

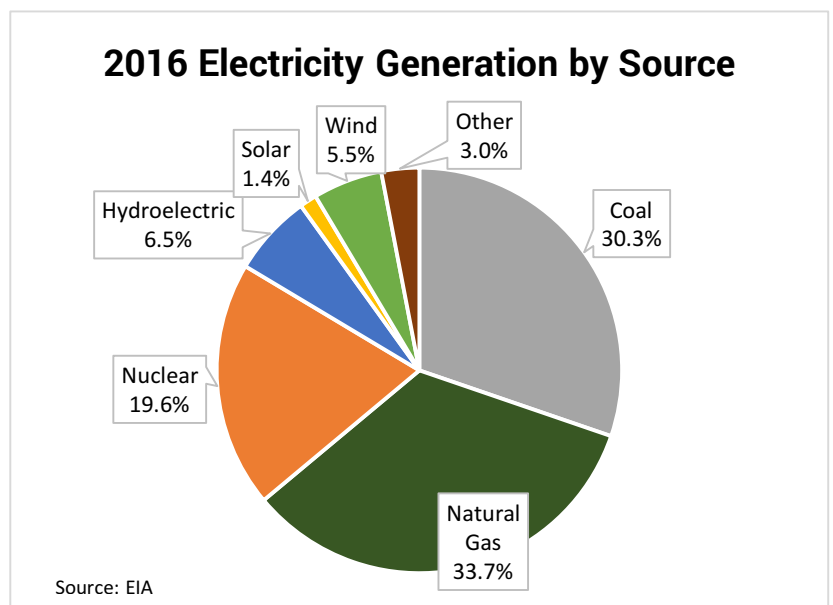
Recently, the value to the national electric grid of solar and other renewable energy sources has been questioned. As can be seen from the numerous studies referenced in this paper, solar and renewables provide significant benefits to the national grid in terms of reliability, fuel diversity, and security. In addition, the 9,000 American solar companies employ over 260,000 American workers and invest tens of billions of dollars every year into the American economy. Photovoltaic technology was invented in the U.S.A., developed as a marketable energy source in the U.S.A., and last year was the largest single source of electric generating capacity in the U.S.A. America should maintain its global leadership in solar.

Despite solar’s spectacular growth over the last decade, it still makes up only 1.4% of the nation’s total electricity mix. By 2020 solar is expected to represent close to 4% of total electricity generated. The studies cited below, many of them done by the U.S. Department of Energy or its national laboratories, make very clear that our national grid is more than capable of accommodating much higher levels of solar, even with today’s technologies.

Finally, some have questioned the impact on the electricity markets of the federal Solar Investment Tax Credit (ITC), despite the growing value solar energy brings to the grid and the nation’s energy security, all the while lowering electricity costs, promoting investment and creating thousands of new jobs. Under current law, the ITC is scheduled to ramp down in value from 30% to 10% in 2021 [down to zero for the homeowners ITC]. This is in contrast to the permanent federal tax benefits enjoyed by other conventional energy sources.

Solar Provides Reliable Energy to the Grid

- Multiple studies from the Department of Energy’s (DOE) National Renewable Energy Laboratory (NREL) have shown that the existing grid can handle high penetrations of renewable energy without compromising reliability and performance. In their *Western Wind and Solar Integration Study* and *Eastern Renewable Generation Integration Study* NREL finds that both the existing western and eastern electric grids can accommodate upwards of 30% of solar and wind power without requiring extensive infrastructure investments. An additional study from NREL finds that “renewable electricity generation



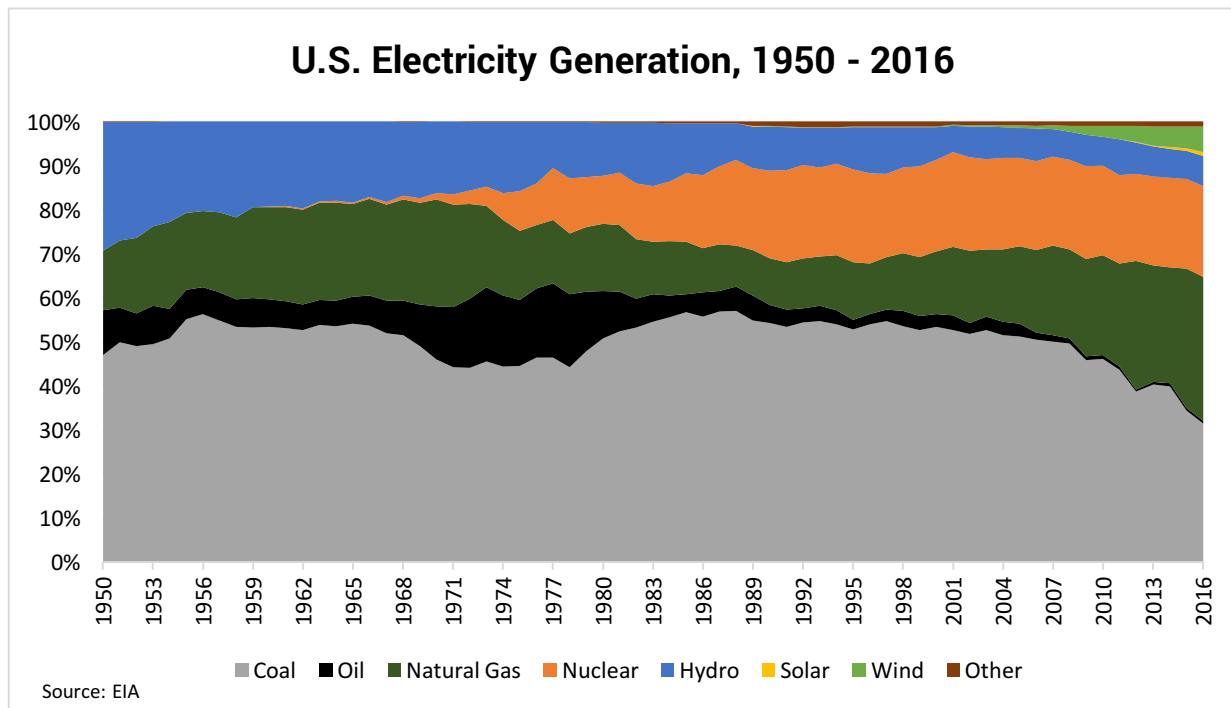
from technologies that are commercially available today, in combination with a more flexible electric system, is more than adequate to supply 80% of total U.S. electricity generation in 2050”.

- In phase two of their Western Grid Study, NREL also found that any maintenance costs created by a need to cycle fossil-fuel plants to accommodate wind and solar generation are more than offset by the fuel savings associated with those resources. Phase three of the same study demonstrated that reliability of the western grid can be maintained at high renewable penetration rates in the face of large system disturbance (such as the loss of a fossil plant).
- Grid Operators across the country have found that reliability on the grid can be maintained at higher penetrations of renewables. The California Independent System Operator (CAISO), which manages the largest amount of solar resources in the country, finds that the state will have no issues in maintaining reliability in hitting its 33% renewables target by 2020. PJM, which operates much of the eastern grid in the U.S., found in a 2014 study that they would not encounter reliability issues with 30% of their energy coming from solar and wind.
- In a separate study, CAISO found that solar photovoltaic power plants, when equipped with commercially available inverter technology, can offer “electric reliability services similar, or in some cases superior to, conventional power plants.” Likewise, Concentrating Solar Power plants (CSP), which produce electricity by using the sun to heat boilers and push turbines, are easily paired with thermal energy storage and provide a host of grid benefits that allow them to function similar to any fossil fuel plant.
- **For further reading on solar/renewables and grid reliability:**
 - [NREL; *Western Wind and Solar Integration Study*](#)
 - [NREL; *Eastern Renewable Generation Integration Study*](#)
 - [NREL; *Renewable Electricity Futures Study*](#)
 - [CAISO; *Beyond 33% Renewables: Grid Integration Policy for a Low-Carbon Future*](#)
 - [GE, PJM; *PJM Renewable Integration Study*](#)
 - [CAISO, NREL, First Solar; *Demonstration of Essential Reliability Services by a 300 MW Solar Photovoltaic Power Plant*](#)
 - [NREL; *Relevant Studies for NERC’s Analysis of EPA’s Clean Power Plan 111\(d\) Compliance*](#)
 - Looks at seven studies, each showing reliable grid performance at high renewable penetration rates
 - [International Energy Agency; *The Power of Transformation*](#)
 - Finds that most countries can achieve high grid reliability at renewable penetration rates of 25 – 40%
 - [Brattle Group; *Integrating Renewable Energy into the Electricity Grid*](#)
 - Using a Case Study approach focusing on ERCOT and Xcel Energy Colorado, finds that renewables can be successfully integrated at penetration levels up to 50% using existing grid infrastructure

- [Union of Concerned Scientists; Renewables and Reliability: Grid Management Solutions to Support California's Clean Energy Future](#)
 - Provides recommendations on how California can achieve its 50% renewables target using commercially available technologies and improved grid practices
- [NREL, Sandia National Laboratories; On the Path to Sunshot: Advancing Concentrating Solar Power Technology, Performance and Dispatchability](#)
 - Details grid benefits of CSP and its role in an evolving U.S. electric grid

Solar Diversifies the Grid and Strengthens Our National Security

- The U.S. electric grid has never had a more diverse array of generating resources (see chart). According to the Energy Information Administration (EIA), in 2016 34% of U.S. electric generation came from natural gas, 30% from coal, 20% from nuclear, 9% from non-hydro renewables and 7% from other sources. 2015 marked the first year ever in which 7 distinct technologies generated at least .5% of the nation's electricity. Using a Shannon-Wiener index, Northeast grid operator PJM recently calculated that 2016 featured the most diverse electricity mix in the nation's history.



- Because most of the cost of a solar installation is up front and no additional fuel cost is needed to operate, solar plays a key role in hedging against rising fossil fuel prices. Building on earlier research, NREL finds in a 2013 study that adding solar and wind to an electricity

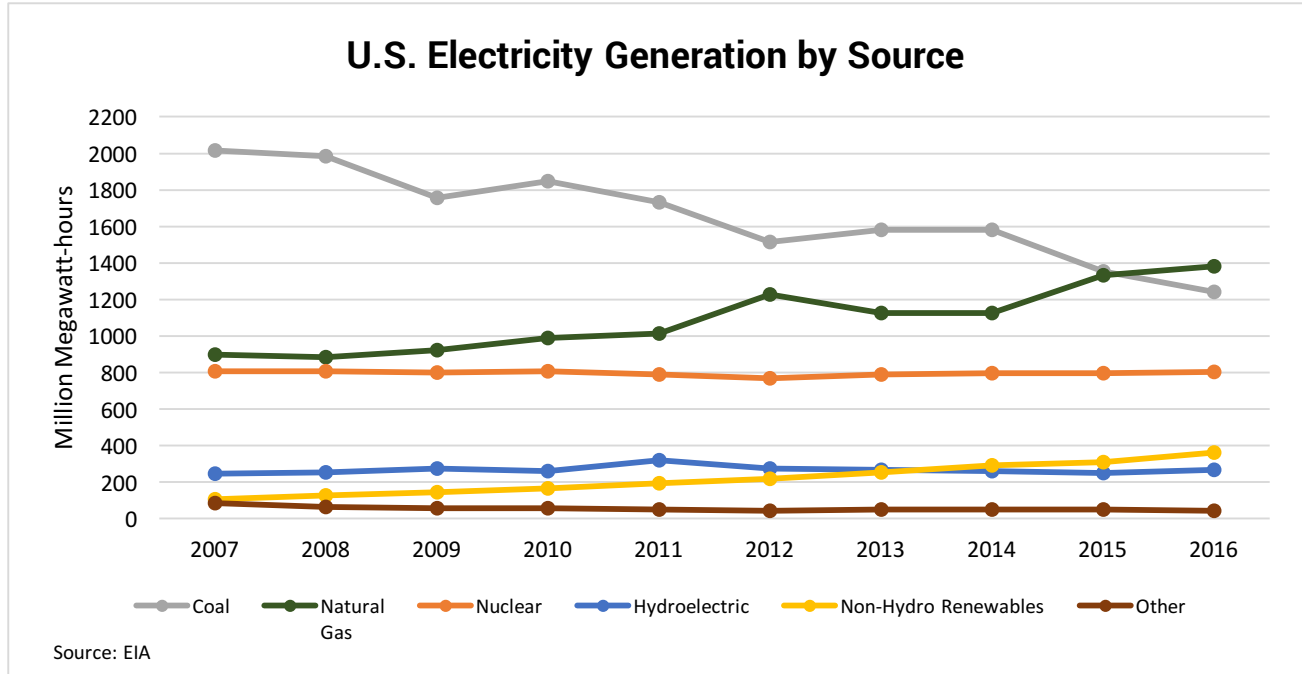
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resource portfolio at penetration rates up to 40% significantly reduces exposure to variability in fossil fuel costs.

- Solar's ability to be used as a distributed resource has important implications for grid security. With smarter grid technology and advanced power electronics, grid operators can reallocate electrons from individual rooftop systems to where they are most needed in the face of disturbances to other generating units. Distributed systems can be paired with storage and turned into resilient microgrids. According to former CIA director James Woolsey, such microgrids could prevent 'a single failure from cascading into a catastrophe'.
- In combination with battery storage, solar has proven to be an easily dispatchable asset at times in which the grid fails. Programs like the SunSmart Emergency Shelter program in Florida have added solar and storage solutions to hundreds of schools and emergency shelters, offsetting everyday electricity costs and establishing a reliable source of electricity in the event of a grade failure.
- One of the biggest users of renewable energy in the U.S. is the military, which values solar for its portability and dispatchability. Solar use on the battlefield and at sea reduces the need for sometimes dangerous and costly fuel resupplies, while solar at a military base reduces electricity costs and, when paired with storage, creates a resilient energy environment in the form of a micro-grid.
- **For further reading on solar/renewables and grid diversity and security:**
 - [PJM interconnection, PJM's Evolving Resource Mix and System Reliability](#)
 - [Appendix](#)
 - [NREL, Sandia National Laboratories; The Use of Solar and Wind as a Physical Hedge against Price Variability within a Generation Portfolio](#)
 - [Hoover Institution, Stanford University; Conversations About Energy: How the Experts See America's Energy Choices](#)
 - [Florida Solar Energy Center, SunSmart E-Shelters Program](#)
 - [SEIA; Enlisting the Sun: Powering the U.S. Military with Solar Energy](#)

Coal Impacted by Natural Gas, not Solar and Other Renewables

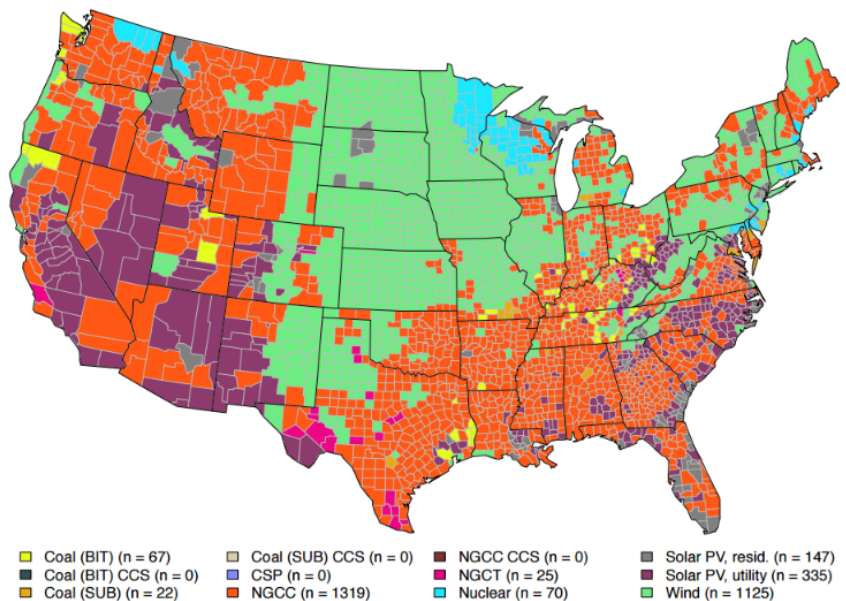
- According to EIA, over the last 10 years U.S. electricity generation from coal has dropped by more than 776 million megawatt-hours annually, while generation from natural gas has increased by nearly 484 million megawatt hours. Over the same time period, generation from solar and wind has increased by 257 million megawatt hours. While coal has dropped from 49% of the electricity mix down to 30%, natural gas has risen from 22% to 34%. Natural Gas is displacing considerably more coal generation than solar and wind (see chart on following page).



- The problems the coal industry faces are primarily in the form of price competition from natural gas. According to Lazard, while the Levelized cost of Electricity (LCOE) for generation from new coal plants has remained around \$100/MWh over the past 5 years, the LCOE for electricity from natural gas plants has dropped from \$75/MWh to \$63/MWh. A new study from the University of Texas shows that natural gas and unsubsidized wind and solar power are the cheapest source for new generation capacity in 95% of counties nationwide (see map).

FIGURE 8

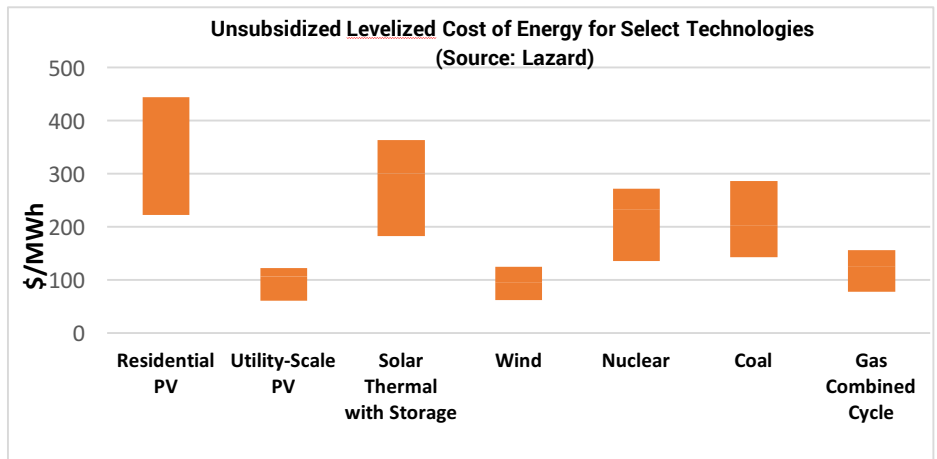
Scenario 4: Minimum cost technology for each county, including availability zones, but not including externalities (Equation 1) with reference case assumptions from Table 1.



- A recent study from the Center on Global Energy Policy at Columbia University itemizes the reasons for coal’s decline: 49% is attributable increased competition from cheap natural gas, lower-than-expected demand is responsible for 26% and the growth of renewables is responsible for 18%. Regulatory burden only plays a role insofar as it hastened the switch from coal to natural gas, but the study finds that the regulations were a “significantly smaller factor than recent natural gas and renewable energy cost reductions”.
- **For further reading on the reasons behind coal’s fall:**
 - [Lazard, Levelized Cost of Energy Analysis, 10.0 \(2016\)](#)
 - [6.0 \(2012\)](#)
 - [University of Texas at Austin Energy Institute; New U.S. Power Costs: by County with Environmental Externalities](#)
 - [Columbia University Center on Global Energy Policy; Can Coal Make a Comeback?](#)

Solar is the Lowest Cost Option for Many

- As the University of Texas study notes, solar is now the cheapest electricity option in many areas across the country. This is primarily due to the steep decline in the price to install a solar energy system—which has dropped by nearly 70% in the last 5 years.



According to Lazard, the unsubsidized levelized cost of utility scale solar now ranges

from \$46 - \$92/MWh, on par with wholesale electricity from new wind and natural gas plants. Residential solar, which competes against retail electricity prices is now competitive in most markets. Innovations in system financing have opened up the residential and commercial solar marketplace to more consumers than ever before, giving all Americans the opportunity to go solar.

- At the federal level, the solar industry currently receives a 30% Investment tax credit (ITC) that was first put in place in 2006. Under current law, the ITC is set to ramp down to 26% in 2020 and then to 22% in 2021 before dropping to 10% for commercial systems and expiring entirely for residential systems at the end of 2021. The ITC and other incentive mechanisms for renewable energy represent less than 15% of all federal incentives for energy from 1947 to 2015, while fossil fuels comprise 65% of federal energy incentive spending over the same time period, according to a study of government data by the American Wind Energy Association

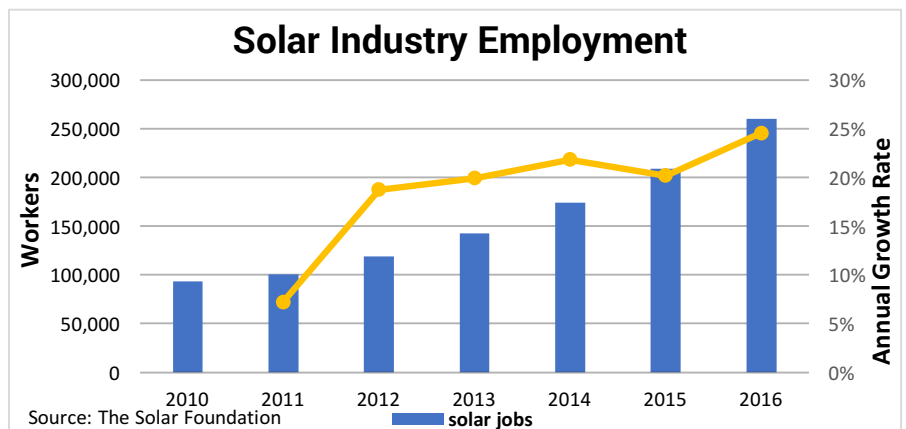
(AWEA). Moreover, while the tax benefits for fossil and nuclear energy are permanent and have existed for decades, solar incentives are temporary and only relatively recently created.

- **For further reading on solar and renewable’s cost competitiveness:**

- [SEIA/GTM Research U.S. Solar Market Insight](#)
- [Lazard, Levelized Cost of Energy Analysis, 10.0 \(2016\)](#)
- [SEIA, Solar Investment Tax Credit](#)
- [AWEA, New Analysis: Wind energy less than 3 percent of all federal energy incentives](#)
- [International Monetary Fund, How Large Are Global Energy Subsidies](#)
 - IMF calculates that fossil fuels receive \$5.3 trillion in subsidies globally, amounting to more than \$10 million every minute. The U.S. ranks second behind China in fossil fuel subsidies.

Solar Delivers Major Benefits for America’s Economy

- In 2016, solar industry employment grew 25% over 2015 to reach over 260,000 workers, according to the Solar Foundation. Last year, the solar industry was responsible for 1 out of every 50 new jobs created in the U.S. These are jobs in fields ranging from contracting and engineering to manufacturing, R&D and finance with median wages over \$25/hour. While California leads the way in solar jobs, states like Nevada, Florida, Arizona and North Carolina each employ more than 7,000 solar workers.



- In 2016, the DOE reported that the U.S. solar industry employed more workers than the natural gas industry and more than twice as many workers as the coal industry. In fact, solar represented 18% of all U.S. energy jobs, second only to the oil industry.
- The solar industry has pumped more than \$111 billion into the U.S. economy since 2000, with nearly \$23 billion invested in 2016 alone. By 2021, the solar energy industry will invest at least \$86 billion in communities across the U.S. These investments not only put Americans to work, but represent millions of dollars in new tax revenue for state and local governments.
- **For further reading on the economic benefits of solar and other renewables:**
 - [The Solar Foundation National Solar Jobs Census](#)
 - [U.S. Department of Energy, U.S. Energy and Employment Report](#)
 - [SEIA/GTM Research U.S. Solar Market Insight](#)