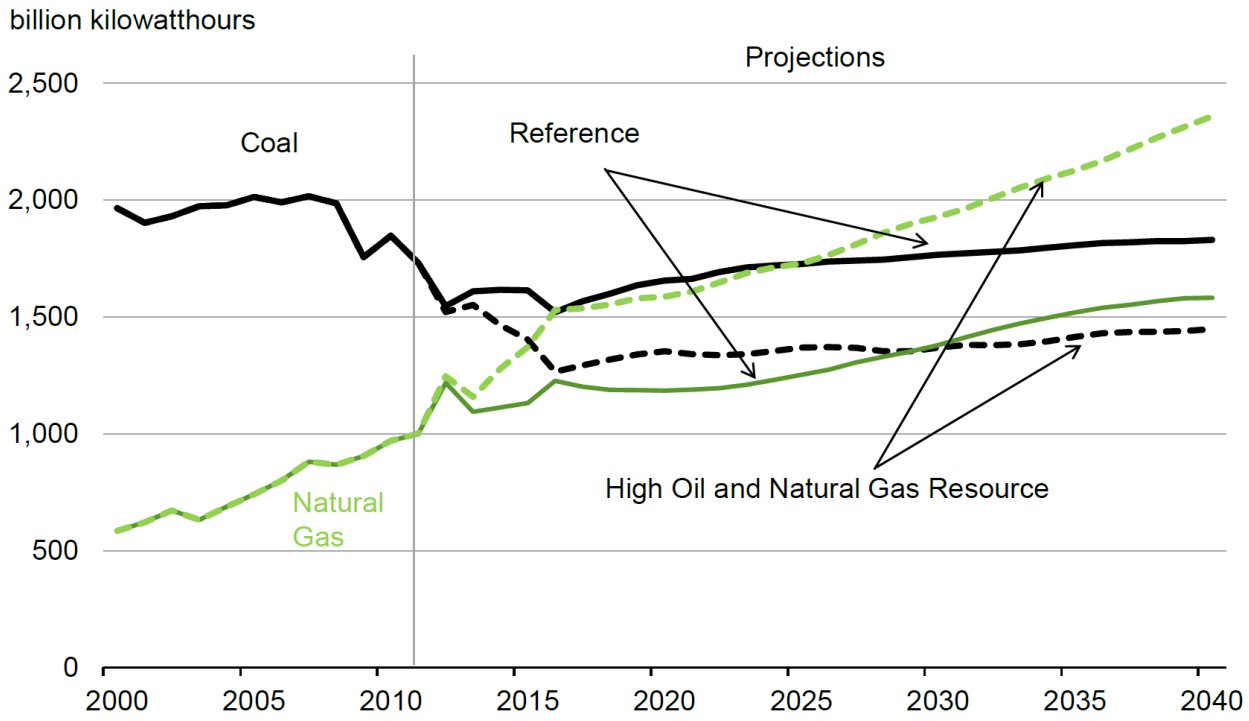
Source: Principal Interstate Natural Gas Flow Summary, 2012; U.S. Energy Information Administration

Figure 13. Electricity generation by fuel, 1990-2040 (trillion kilowatthours)



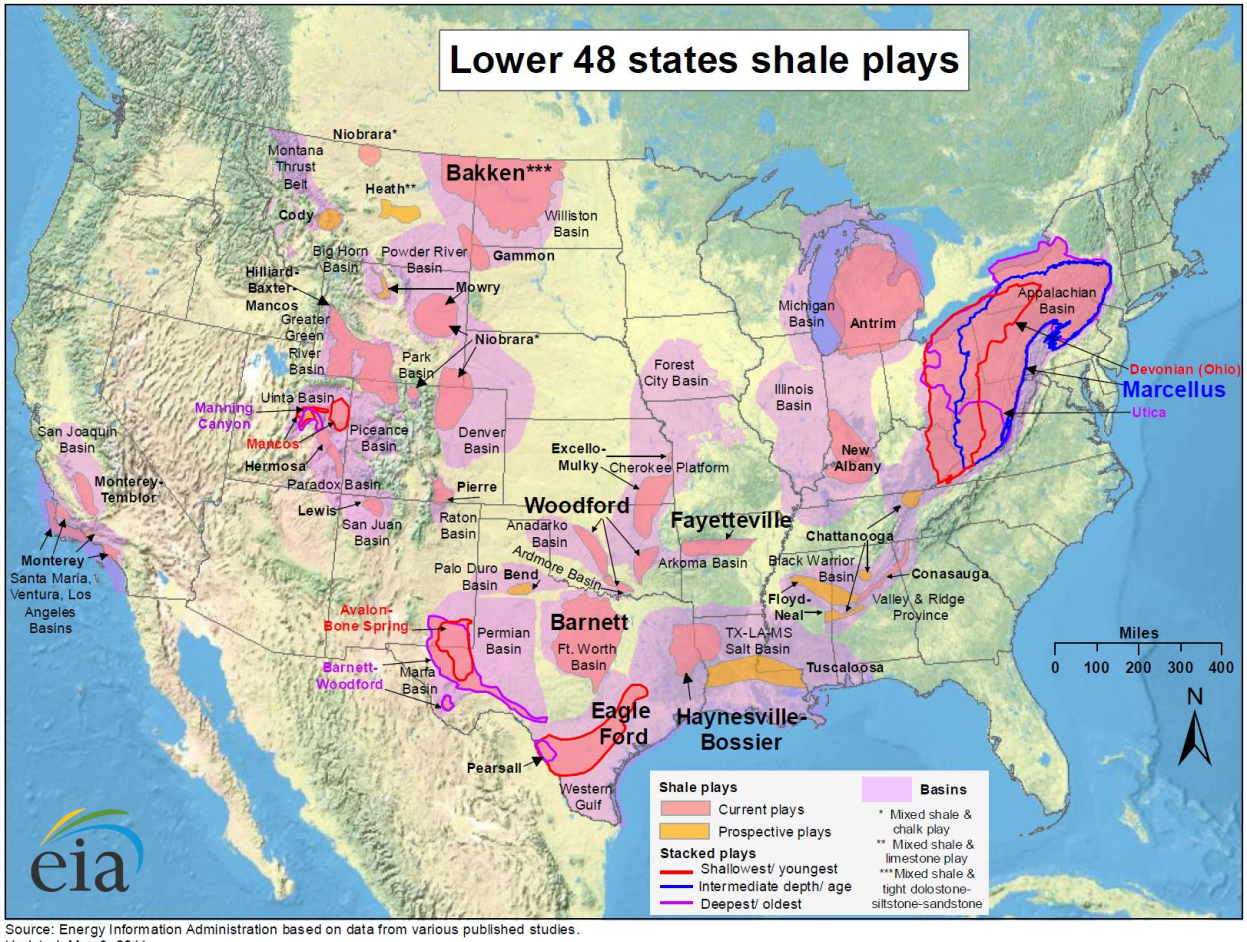
Source: EIA AEO2014 Early Release Overview

If natural gas prices stay low, coal is permanently displaced as the leading generation source in the near future

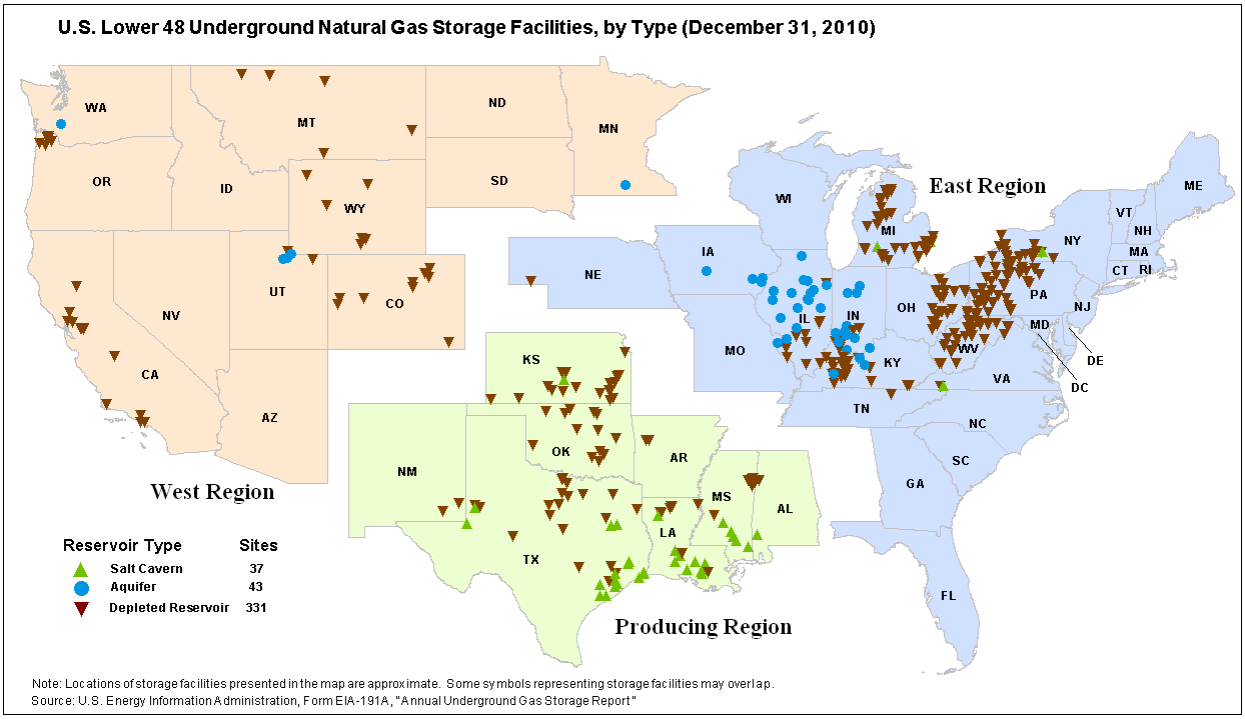


Source: EIA, Annual Energy Outlook 2013

Source: http://www.eia.gov/forecasts/aeo/section_issues.cfm, see tab "Past AEO analyses that remain relevant," list item "Competition between coal and natural gas in the electric power sector," last accessed June 11, 2014.



Source: Energy Information Administration based on data from various published studies.
Updated: May 9, 2011



Note: Locations of storage facilities presented in the map are approximate. Some symbols representing storage facilities may overlap.
Source: U.S. Energy Information Administration, Form EIA-191A, "Annual Underground Gas Storage Report"

Excerpt from "A Primer of the Natural Gas and Electric Power Interdependency in the United States," North American Electric Reliability Corporation (December 2011), page 100:

OBSERVATIONS

The electric power industry has become the natural gas industry's biggest consumer and likely will account for most of the growth in natural gas demand over the next two decades. In addition, the industries have become highly dependent upon each other. In the case of the gas industry there has been an increased use in electric compressors, while the increased market share of gas-fired generation within the power industry has been significant and likely will continue to occur. These phenomena create interdependency between the two industries, particularly in certain regions, and overall requires an increased need for coordination, particularly during times of stress.

For example, in the event of an electricity brown out because of a severe weather event, power to run the electric compressors for a pipeline(s) might be reduced or cut off. This, in turn, could cause pressure in the very gas pipelines that supply fuel to the gas-fired electric units in the region to decline, causing gas-fired electric units in a given area to trip, particularly if the specific electric units do not have booster compression. Unlike transmission systems, a single failure in the gas pipeline could result in a loss of electric system capacity exceeding the most severe single contingency. Depending on the particular conditions, the failure of multiple compressor stations or a pipeline break could result in the loss of a significant amount of generation connected to the pipeline. The tripping of gas-fired units would likely lower overall power supply, significantly affecting reliability. The latter could create a downward spiral affecting additional electric compression, and thus, causing further pipeline pressure declines.[113]

Gas-pipeline disruptions (e.g., declines in production, pipeline failure) can propagate upstream through the rest of the gas delivery chain, ultimately disrupting delivery in areas outside a given electrical control area—or even outside an interconnection. The most recent example of this occurred during the February 2011 "Southwest Cold Snap".[114] Electrical disruptions in ERCOT resulted in gas curtailments in New Mexico, Arizona, and other parts of Texas outside of ERCOT. Well-head freeze-offs and rolling electric blackouts were principally the cause of gas curtailments outside of ERCOT.

Long-term growth of gas-fired generation should be considered in pipeline infrastructure planning. Over the next ten years, a significant amount of gas-fired generation is projected—45 GW of Planned and an additional 48 GW of Conceptual capacity (Figure 7-12).[115,116]

Explanatory Notes:

1. Our Electric Reliability Risk Index is calculated based on electricity consumed (including line losses), not nameplate capacity of generation plants. Some states with high Electric Reliability Risk Indexes may have rarely-used generation plants with significant nameplate capacity. However, due to low fuel inventory, delivery interruptions, and operational difficulty in switching fuels, this nameplate capacity may not be available in emergencies; an example is shortage of oil for duel fuel petroleum and gas-fired plants during the New England winter of 2013.

2. Permitting of electricity generation plants is regulated by the states. Reliability of the bulk electric transmission system is regulated at the federal level by FERC and NERC. Economic regulation of interstate gas pipelines is the responsibility of FERC. Safety of interstate pipelines is regulated by the Pipeline and Hazardous Materials Safety Administration, a unit of the U.S. Department of Transportation. Reliability of interstate natural gas pipelines is largely unregulated at the federal and state level.

3. Because generation plant permitting is at the state level, and because states represent political boundaries, we have elected to display the Electric Reliability Risk Indexes at the state level. Nonetheless, electric grid reliability is often managed by multi-state coordination areas; as a result, grid reliability issues in one state may impact adjacent states.

4. Some states have high dependence upon a few generation facilities, especially nuclear plants that must be shut down during periods of electric grid instability. Examples include New Hampshire's dependence upon generation at the Seabrook nuclear plant or Vermont's dependence (through 2014) on the Vermont Yankee nuclear plant. Our Electric Reliability Risk Indexes does not take into account nuclear-electric dependency, although this dependency can be important in some regions.

5. Recently promulgated air quality regulations of the Environmental Protection Agency are likely to accelerate decommissioning of coal-fired electric generation plants and a switch to natural gas generation. Also, nuclear plants are expected to close in a number of states for economic reasons. As a result, we expect the Electric Reliability Risk Index to significantly increase for some states. Computing forward projections of Electric Reliability Risk Indexes is a future project of Resilient Societies.