Renewables on the Rise

A Decade of Progress Toward a Clean Energy Future

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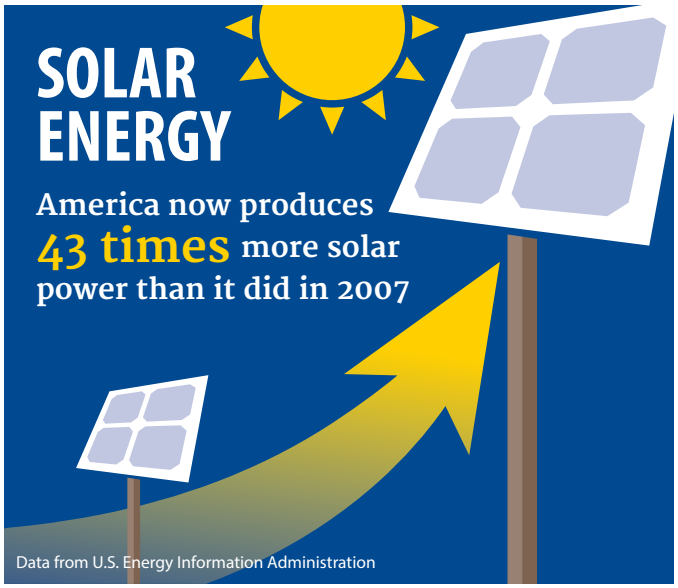
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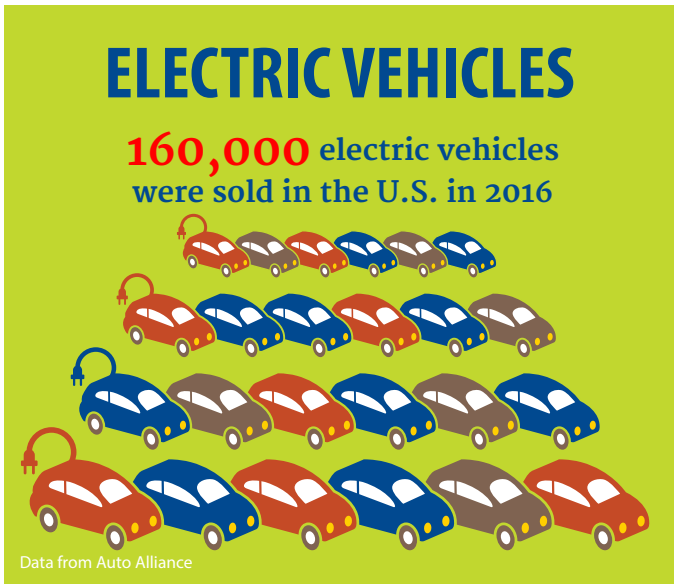
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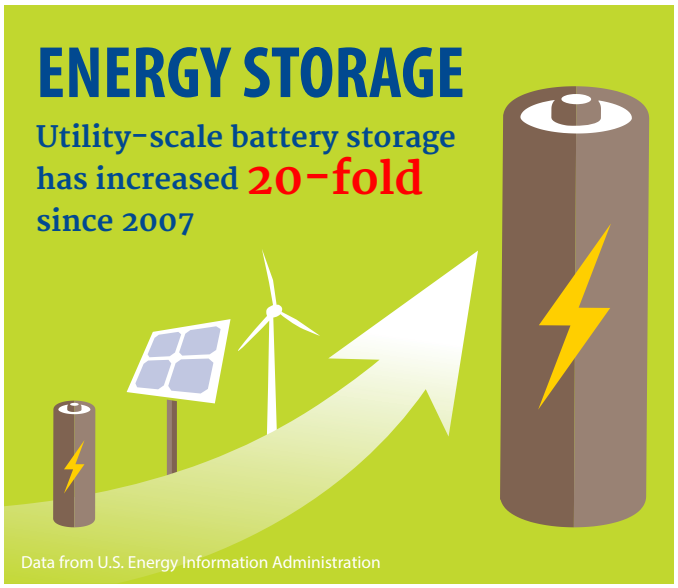
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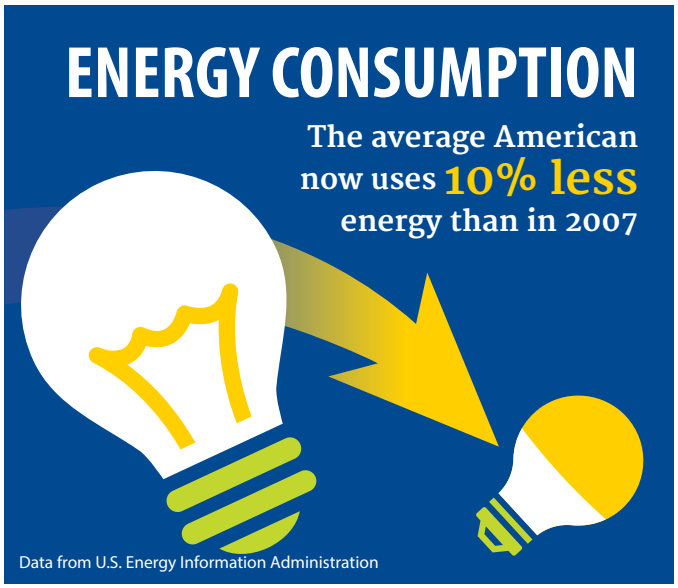
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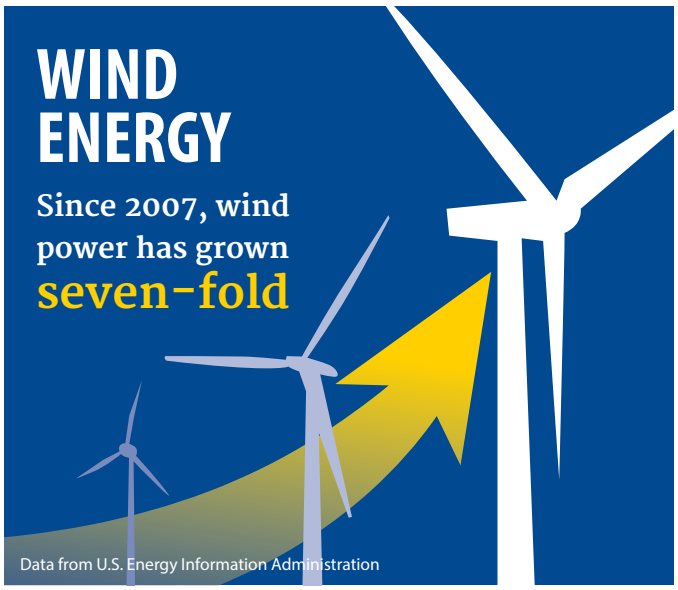
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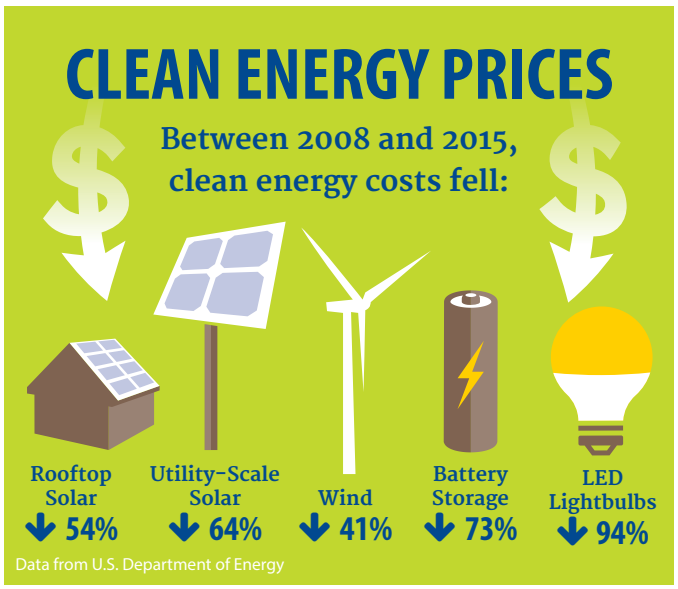
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Executive Summary

Clean energy is sweeping across America, and is poised for further dramatic growth in the years ahead.

Wind turbines and solar panels were novelties 10 years ago; today, they are everyday parts of America's energy landscape. Energy-saving LED light bulbs cost $40 apiece as recently as 2010; today, they cost a few dollars at the local hardware store.[1] Electric cars and the use of batteries to store excess energy on the grid seemed like far-off solutions just a few years ago; now, they are poised to break through into the mass market.

Virtually every day, there are new developments that increase our ability to produce more renewable energy, apply renewable energy more widely and flexibly to meet a wide range of energy needs, and reduce our overall energy use – developments that enable us to envision an economy powered entirely with clean, renewable energy.

America produces **nearly eight times as much renewable electricity** from the sun and the wind as in 2007,[2] and in March 2017, for the first time ever, wind and solar produced 10 percent of America's electricity.[3] At the same time, the average American uses **10 percent less energy** than a decade ago, due in great part to improvements in energy efficiency.[4]

The last decade has proven that clean energy technology can power American homes, businesses and industry – and leaves America poised to dramatically accelerate its shift away from fossil fuels. With renewable energy prices falling and new energy-saving technologies coming on line every day, **America should work to obtain 100 percent of our energy from clean, renewable sources.**

The last decade has seen explosive growth in the key technologies needed to power America with clean, renewable energy.

- **Solar energy:** America produces 43 times more solar power than it did in 2007, enough to power more than 5 million average American homes. In 2007, solar rooftops and utility-scale solar power plants produced 0.03 percent of U.S. electricity; by 2016, they produced 1.4 percent of America's power.[5]
- **Wind energy:** America produces seven times as much wind power as it did in 2007, enough to power 21 million homes. In 2007, wind turbines produced 0.8 percent of the nation's electricity; by 2016, they produced 5.5 percent of America's power.[6]
- **Energy efficiency:** America uses 3.6 percent less energy than in 2007, in great part due to more energy efficient lighting, appliances and cars.[7] The average American uses 10 percent less energy than in 2007, and the nation's energy consumption per unit of GDP has fallen by 14 percent.[8]
- **Electric vehicles:** Building an economy reliant on clean, renewable energy means ending the use of fossil fuels for all activities, including transportation. There were 157,000 electric vehicles sold in the U.S. in 2016, up from virtually none in 2007.[9] Electric vehicle sales surged by nearly 40 percent in 2016 over 2015, fueled by lower prices, better performance and a range of attractive and afford-

able new vehicle models.[10] In the first five months of 2017, electric vehicle sales were up an additional 44 percent over 2016.[11]

- **Energy storage:** Expanding the ability to store electricity can help the nation take full advantage of its vast potential for clean, renewable energy. The United States saw a 20-fold increase in utility-scale battery storage from 2007 to 2016, with the greatest increase taking place in 2016.[12] The recent introduction of home electricity storage systems produced by companies like Tesla could set the stage for further growth in the years to come.[13]

Clean energy leadership is not concentrated in one part of the country. Rather, it is distributed across the United States, in states with different economic and demographic makeups, driven by a combination of clean energy attributes and policies that have helped clean energy measures succeed.

- **Solar energy:** California, Arizona, North Carolina, Nevada and New Jersey have seen the greatest total increases in solar energy since 2007. California's landmark "Million Solar Roofs" program, which accelerated the state's solar industry in the mid-2000s, along with its strong renewable electricity standard and other policies, helped to trigger the dramatic rise of solar power there.

- **Wind energy:** Texas, Oklahoma, Iowa, Kansas and Illinois experienced the greatest total increases in wind energy generation from 2007 to 2016. Texas' policies to upgrade its grid to accommodate more wind power from rural west Texas played an important role in the boom.

- **Energy efficiency:** Rhode Island, Massachusetts, Michigan, Illinois and Maryland saw the greatest increases in the share of electricity saved through efficiency measures, according to the American Council for an Energy-Efficient Economy. By 2015, Rhode Island was implementing efficiency measures designed to save the equivalent of 3 percent of statewide electricity consumption in their first year.

- **Electric vehicles:** California, Hawaii, Oregon, Washington and Georgia have seen the most plug-in electric and plug-in hybrid vehicles sold since 2012, as a percentage of in-state vehicles.[14] Six of the top 10 states for EV sales require that a certain percentage of each automakers' sales be zero-emission vehicles, including California, which is home to nearly half of the nation's electric vehicles.[15]

- **Energy storage:** California, Illinois, West Virginia, Ohio and Pennsylvania lead the nation in additions to energy storage since 2007, though the industry is still in its infancy. All of those states, except for California, are part of the PJM regional grid; PJM (the regional transmission organization that operates the electric grid in much of the Mid-Atlantic and Midwest) increased battery storage as a response to a decision by the Federal Energy Regulatory Commission to increase compensation for grid additions that allow for rapid changes in electricity production.[16]

Rapid improvements in technology and plummeting prices for clean energy suggest that America has only begun to tap its vast clean energy potential.

- Nearly every segment of the clean energy market is seeing rapid price declines. A Department of Energy survey of clean energy prices found that, from 2008 to 2015, the cost of land-based wind energy fell by 41 percent; the cost of distributed solar photovoltaics (PV) capacity by 54 percent; the cost of utility-scale PV by 64 percent; the cost of batteries by 73 percent; and the cost of LED bulbs by 94 percent.[17] Today, after years of price declines, the unsubsidized costs of utility-scale wind and solar energy have fallen to levels that are "cost-competitive with conventional generation technologies under some scenarios," accord-

ing to Lazard's most recent levelized cost of energy survey.[18]

- Experts predict that prices will continue to fall. A recent survey of wind energy experts by the National Renewable Energy Laboratory found that the global price of wind power is expected to fall 24-30 percent by 2030 and 35-41 percent by 2050.[19] Bloomberg New Energy Finance predicts that "[b]y 2025, solar may be cheaper than using coal on average globally," even when the costs imposed by coal use on public health and the environment are excluded.[20]
- Technology advances are also making renewable energy technologies more efficient and effective. In 2007, the highest-capacity wind turbine in the world was 6 MW, with only one such test prototype actually in operation.[21] Today, an entire wind farm of 8 MW turbines is generating electricity off the coast of England; according to DONG Energy, which led the project, a single revolution of the blades on just one turbine can power a home for 29 hours.[22] Meanwhile, the average residential solar panel installed in 2015 was 18 percent more efficient than that installed just five years earlier, in 2010.[23]
- Advanced new products are also helping to reduce energy consumption. For example, sales of smart thermostats, which give homeowners more control over home energy use, grew from 2 million units in 2013 to 5 million units in 2015.[24]

The U.S. should plan to meet all of its energy needs – for electricity, transportation and industry – with clean, renewable energy, and put policies and programs in place to achieve that goal.

- Repowering America with clean, renewable energy is a key strategy in phasing out carbon pollution by 2050 – a necessary step to prevent the worst impacts of global warming. Transitioning to clean, renewable energy will also improve our health by preventing hazardous air pollution, and increase our safety by protecting us from the hazards of extracting, transporting and processing dangerous fuels.
- America's renewable energy resources are sufficient to power the nation several times over. The technologies needed to harness and apply renewable energy are advancing rapidly. And researchers from a wide variety of academic and governmental institutions have developed a variety of scenarios suggesting renewable energy can meet all or nearly all of our society's needs.[25]
- While clean, renewable energy is advancing rapidly, fully replacing fossil fuels will require additional commitment and action. If the nation were to install as much renewable energy every year as we did in 2016, by 2050 American would be producing enough electricity to meet only 57 percent of today's electricity demand, before accounting for non-electricity energy needs.
- To accelerate progress, a growing number of businesses, cities and states are adopting 100 percent renewable energy targets and goals. In 2015, Hawaii became the first state in the country to set a 100 percent renewable energy requirement for its electricity sector, through its renewable energy standard.[26] According to the Sierra Club, 29 cities have committed to 100 percent renewable energy, and six cities have already achieved it.[27] The organization RE100 has collected 100 percent renewable energy commitments from 96 companies, including Bank of America, Google, and Anheuser-Busch InBev.[28]

America has already made incredible progress toward getting its energy from clean, renewable sources. Policymakers at all levels should fully commit to repowering America with clean, renewable energy.

Introduction

The cost of America's dependence on fossil fuels is steep. Our dependence on oil, gas and coal pollutes our environment, jeopardizes our health, costs us money, and threatens our national security. Burning fossil fuels in our homes, businesses, factories and cars is the leading source of the pollutants that cause global warming, which is already contributing to more intense storms, punishing droughts, and rising seas – and which threatens far greater consequences in the years and decades to come.[29]

Repowering our economy with clean, renewable energy can put our nation on a healthier, more sustainable course. And with rapid improvements in technology, vast clean energy resources, and a willing public, a future powered entirely by clean renewable energy is increasingly within our reach.

The last decade has seen solar power sweep across the country, becoming a common feature on homes and businesses, and in solar farms and community solar gardens. Tens of thousands of wind turbines have popped up on the plains, mountains and coasts of the United States. Advanced energy-saving technologies – from LED light bulbs to "smart" thermostats – have made their way into millions of Americans' homes.

For America to take full advantage of that momentum, however, cities, states, businesses and individuals will need to take the lead. Strong public policies that support renewable energy development will be necessary, as will individual, corporate and governmental commitments to clean, renewable energy.

The American people are ready to move forward. Eight in 10 Americans support expanding wind power, and nine in 10 support expanding solar power – nearly double the support for any other type of energy.[30] Twice as many Americans want energy policy to emphasize conservation as opposed to production.[31] And a 2014 consumer demand survey found that energy efficiency is the number one unmet concern of homeowners.[32]

A decade ago – even five years ago – the idea of transitioning to 100 percent renewable energy might have seemed a fantasy. The experience of the last decade, however, as documented in this report, shows that rapid adoption of clean energy technologies is possible. By continuing to foster and accelerate the growth of renewable energy and the technologies that can successfully integrate it into our energy system, we can achieve a clean energy future for America.

Clean Energy Technologies Are Booming Across America

Since 2007, America has made rapid progress toward repowering our economy with clean, renewable energy.

Just nine years ago, many key clean energy technologies were limited to niche markets or perceived as too expensive. Today, the rapid adoption of wind and solar power and energy efficient technologies – along with the emergence of electric vehicles and energy storage – provides a glimpse of what is possible in the transition to an economy powered entirely with clean, renewable energy.

Solar Energy Has Grown 43-Fold Since 2007

Energy from the sun is emission-free and virtually unlimited: Enough sunlight hits the earth every hour to supply the world's energy needs for an entire year.[33]

Despite its abundance, tapping into solar energy was too difficult and prohibitively expensive for most people until the early part of the 21st century. By 2007, years of intensive research, along with pioneering pro-solar policies adopted by states such as California, had begun to pave the way for increased adoption of solar energy. That year, solar rooftops and utility-scale solar power plants produced 0.03 percent of America's electricity, or enough electricity to power 120,000 average American homes.[34]

What Is Clean, Renewable Energy?

Not all renewable energy sources have an equal benefit for the environment. Some forms of biomass and hydroelectric power, for example, can create serious environmental problems. Truly clean, renewable energy is:

- Virtually pollution-free, producing little to no global warming pollution or health-threatening pollution;
- Inexhaustible, coming from natural sources that are regenerative or practically unlimited. No matter how much we use, there will always be more;
- Safe, with minimal impacts on the environment, community safety and public health, and those impacts that do occur are temporary, not permanent; and,
- Efficient, representing a wise use of resources.

Although all energy sources must be deployed responsibly, solar and wind energy generally meet these criteria, as do many types of ocean, tidal, river current and geothermal energy. Energy efficiency technologies also count as "clean energy" – delivering continuous environmental benefit at limited to no environmental cost.

Since 2007, however, solar power has boomed. By 2012, solar power was generating enough electricity to power one million average U.S. homes. In April 2016, the U.S. saw its one millionth solar panel installation.[35]

And by the end of 2016, the U.S. had wrapped up its biggest solar year in history, generating 43 times more solar power than in 2007. In 2016, solar power generated 1.4 percent of America's electricity, enough to power more than 5 million average American homes, a 44 percent increase over the previous year.[36] Solar energy continued its rapid growth in early 2017, as the nation produced 34 percent more solar electricity in the first quarter of the year than it did in 2016.[37]

Solar energy may still produce only a small share of America's electricity, but it is growing rapidly. Distributed solar energy, including panels installed on residential and commercial rooftops, grew 28-fold from 2007 to 2016, while utility-scale generation grew 60-fold. America's capacity to produce electricity from concentrated solar power – in which mirrors concentrate sunlight to store energy as heat in a thermal storage fluid – has grown eightfold since 2007.[38] Meanwhile, solar heating systems for homes and businesses, which make direct use of sunlight's thermal energy to provide air or water heating, produced 20 percent more energy in 2016 than in 2007, enough to provide annual water heating for 3.9 million average American households.[39]

Figure 1. Solar Electricity Production Grew 43-Fold from 2007 to 2016[41]

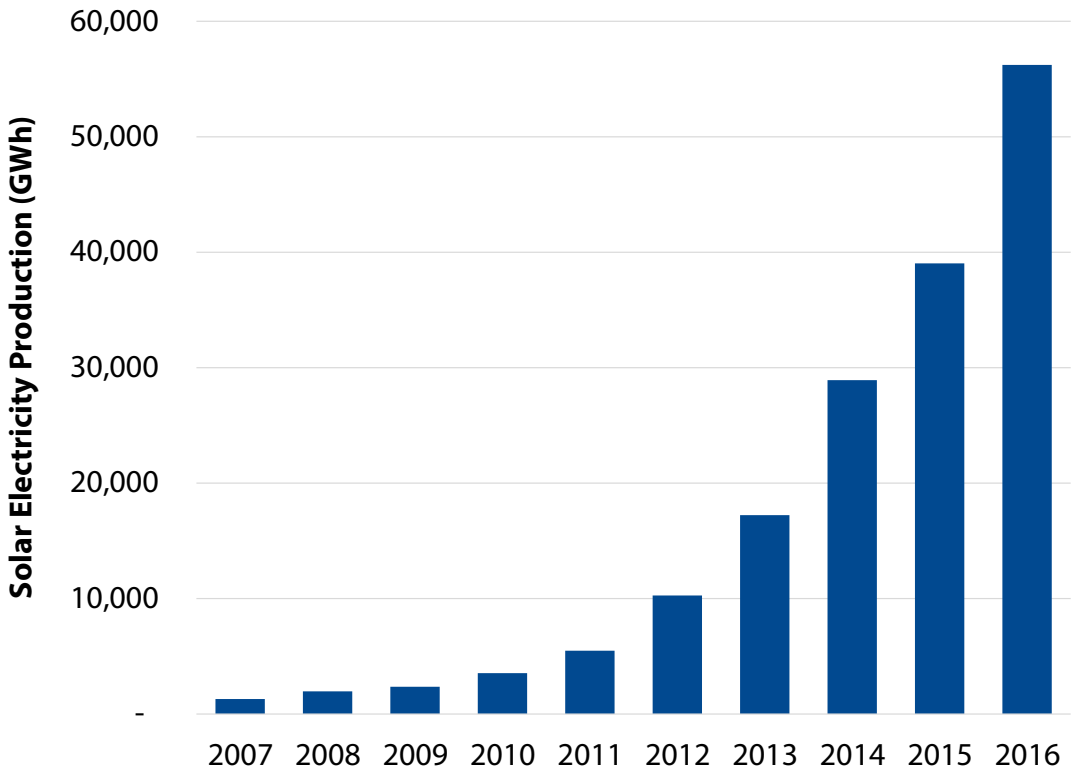
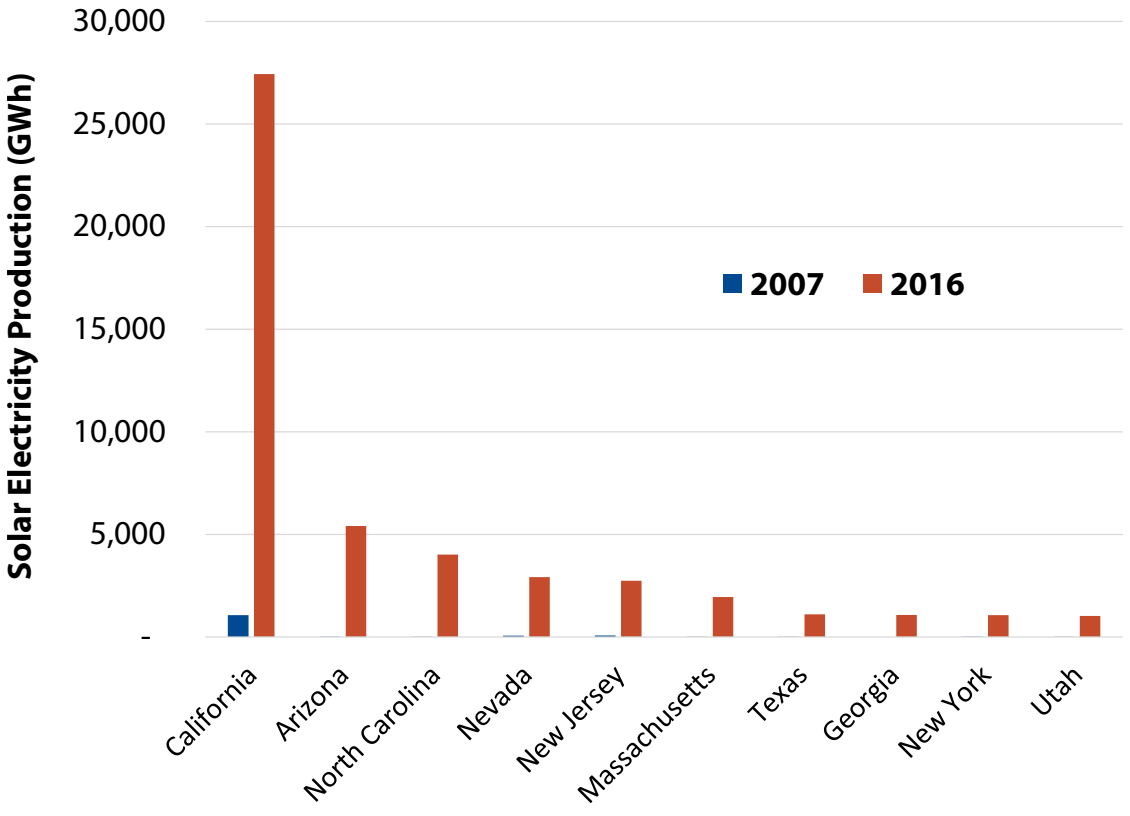


Table 1. Top States for Solar Electricity Growth 2007 to 2015 (GWh)[44]

State	Solar electricity production, 2007	Solar electricity production, 2016	Increase, 2007 - 2016	Rank, by Increase
California	1,062	27,432	26,370	1
Arizona	17	5,408	5,391	2
North Carolina	1	4,016	4,015	3
Nevada	65	2,918	2,853	4
New Jersey	73	2,746	2,673	5
Massachusetts	6	1,949	1,943	6
Texas	5	1,108	1,103	7
Georgia	-	1,076	1,076	8
New York	16	1,067	1,051	9
Utah	0.3	1,023	1,023	10

Figure 2. Solar Electricity Production, Top States, 2007 and 2016



The growth of solar energy can be witnessed not only in the proliferation of solar panels on rooftops, but also in changes in the workforce. The growth of solar energy has created a wide variety of employment opportunities, from research to manufacturing to installation to sales. The solar industry now employs more than 260,000 solar workers, more workers than are employed by the natural gas industry, and more than twice as many as are employed by the coal industry.[40]

California stands apart in solar energy growth and overall production of solar energy. California was responsible for nearly half the growth in solar energy production nationwide between 2007 and 2016, with the amount of solar electricity produced in the state increasing 26-fold over that time. California's booming solar market has benefited from strong policy support, including the innovative "Million Solar Roofs" program that accelerated state solar growth in the mid-2000s.[42]

The top 10 states for solar energy additions since 2007 include some of America's sunniest states, like Arizona and Nevada, as well as northeastern states such as New Jersey, Massachusetts, and New York that have provided strong policy support for solar energy. Many of the states with the most rapid solar energy growth have benefited from a suite of strong solar policies.[43]

Figure 3. America's Top 10 States for Growth in Solar Electricity Production Since 2007

Wind Energy Has Grown Seven-Fold Since 2007

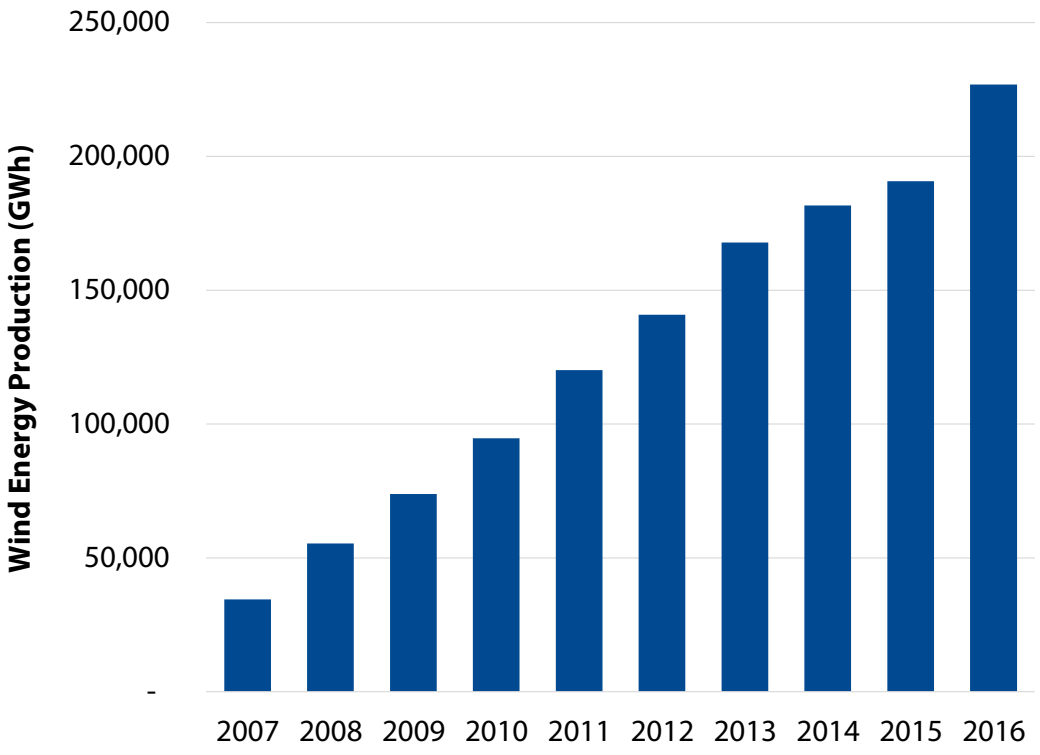
Like sunlight, the wind is abundant and emission-free, and wind energy has experienced dramatic growth over the last decade.

Wind power is not a new technology. Humans have used windmills to do work for more than 1,000 years, and the first electric-generating wind turbine was built in the late 19th century. By 2007, America had built up modest capacity for generating electricity from the wind, producing 0.8 percent of the nation's electricity, enough to power more than 3 million homes.[45]

The last decade has seen dramatic growth in wind energy. In January 2016, the 50,000th wind turbine was installed in the U.S. From 2007 through 2016, American wind generation grew seven-fold. In 2016, wind turbines produced 5.5 percent of America's power, enough to power 21 million homes, an increase of 19 percent over the previous year.[46] Today, the U.S. is also just beginning its offshore wind era: In 2016, America's first utility-scale offshore turbines began spinning off the coast of Rhode Island, where the 30 MW wind farm generates enough electricity to power 17,000 homes.[47] Other states are also moving toward offshore wind. In Massachusetts, in July 2017 utilities began requesting bids for new offshore wind projects as part of the state's plan to acquire 1,600 MW of offshore wind capacity.[48]

State and federal policies, including the federal investment and production tax credits, have helped enable the dramatic rise of wind and solar power. A study by the Natural Resources Defense Council estimated that the extension of those tax credits in late 2015 "will prompt the development of nearly 29,000 megawatts

Figure 4. U.S. Wind Energy Production Grew Seven-Fold from 2007 to 2016[50]



of additional new utility-scale wind and solar capacity by 2020, enough to power nearly 8 million homes."[49]

To date, Plains states have led the American wind energy revolution. From 2007 to 2016, Texas, Iowa and Oklahoma led the nation in added wind power. In all three states, wind generation grew more than six-fold over that time period.

In Texas alone there are now more than 10,000 wind turbines; during the early morning hours on one day in February 2017, wind power supplied more than half of Texas' electricity demand.[51] Texas' wind energy growth was made possible in part by a $7 billion investment in the state grid, which allows for the transmission of wind energy from the state's windiest regions to its biggest cities.[52]

Among the states with the biggest growth in wind energy, four produced at least 10 times as much wind energy in 2016 as they did in 2007: Oklahoma, Kansas, Illinois, and North Dakota.

Table 2. States with Most Additional Wind Energy Production 2016 Vs. 2007 (GWh)[53]

State	2007	2016	Additional Generation 2017 - 2016	Rank
Texas	9,006	57,551	48,544	1
Oklahoma	1,849	19,913	18,064	2
Iowa	2,757	20,049	17,293	3
Kansas	1,153	14,113	12,961	4
Illinois	664	10,627	9,963	5
Colorado	1,292	9,425	8,134	6
California	5,585	13,698	8,113	7
Minnesota	2,639	10,637	7,998	8
North Dakota	621	8,080	7,459	9
Oregon	1,247	7,163	5,916	10

Figure 5. Wind Energy Production, Top States, 2007 and 2016

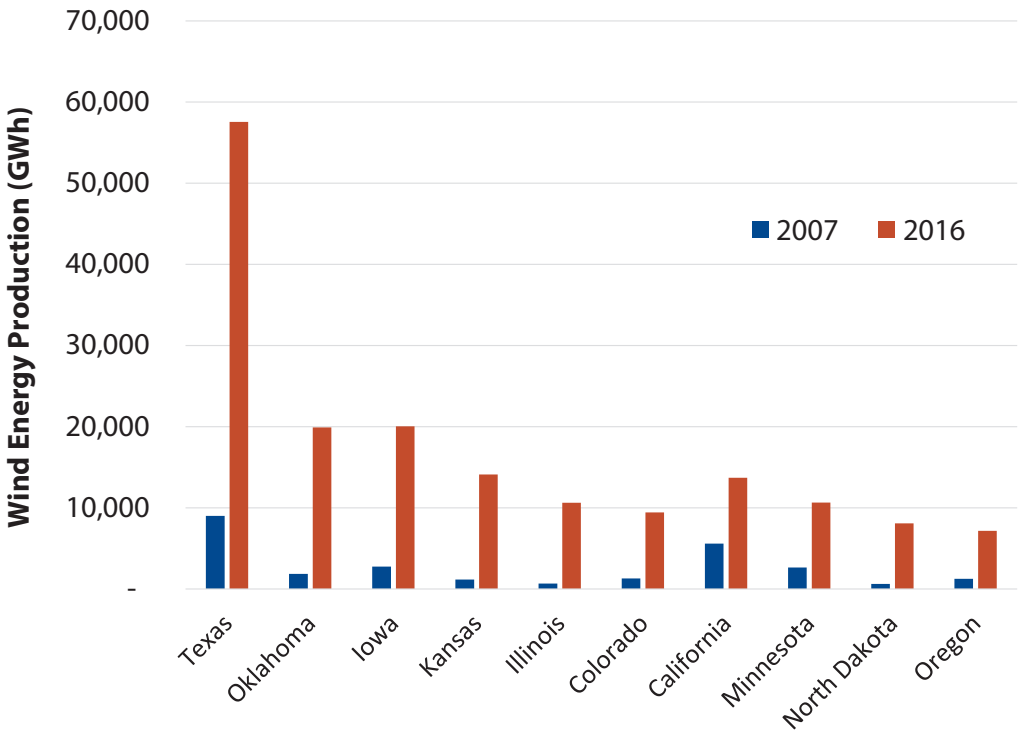
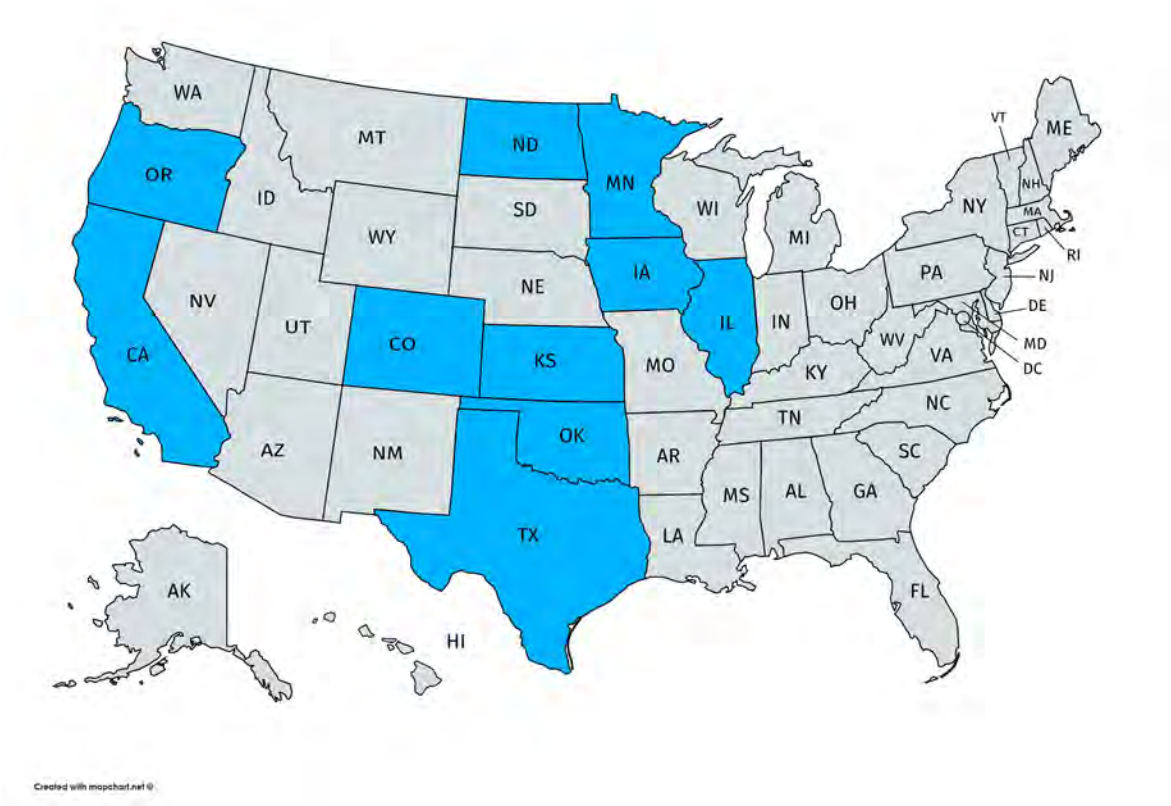


Figure 6. America's Top 10 States for Wind Energy Growth Since 2007



U.S. Energy Consumption Has Dropped by 3.6 Percent Since 2007

The task of moving to 100 percent clean, renewable energy can be made dramatically cheaper and easier by reducing the amount of energy wasted in inefficient buildings, cars and equipment.

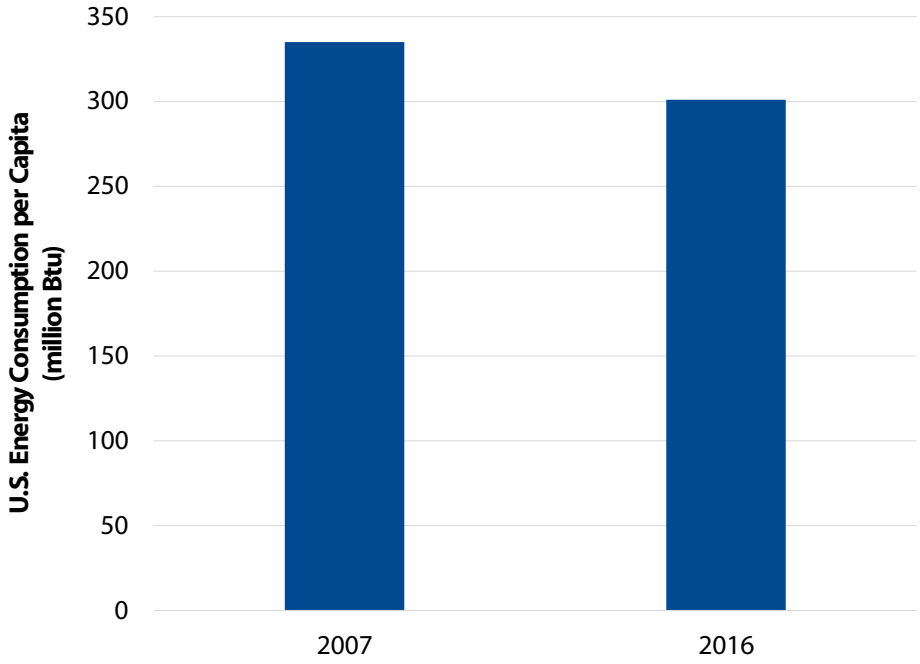
Between 1950 and 2007, total energy use in the United States nearly tripled.[54] Since 2007, however, energy use in the United States has fallen by 3.6 percent, despite a growing population and economy.[55] Today, America uses less energy than it did in 2002, when the country had 34 million fewer people.

On a per-capita basis, energy consumption in the U.S. dropped by 10 percent between 2007 and 2016, while energy consumption per unit of GDP fell by 14 percent, even as real GDP increased by more than 10 percent.[56]

Energy consumption can vary due to a number of factors – including weather and economic trends – but public policy has played an important role in helping to reduce energy consumption in the U.S.

- Federal fuel economy standards have led to more efficient vehicles.[57] In 2007, the average fuel economy of a new vehicle was 20.6 miles per gallon, no better than 20 years earlier.[58] In 2016, the average fuel economy was 25.6 miles per gallon – an improvement of 24 percent.
- According to a survey by the American Council for an Energy-Efficient Economy (ACEEE), electric efficiency programs across the U.S. saved nearly 2.7 times as much energy in 2015 as in 2007, as states ramped up their investments in efficiency.[59] In 2015, these programs saved enough electricity to power 2.5 million homes, equivalent to 0.7 percent of all U.S. electricity sales in 2015.
- Dozens of state energy efficiency policies, along with the federal Energy Independence and Security Act of 2007, have driven adoption of efficient appliances and lighting, including light emitting diode (LED) lighting.[60] From 2009 to 2015, the percentage of homes with at least one energy-efficient lightbulb in the house – typically either

Figure 7. U.S. Per Capita Energy Consumption Dropped by 10 Percent from 2007 to 2016



an LED or CFL bulb – increased from 58 percent to 86 percent.[61] In 2014, LED lighting saved approximately 143 trillion Btu, equivalent to the total energy used by 1.6 million homes.[62]

- State energy building codes are reducing building energy use; residential and commercial buildings account for 40 percent of U.S. energy consumption.[63] In recent years many states either implemented or updated building codes.[64] In 2014, building energy codes saved approximately 1.1 quadrillion Btu, equivalent to the total energy used by 12 million homes.[65]

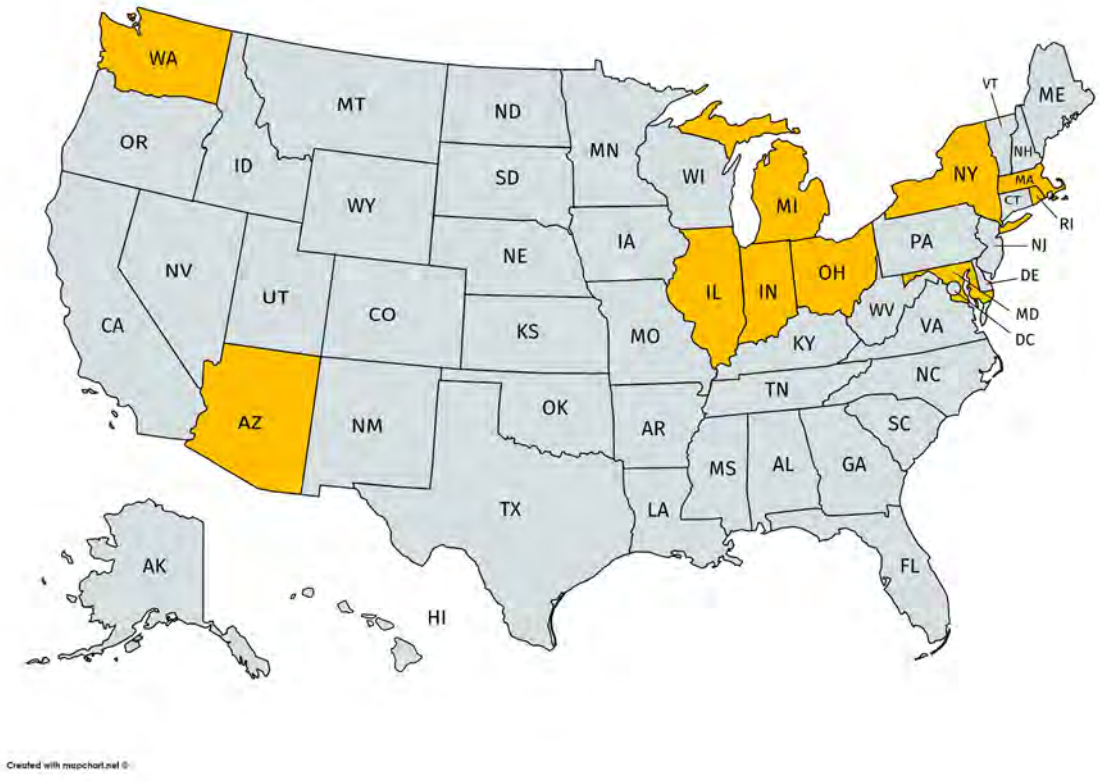
ACEEE's data on electricity efficiency also reveals improvements in state-level electricity efficiency programs and policies. Rhode Island, Massachusetts, Michigan, Illinois and Maryland led the nation in additional electricity efficiency savings in 2015 compared with 2007.[66] Over that time period, Rhode Island more than tripled its electricity savings, and in 2015 Rhode Island's electricity savings were equivalent to nearly 3 percent of the state's total electricity consumption. These savings were thanks to a number of energy saving programs in the state. Significant savings have been due to Rhode Island's Comprehensive Energy Conservation, Efficiency and Affordability Act of 2006, which requires utilities to acquire all cost-effective energy efficiency.[67] And, since 2008, Rhode Island has invested millions of dollars in revenue from the Regional Greenhouse Gas Initiative (RGGI, the northeast's cap-and-trade program) in energy efficiency, in programs including efficient public-sector buildings, adoption of LED streetlights, and financial incentives for consumer efficiency.[68]

Two states that rank in the top five for biggest improvement in electric efficiency gains – Michigan and Illinois – had zero efficiency savings in 2007. Michigan, which was recognized as a "most-improved" state in ACEEE's 2016 efficiency rankings, has made significant improvements in recent years to its building efficiency standards.[69]

Table 3. Most Improved States for Electricity Efficiency[70]
Data reported by ACEEE's 2009 and 2016 State Energy Efficiency Scorecard reports.

State	Electricity Saved as % of Retail Sales 2007	Electricity Saved as % of Retail Sales 2015	Change (Percentage points)	Rank
Rhode Island	0.81%	2.91%	2.10	1
Massachusetts	0.86%	2.74%	1.88	2
Michigan	0.00%	1.16%	1.16	3
Illinois	0.00%	1.13%	1.13	4
Maryland	0.00%	1.01%	1.01	5
Ohio	0.02%	0.92%	0.90	6
Arizona	0.41%	1.19%	0.78	7
Indiana	0.02%	0.76%	0.74	8
New York	0.36%	1.05%	0.69	9
Washington	0.74%	1.42%	0.68	10

Figure 8. America's Top 10 States for Electricity Efficiency Gains Since 2007



Annual Sales of Electric Vehicles Have Grown to 160,000 Since 2007

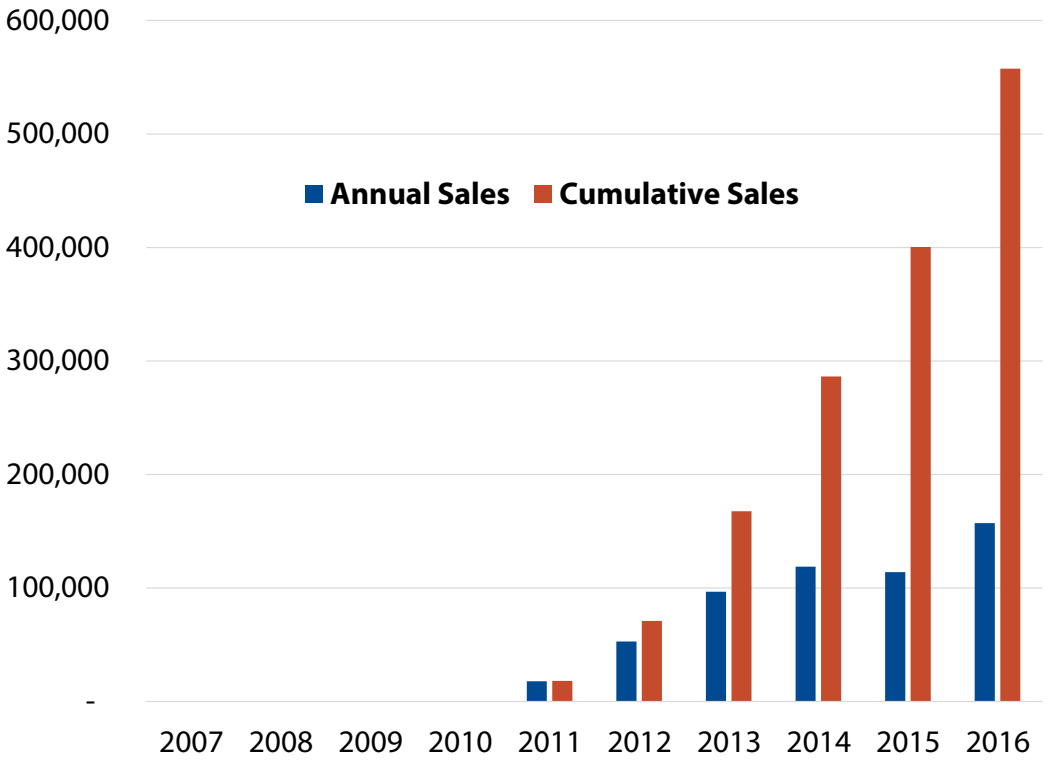
Achieving an economy powered by 100 percent renewable energy means ending the use of fossil fuels for all activities, not just electricity. That means ending the use of petroleum for transportation – a sizeable task, given that it that currently powers the overwhelming majority of our vehicles. Although there are a number of strategies for reducing transportation fossil fuel use – like encouraging public transportation, walking and biking, and limiting sprawl – as long as Americans continue driving cars and trucks, adopting electric vehicles (combined with a renewable electric grid) is a necessity.

The first modern electric vehicles (EVs) did not appear on American roads until the late 2000s, and as late as 2010 the number of EVs – including plug-in hybrids – on American roads numbered only in the hundreds.

To date, however, there have been more than 620,000 EVs (including plug-in hybrid vehicles) sold in the U.S.[71] There are more than 20 models on the market, ranging from affordable commuter cars to ultra-fast luxury supercars.[72] In 2016, 157,000 EVs were sold.[73] In the first five months of 2017, EV sales were up an additional 44 percent compared with 2016.[74] New models – such as Tesla's newly released Model 3, of which more than 400,000 have already been pre-ordered by consumers – continue to generate excitement.

California leads the nation in electric vehicle adoption. Since 2011, nearly half of all EVs sold in the country were sold in California.[76] Six of the states leading the nation in EV sales (ranked by EVs per

Figure 9. Electric Vehicle Sales Reached Nearly 160,000 in 2016[75]



registered vehicle) – California, Maryland, New Jersey, New York, Oregon and Vermont – have requirements that a certain percentage of each automakers' sales be zero-emission vehicles.[77] Georgia, which ranks fifth for EV sales per registered vehicle (and second for cumulative EV sales), had seen its EV market boom under a tax incentive program – since that program was repealed and replaced with a registration fee for EVs, electric vehicle sales have dropped by 80 percent.[78] Georgia's experience suggests the importance of policy for the adoption of EVs.

Recent years have also seen the widespread deployment of electric vehicle charging stations across the country. From 2007 to 2016, the number of public charging stations increased from barely 100 to more than 16,000, with stations appearing throughout the country, particularly along major highways.

Table 4. Top EV States through March 2017 (Ranked by EVs per Registered Vehicle)[79]

State	Plug-In EV Sales through March 2017	Sales per Thousand Registered Vehicles	Rank (EVs per registered vehicle)	Rank (Cumulative sales)
California	283,593	19.9	1	1
Hawaii	5,814	11.3	2	19
Oregon	12,421	8.8	3	9
Washington	23,243	8.4	4	3
Georgia	26,018	7.5	5	2
Vermont	1,707	6.8	6	29
Colorado	9,279	5.1	7	13
Maryland	9,105	4.6	8	14
New York	22,099	4.6	9	4
New Jersey	12,721	4.4	10	8

Table 5. Top States for Electric Vehicle Charging Stations and EV Sales[80]

State	Public Charging Stations (as of July 5, 2017)	Rank
California	3,850	1
Texas	888	2
Florida	876	3
New York	766	4
Washington	689	5
Georgia	602	6
Massachusetts	486	7
Oregon	484	8
Maryland	446	9
Colorado	445	10

Figure 10. America's Top 10 States for Electric Vehicle Sales Since 2007

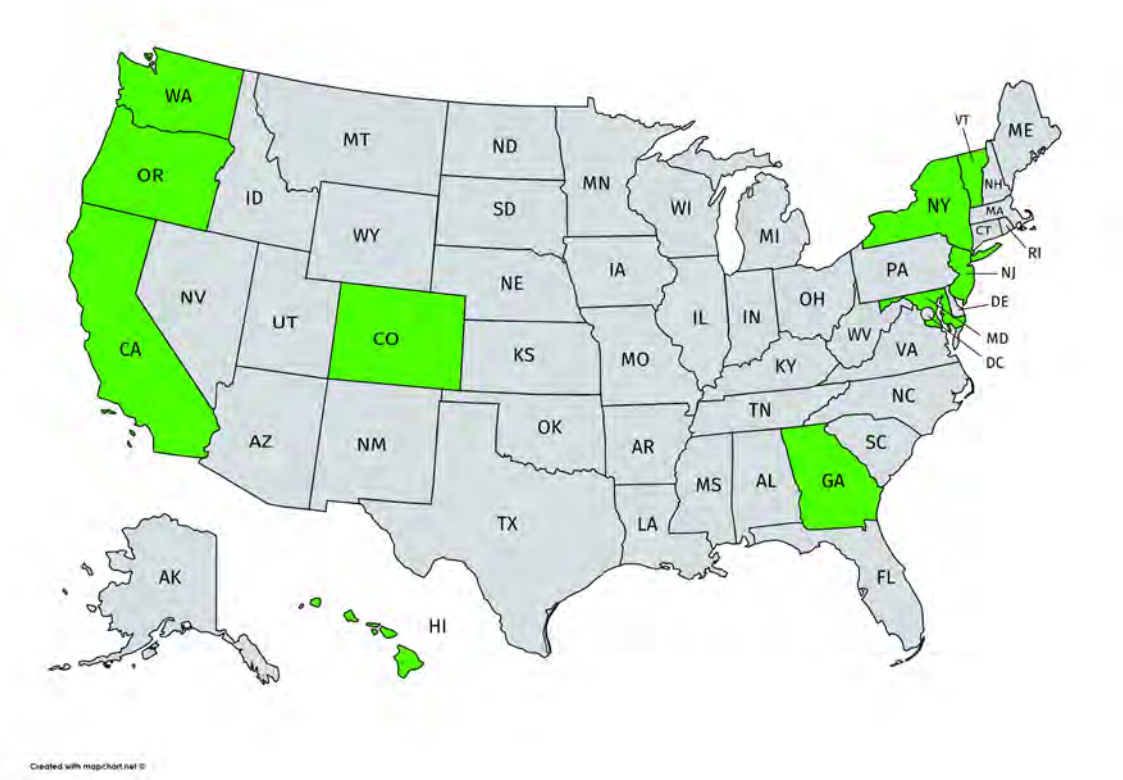
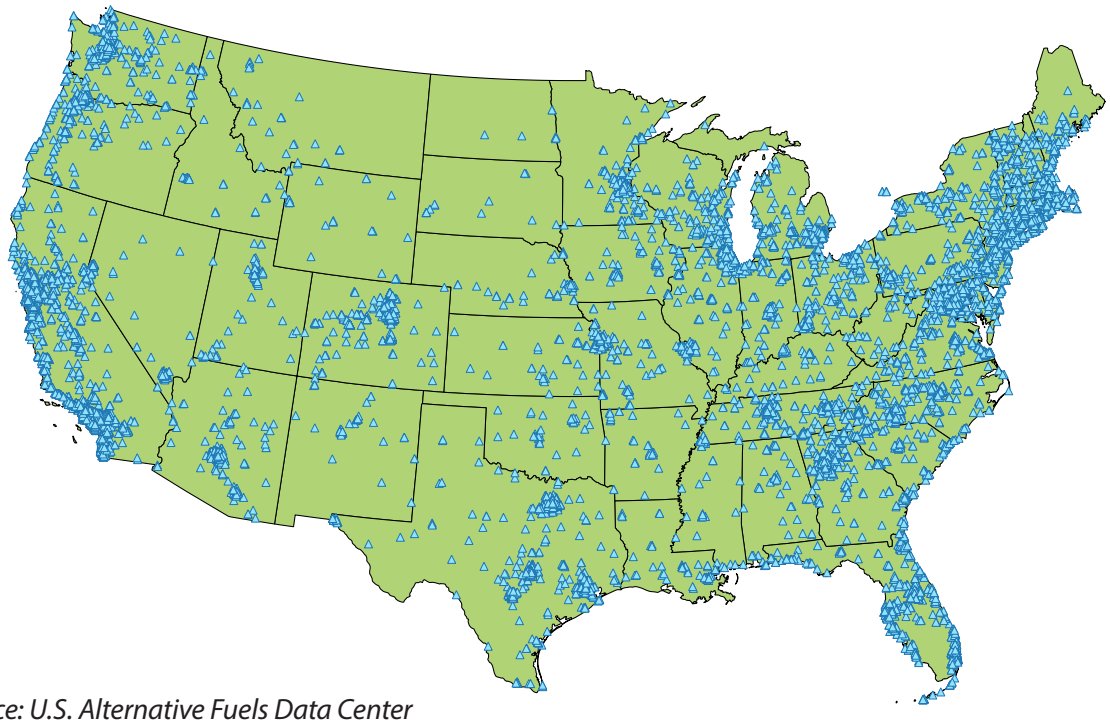


Figure 11. EV Public Charging Stations in the United States



Data Source: U.S. Alternative Fuels Data Center

Battery-Powered Energy Storage Has Grown 20-Fold Since 2007

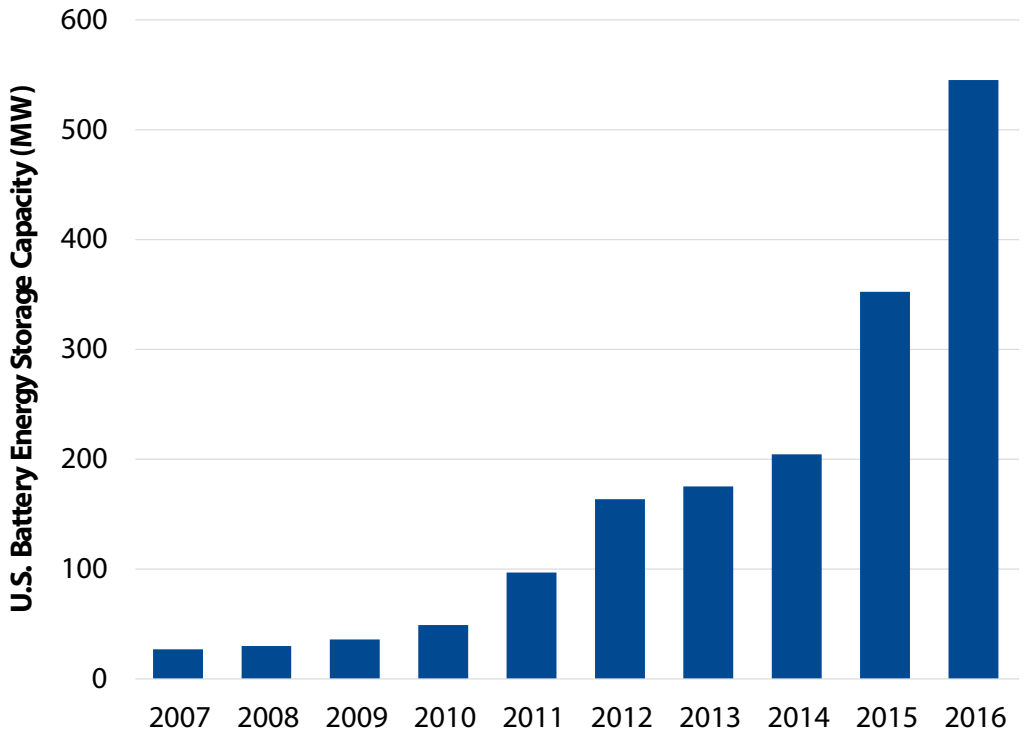
America has vast resources of clean, renewable energy, but taking full advantage of that potential requires an energy system that can accommodate daily and seasonal variations in the availability of energy sources such as solar and wind power. There are many strategies that can be used to integrate renewable energy into a reliable grid. Upgrades to the U.S. transmission system to create an interconnected national grid could allow wind energy to be sent from the western plains to East Coast cities when they need it. The use of "smart grid" technology can allow real-time changes in energy use to reduce demand during times of lower generation. In the long run, overbuilding wind and solar energy might allow for adequate generation even on days when there is less sun and wind.[81]

Energy storage technologies can also help to enable a 100 percent renewable energy future. Energy storage technologies like batteries can smooth the deployment of renewable energy by storing excess energy for later use. For example, when the sun shines during the day, excess energy can be stored for use at night.

Energy storage has not yet seen a boom comparable to wind or solar power, but there are signs that such a boom may soon be on the way.

Between 2007 and 2016, the U.S. added 602 MW of utility-scale energy storage, for a total of 22.2 GW – a modest increase of 3 percent in total storage capacity.[82] Most storage that existed prior to 2007 was in the form of large-scale hydroelectric pumped storage systems. In these systems, water is pumped to a higher elevation during periods of surplus generation, and

Figure 12. America's Utility-Scale Battery Storage Capacity Grew 20-Fold from 2007 to 2016[86]



allowed to flow back down through a hydroelectric generator system when electricity is later needed.

Since 2007, however, one sector of energy storage has seen dramatic progress: battery storage. Aided in part by the rise of battery-powered electric vehicles, recent price declines and technology improvements have, for the first time, made batteries a viable and flexible option for expanding energy storage capacity, and have enabled the first-ever widescale rollout of utility-scale battery storage.

More than 90 percent of the energy storage added since 2007 has been in the form of battery storage, which increased 20-fold in terms of capacity through 2016.[83] The first widespread installations of home and business-scale energy storage – sometimes paired with solar energy – have taken place in the last two years.[84]

Experts predict that improving batteries will propel rapid growth in energy storage in the coming years. GTM Research, for example, projects that annual U.S. energy storage additions will reach 1.7 GW by 2020 – nearly three times the total energy storage additions from 2007 to 2016.[85]

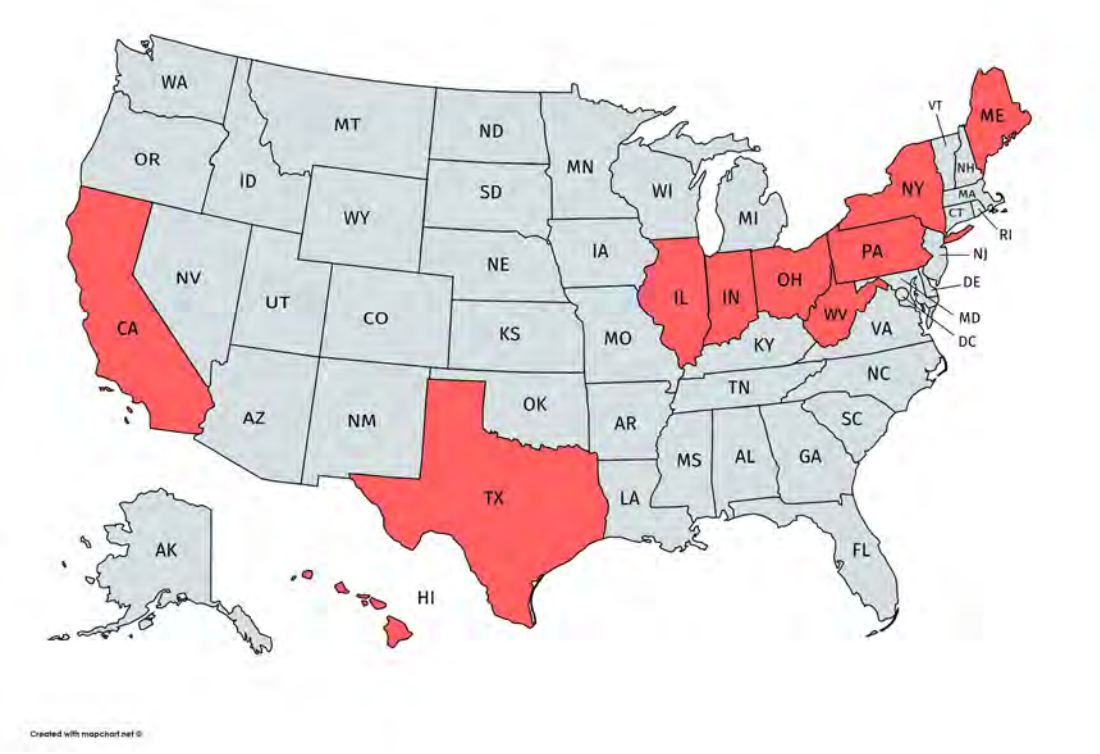
At the state level, California, Illinois, West Virginia, Ohio and Pennsylvania led the nation in energy storage additions from 2007 to 2016. All of those states, except for California, are part of the PJM regional grid. PJM (the regional transmission organization that operates the electric grid in much of the Mid-Atlantic and Midwest) increased battery storage as a response to a decision by the Federal Energy Regulatory Commission to increase compensation for grid additions that allow for rapid changes in electricity production.[87] Illinois, West Virginia and Ohio had no energy storage capacity before 2007.

Table 6. States That Added Most Energy Storage 2007 – 2016

State	2007 Energy Storage Capacity (MW)	2016 Energy Storage Capacity (MW)	Additions 2007 – 2016 (MW)	Rank
California	3709	3868.5	159.5	1
Illinois	0	112.4	112.4	2
West Virginia	0	65.5	65.5	3
Ohio	0	53	53	4
Pennsylvania	1541	1591.4	50.4	5
Texas	0	41	41	6
Hawaii	0	27	27	7
Indiana	0	22	22	8
New York	1240	1260	20	9
Maine	0	16.7	16.7	10

California led the nation in installation of new energy storage, installing 159 MW from 2007 to 2016, with 118 MW of California's new capacity in the form of battery storage. In 2016, California accounted for more than a fifth of the nation's total battery storage capacity. California's aggressive adoption of energy storage was due in part to a California Public Utilities Commission requirement that utilities increase energy storage capacity; additions also increased rapidly in response to the Aliso Canyon natural gas leak, in which energy storage was used to minimize grid disruptions.[88]

Figure 13. America's Top 10 States for Energy Storage Additions Since 2007



Three States Now Generate a Third (or More) of Their Electricity with Renewable Energy

With falling energy use, and expanding wind and solar generation, renewable energy now accounts for a significant percentage of U.S. electricity use.

In 2016, wind and solar power produced 7 percent of all U.S. electricity generation, eight times greater than the percentage they produced in 2007. In March 2017, for the first time, wind and solar power produced 10 percent of all U.S. electricity for an entire month.[89] Although renewable energy penetration in March is not representative of the entire year – spring months are generally windier and see more wind energy production – the 10 percent mark is nevertheless an important milestone.[90]

In 2016, 17 states generated enough wind and solar energy to supply more than 10 percent of their electricity needs.[91] Three states – North Dakota, Iowa and Oklahoma – generated enough wind and solar power to supply at least a third of their electricity needs. North Dakota generated sufficient wind and solar electricity to supply 45 percent of its electricity needs.

Table 7. Top 10 States by Wind and Solar Generation as Percentage of Electricity Consumption[92]

State	Wind and Solar Generation as Percentage of Electricity Consumption (2016)	2016 Rank
North Dakota	45%	1
Iowa	42%	2
Oklahoma	33%	3
Wyoming	26%	4
South Dakota	26%	5
New Mexico	20%	6
Colorado	19%	7
Minnesota	17%	8
Kansas	17%	9
California	16%	10

The U.S. Can and Must Accelerate Clean Energy Progress

In order to prevent the worst impacts of global warming, the U.S. must rapidly phase out the use of fossil fuels. Transitioning to clean, renewable energy will also improve our health by preventing hazardous air pollution, and increase our safety by protecting us from the hazards of extracting, transporting and processing dangerous fuels.

Fortunately, the United States has more than enough renewable energy potential to support all of our energy needs. According to the National Renewable Energy Laboratory, the United States has the technical potential to meet its current electricity needs more than 100 times over with solar energy and more than 10 times over with wind energy.[93] Every state in the country has enough solar energy potential to supply all of its electricity needs.[94]

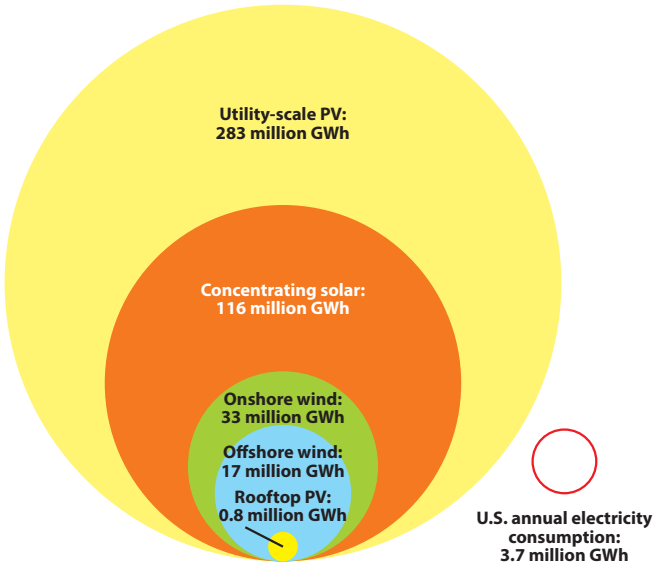
Transitioning to an economy powered entirely by clean, renewable fuels will require us to find ways to tap more of that clean energy potential, to take advantage of advances in technology, and to integrate clean energy thoughtfully into our energy system.

Accelerating the Pace of Change

The United States is adding renewable energy at a record pace. But that pace is not fast enough to eliminate our dependence on fossil fuels by mid-century – the critical time period for preventing the worst impacts of global warming.

If the nation were to install as much renewable energy every year as we did in 2016, by 2050 American would be producing enough electricity to meet only 57 percent of today's electricity demand. That figure does not account for replacing fossil fuels that we use directly in our homes, businesses, factories and vehicles.

Figure 14. Comparison of Renewable Energy Technical Potential and Current Consumption (Data: NREL)[95]



If America can continue to accelerate its adoption of renewable energy – as we have over the past decade – the goal of repowering our electricity system, and eventually our entire economy, begins to come within view. Between 2009 and 2016, U.S. wind and solar generation grew at an annual rate of 26 percent. If generation continues to grow by 15 percent per year, or slightly more than half of its current growth rate, wind and solar will produce enough electricity to meet all of our current electricity needs by 2035.

Technology Is Improving

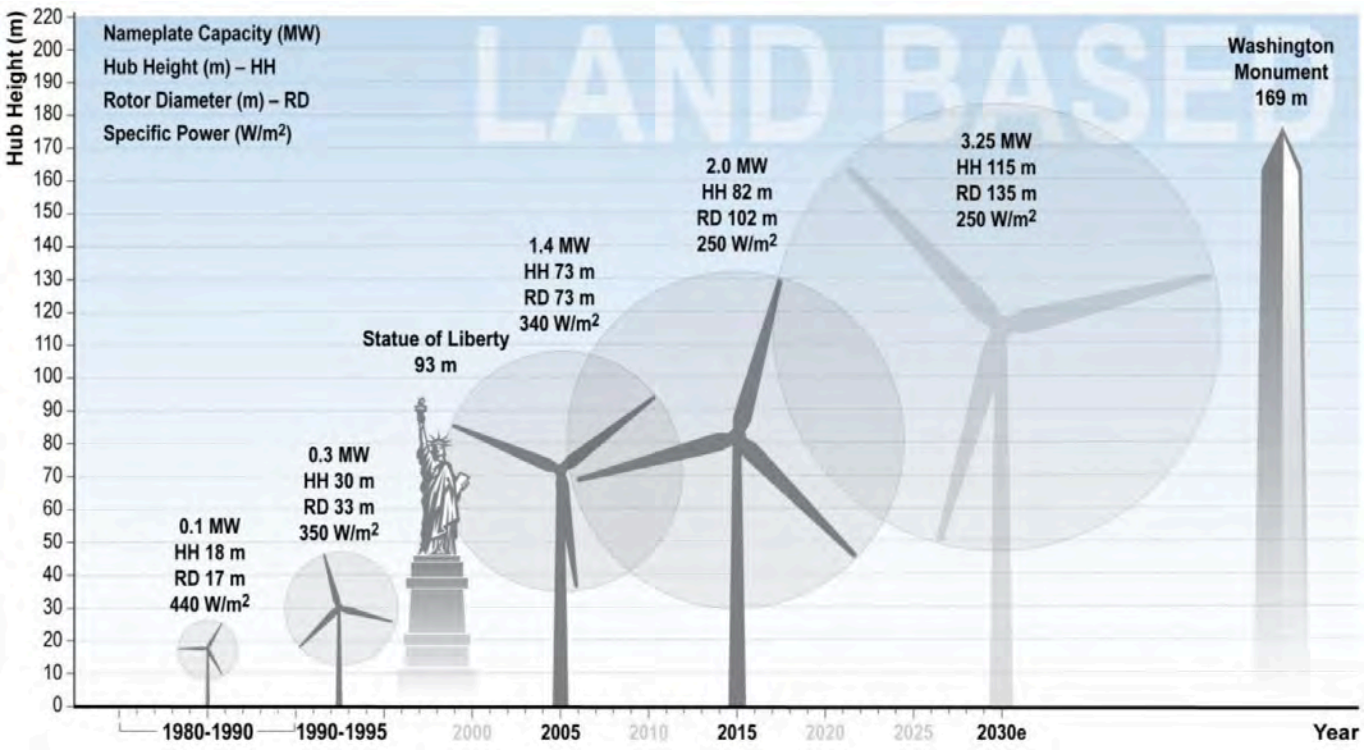
Recent improvements in technology, and reductions in cost – along with predictions that those trends will continue over the coming years – suggest that America can continue to accelerate its progress toward a clean energy economy.

Modern wind turbines are almost 50 percent taller and have blades that are more than double the length of turbines made 15 years ago, enabling the average wind turbine installed today to have capacity more than double that of the average wind turbine installed in the year 2000.[96] In 2007, the highest-capacity wind turbine in the world was 6 MW, with only one such test prototype actually in operation.[97] Today, an entire wind farm of 8 MW turbines is generating electricity off the coast of England. According to DONG Energy, which led the project, a single revolution of the blades on just one turbine can power a home for 29 hours.[98]

Wind manufacturers already have plans to develop 10 MW prototypes by 2020.[99] By 2030, experts suggest that massive 11 MW wind turbines will be regularly installed offshore, with enormous rotors with "a swept area more than five times the size of a football field."[100]

Other developments in offshore wind, like the development of floating turbines, could allow the U.S. to tap into the enormous wind potential off the West Coast, where the ocean is far too deep to allow the installation of traditional seafloor-mounted turbines.[101] Based on data from the National Renewable Energy Laboratory, the West Coast has the potential to generate more than 10 times as much electricity from the wind as it uses in a given year.[102]

Figure 15. Average Wind Turbine Size and Capacity Is on the Rise



From 2005 to 2015, average U.S. land-based wind turbine capacity increased from 1.4 MW to 2.0 MW, and is projected to increase to 3.25 MW by 2030. Similar growth has been observed, and projected, for offshore wind turbines. Credit: Lawrence Berkeley National Laboratory

Recent years have also seen rapid progress in solar energy technology. The average residential solar panel installed in 2015 was 18 percent more efficient than those installed just five years earlier.[103] For utility-scale solar, efficiency improvements are reducing costs by allowing developers to purchase less land, or fewer modules, to achieve desired project capacity; or to boost the amount of capacity possible on existing land.[104]

Advanced new products are also helping to reduce energy consumption, and to enable smarter energy use. Among them are technologies that fall under the banner of what the American Council for an Energy-Efficient Economy calls "intelligent efficiency" – a new category of energy-saving strategies that harness the power of information technology. Sales of smart thermostats, which give homeowners more control over home energy use and have been shown to reduce energy used for heating and cooling, grew from 2 million units in 2013 to 5 million units in 2015.[105] Industrial operations are embracing intelligent efficiency.[106] In 2015, the U.S. market for industrial energy management systems – systems that allow monitoring and adjustment of energy use in industrial settings – reached $4.3 billion, an increase of 36 percent over 2011.[107] Efficiency technologies and advances in building design, combined with on-site renewable energy, are enabling the spread of net-zero energy buildings, which generate more energy than they consume over the course of a year. A survey by the Net-Zero Energy Coalition found more than 4,000 net-zero energy buildings in the U.S. and Canada in 2016, a more than 20 percent increase from 2015.[108]

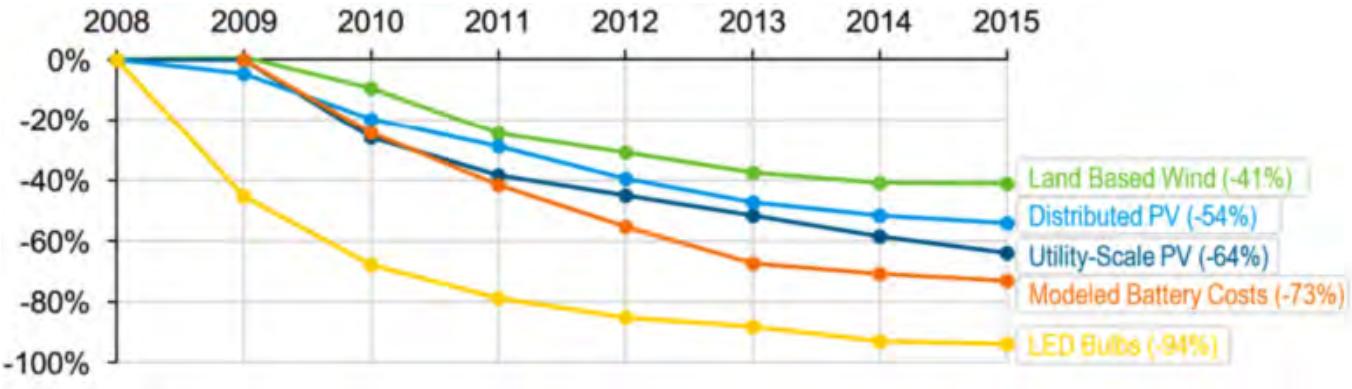
Improvements in battery technology are enabling both energy storage, and long-range electric vehicles. For example, the 2015 version of the Tesla Roadster has a 400-mile range a 40 percent increase over the original 2008 model.[109] Advances in range are due both to improved battery technology, and advances in aerodynamics and rolling resistance.[110] Meanwhile, auto companies continue to invest resources in improving battery technology; in November 2016, Toyota announced it had made a breakthrough that would improve EV range by 15 percent.[111] In addition to reducing reliance on fossil fuels, widespread adoption of electric vehicles would also reduce overall energy use, because electric vehicles are approximately three times more efficient at converting energy to wheel power than gas-powered vehicles.[112]

Prices Are Falling

Advancing technology and increasing economies of scale have led to rapidly falling prices for clean energy technology.

An annual Department of Energy survey of clean energy prices found that, from 2008 to 2015, the cost of land-based wind power fell by 41 percent; distributed PV by 54 percent; utility-scale PV by 64 percent; batteries by 73 percent; and LED bulbs by 94 percent.[113]

Figure 16. Clean Energy Technologies Have Fallen in Price Dramatically since 2008 (DOE Chart)[114]



These and other recent price declines have made many clean energy technologies price competitive when compared to conventional fossil-fuel technology. Lazard, which conducts an annual levelized cost of energy survey, now reports that the unsubsidized cost of utility-scale wind and solar energy have fallen to levels that are "cost-competitive with conventional generation technologies under some scenarios."[115] In the United Arab Emirates in 2016, for example, a record-breaking solar contract was signed promising to deliver energy for 2.42 cents per kilowatt-hour, or half the average global cost of coal power.[116]

Energy-saving LED light bulbs cost more than $40 apiece as recently as 2010; today, they cost a few dollars at the local hardware store.[117] A recent analysis by the Consumer Federation of America found that a household with 20 light bulbs can expect to save approximately $1,000 in a decade by switching from incandescent bulbs to LEDs.[118]

As adoption increases and technology improves, prices are expected to continue to fall. A recent survey of wind experts by the National Renewable Energy Laboratory found that the price of wind power is expected to fall 24-30 percent by 2030 and 35-41 percent by 2050.[119] Bloomberg New Energy Finance predicts that the average utility-scale solar energy system "will cost 73 cents a watt by 2025," a 36 percent price drop from today, and that "[b]y 2025, solar may be cheaper than using coal on average globally."[120] A 2016 analysis by McKinsey found that energy storage "could be $200 per kilowatt-hour in 2020, half today's price, and $160 per kilowatt-hour or less in 2025."[121]

Putting it All Together

America has virtually limitless potential to produce energy from the wind and sun, and many opportunities to curb our energy use. Technological improvements and growing markets for clean energy are making it easier and cheaper to harness that potential with each passing year. At the same time, advances such as those in energy storage and electric vehicles are making it possible for us to put renewable energy to use in new ways, accelerating the transition away from fossil fuels.

It is now possible to envision an energy future for America in which we rely completely on clean, renewable sources of energy – eliminating our dependence on the fossil fuels that contribute to global warming and on other damaging sources of energy.

With many potential pathways and rapid changes in technology, it is difficult to foresee the precise path by which America will achieve 100 percent renewable energy. Researchers from a wide variety of academic and governmental institutions have put forward a variety of scenarios by which America can power all, or nearly all, of our electricity system – and even our entire economy – with renewable energy.[122] Many other such scenarios are likely to emerge in the years to come as technology advances and leading communities, states and nations gain experience with the transition.

Achieving a future powered by clean, renewable energy will require bold commitments and equally bold action. The benefits are immense. The potential is clear. The time to begin is now.

Conclusion and Recommendations

American clean energy is growing at an incredible pace. Over just nine years – from 2007 to 2016 – America saw solar energy grow 43-fold, wind energy grow seven-fold, total energy consumption drop by nearly 4 percent, and battery-powered electric vehicles and energy storage emerge as viable new solutions to enable the transition to renewable energy.

To transition to a clean, renewable energy system by 2050, however, the U.S. must dramatically accelerate its clean energy progress.

Many public and private institutions have already set their sights on a 100 percent renewable energy future. In 2015, Hawaii became the first state in the country to set a 100 percent renewable energy goal for its electricity sector, through its renewable energy standard.[123] According to the Sierra Club, 29 cities have committed to 100 percent renewable energy, and six cities have already achieved it.[124] The city of Greensburg, Kansas, has a wind farm that produces enough energy to power every single one of its homes, businesses and municipal buildings.[125] The organization RE100 has collected 100 percent renewable energy commitments from 96 companies, including Bank of America, Google, and Anheuser-Busch InBev.[126]

In order to break our dependence on fossil fuels, and achieve a renewable energy future, leaders of cities, states, companies and institutions should:

- Set goals to meet all of their energy needs across all sectors by 2050.
- Prioritize energy savings. Conserving energy and using it more efficiently can ease the transition from dirty fuels to clean, renewable energy.
- Work to ensure the rapid deployment of renewable energy. Policymakers should require utilities to ramp up renewable energy generation over time, work to make clean energy technologies accessible to and affordable for consumers, and encourage adoption of clean energy at all scales, from small rooftops to large wind and solar farms.
- Support the development of emerging technologies critical to the development of a fully renewable energy system, including offshore wind power, smart grid improvements, and electrification of heating and transportation.
- Set limits on carbon and greenhouse gas emissions that will shift us away from fossil fuels.

Appendix

Table A1. Clean Energy Progress by State (National Rank in Parentheses)

State	Increase in Solar Electricity Generation, 2007 - 2016 (GWh)	Increase in Wind Electricity Generation, 2007 - 2016 (GWh)	Increase in Electricity Efficiency Savings (percentage point increase in savings as share of electricity consumption) 2007 - 2015	Number of EVs Sold through March 2017	Increase in Energy Storage Capacity 2007 - 2016 (MW)
Alaska	0 (50)	163 (35)	-0.01 (49)	306 (47)	5 (13)
Alabama	35 (39)	0 (41)	0.08 (45)	1,311 (34)	None
Arkansas	37 (37)	0 (41)	0.6 (17)	614 (44)	None
Arizona	5,391 (2)	543 (28)	0.78 (7)	8,593 (15)	None
California	26,370 (1)	8,113 (7)	0.65 (11)	283,593 (1)	159.5 (1)
Colorado	1011 (11)	8,134 (6)	0.61 (15)	9,279 (13)	None
Connecticut	343 (17)	14 (37)	0.38 (24)	5,657 (20)	0.8 (20)
District of Columbia	53 (33)	0 (41)	0.61 (15)	N/A	None
Delaware	169 (23)	5 (39)	0.19 (39)	973 (40)	None
Florida	599 (15)	0 (41)	-0.04 (50)	21,696 (5)	None
Georgia	1076 (8)	0 (41)	0.23 (36)	26,018 (2)	1 (18)
Hawaii	813 (14)	406 (31)	0.32 (29)	5,814 (19)	27 (7)
Iowa	56 (31)	17,293 (3)	0.29 (30)	1,526 (32)	None
Idaho	39 (35)	2,255 (19)	0.26 (32)	771 (42)	None
Illinois	91 (26)	9,963 (5)	1.13 (4)	12,258 (10)	112.4 (2)
Indiana	285 (18)	4,903 (12)	0.74 (8)	3,276 (26)	22 (8)
Kansas	49 (34)	12,961 (4)	0.51 (20)	1,329 (33)	None
Kentucky	29 (41)	0 (41)	0.34 (27)	1,106 (36)	None
Louisiana	194 (20)	0 (41)	0.08 (44)	959 (41)	None
Massachusetts	1943 (6)	237 (34)	1.88 (2)	10,040 (11)	None
Maryland	912 (13)	527 (29)	1.01 (5)	9,105 (14)	11 (11)
Maine	29 (41)	1,515 (22)	0.62 (14)	1,277 (35)	16.7 (10)
Michigan	60 (29)	4,690 (13)	1.16 (3)	12,722 (7)	None
Minnesota	56 (30)	7,998 (8)	0.47 (23)	4,837 (22)	1.1 (17)
Missouri	210 (19)	1,123 (26)	0.6 (17)	3,535 (25)	1 (18)
Mississippi	5 (47)	0 (41)	0.28 (31)	326 (46)	None
Montana	9 (44)	1,634 (21)	0.38 (25)	656 (43)	None

Table A1 cont'd. Clean Energy Progress by State (National Rank in Parentheses)

State	Increase in Solar Electricity Generation, 2007 - 2016 (GWh)	Increase in Wind Electricity Generation, 2007 - 2016 (GWh)	Increase in Electricity Efficiency Savings (percentage point increase in savings as share of electricity consumption) 2007 - 2015	Number of EVs Sold through March 2017	Increase in Energy Storage Capacity 2007 - 2016 (MW)
North Carolina	4,015 (3)	6 (38)	0.62 (13)	6,639 (18)	None
North Dakota	0 (50)	7,459 (9)	0.01 (48)	165 (49)	None
Nebraska	8 (45)	3,577 (15)	0.51 (20)	981 (39)	None
New Hampshire	54 (32)	447 (30)	-0.11 (51)	1,613 (31)	None
New Jersey	2673 (5)	2 (40)	0.25 (34)	12,721 (8)	None
New Mexico	976 (12)	2,221 (20)	0.51 (20)	1,089 (37)	2.6 (15)
Nevada	2,853 (4)	344 (32)	0.07 (46)	3,182 (27)	None
New York	1,051 (9)	3,112 (16)	0.69 (9)	22,099 (4)	20 (9)
Ohio	192 (21)	1,240 (25)	0.9 (6)	6,676 (17)	53 (4)
Oklahoma	11 (43)	18,064 (2)	0.32 (28)	1,620 (30)	None
Oregon	179 (22)	5,916 (10)	0.19 (38)	12,421 (9)	5 (13)
Pennsylvania	381 (16)	3,002 (17)	0.64 (12)	9,537 (12)	50.4 (5)
Rhode Island	38 (36)	33 (36)	2.1 (1)	989 (38)	None
South Carolina	35 (40)	0 (41)	0.52 (19)	1,833 (28)	None
South Dakota	2 (49)	2,995 (18)	0.24 (35)	223 (48)	None
Tennessee	150 (25)	-12 (51)	0.13 (42)	4,082 (23)	None
Texas	1,103 (7)	48,544 (1)	0.05 (47)	18,139 (6)	41 (6)
Utah	1,023 (10)	827 (27)	0.35 (26)	3,550 (24)	None
Virginia	71 (28)	0 (41)	0.25 (33)	7,922 (16)	None
Vermont	154 (24)	283 (33)	0.21 (37)	1,707 (29)	2 (16)
Washington	88 (27)	5,604 (11)	0.68 (10)	23,243 (3)	5.2 (12)
Wisconsin	36 (38)	1,411 (23)	0.13 (41)	5,237 (21)	None
West Virginia	6 (46)	1,265 (24)	0.19 (39)	439 (45)	65.5 (3)
Wyoming	3 (48)	3,608 (14)	0.09 (43)	140 (50)	None

Table A2. Solar Generation Percentage Change by State[132]

State	Solar Generation 2007 (GWh)	Solar Generation 2016 (GWh)	Percentage Change
Alabama	-	35	N/A
Alaska	-	-	N/A
Arizona	17	5,408	31,067%
Arkansas	-	37	N/A
California	1,062	27,432	2,583%
Colorado	9	1,020	10,837%
Connecticut	4	347	7,974%
Delaware	3	172	6,070%
District of Columbia	1	54	4,104%
Florida	2	601	28,278%
Georgia	-	1,076	N/A
Hawaii	8	821	9,893%
Idaho	0.1	39	38,535%
Illinois	4	95	2,407%
Indiana	-	285	N/A
Iowa	-	56	N/A
Kansas	-	49	N/A
Kentucky	-	29	N/A
Louisiana	-	194	N/A
Maine	-	29	N/A
Maryland	1	913	180,422%
Massachusetts	6	1,949	31,061%
Michigan	0	60	59,284%
Minnesota	1	57	6,258%
Mississippi	-	5	N/A
Missouri	-	210	N/A
Montana	2	11	518%
Nebraska	-	8	N/A
Nevada	65	2,918	4,505%
New Hampshire	0.1	54	53,356%
New Jersey	73	2,746	3,774%
New Mexico	0.2	976	482,179%
New York	16	1,067	6,548%
North Carolina	1	4,016	440,900%
North Dakota	-	-	N/A
Ohio	1	193	19,070%
Oklahoma	-	11	N/A
Oregon	4	183	4,109%
Pennsylvania	2	383	25,229%
Rhode Island	3	41	1,307%
South Carolina	0.1	35	34,583%
South Dakota	-	2	N/A
Tennessee	1	151	12,433%
Texas	5	1,108	21,466%
Utah	0.3	1,023	336,933%
Vermont	1	155	19,144%
Virginia	0	71	17,538%
Washington	1	89	17,588%
West Virginia	-	6	N/A
Wisconsin	2	38	2,503%
Wyoming	0.1	3	2,964%
United States	**1,297**	**56,221**	**4,334%**

Table A3. Wind Generation Percentage Change by State[133]

State	Wind generation 2007 (GWh)	Wind generation 2016 (GWh)	Percentage change
Alabama	-	-	N/A
Alaska	1	164	16,213%
Arizona	-	543	N/A
Arkansas	-	-	N/A
California	5,585	13,698	245%
Colorado	1,292	9,425	730%
Connecticut	-	14	N/A
Delaware	-	5	N/A
District of Columbia	-	-	N/A
Florida	-	-	N/A
Georgia	-	-	N/A
Hawaii	238	644	270%
Idaho	172	2,427	1,409%
Illinois	664	10,627	1,599%
Indiana	-	4,903	N/A
Iowa	2,757	20,049	727%
Kansas	1,153	14,113	1,225%
Kentucky	-	-	N/A
Louisiana	-	-	N/A
Maine	99	1,614	1,629%
Maryland	-	527	N/A
Massachusetts	-	237	N/A
Michigan	3	4,693	172,353%
Minnesota	2,639	10,637	403%
Mississippi	-	-	N/A
Missouri	-	1,123	N/A

State	Wind generation 2007 (GWh)	Wind generation 2016 (GWh)	Percentage change
Montana	496	2,130	430%
Nebraska	217	3,793	1,750%
Nevada	-	344	N/A
New Hampshire	-	447	N/A
New Jersey	20	22	109%
New Mexico	1,393	3,614	259%
New York	833	3,946	473%
North Carolina	-	6	N/A
North Dakota	621	8,080	1,302%
Ohio	15	1,255	8,510%
Oklahoma	1,849	19,913	1,077%
Oregon	1,247	7,163	574%
Pennsylvania	470	3,472	739%
Rhode Island	-	33	N/A
South Carolina	-	-	N/A
South Dakota	150	3,145	2,096%
Tennessee	50	38	76%
Texas	9,006	57,551	639%
Utah	-	827	N/A
Vermont	11	293	2,792%
Virginia	-	-	N/A
Washington	2,438	8,042	330%
West Virginia	168	1,432	855%
Wisconsin	109	1,521	1,391%
Wyoming	755	4,363	578%
United States	**34,450**	**226,872**	**659%**

Table A4. Wind and Solar Generation as Percentage of State Electricity Consumption by State[134]

State	Total Wind and Solar Generation 2016 (GWh)	Wind and Solar Generation as Percentage of State Electricity Consumption	Rank (Percentage of Consumption)
Alabama	35	0%	50
Alaska	164	3%	33
Arizona	5,951	8%	23
Arkansas	37	0%	48
California	41,130	16%	10
Colorado	10,445	19%	7
Connecticut	361	1%	39
Delaware	172	2%	38
District of Columbia	54	0%	44
Florida	601	0%	45
Georgia	1,076	1%	43
Hawaii	1,465	16%	12
Idaho	2,466	11%	17
Illinois	10,722	8%	21
Indiana	5,188	5%	25
Iowa	20,105	42%	2
Kansas	14,162	17%	9
Kentucky	29	0%	51
Louisiana	194	0%	46
Maine	1,643	14%	15
Maryland	1,440	2%	35
Massachusetts	2,186	4%	29
Michigan	4,753	5%	27
Minnesota	10,694	17%	8
Mississippi	5	0%	52
Missouri	1,333	2%	37
Montana	2,141	15%	13
Nebraska	3,801	13%	16
Nevada	3,262	9%	19
New Hampshire	501	5%	26
New Jersey	2,768	4%	30
New Mexico	4,590	20%	6
New York	5,013	3%	31
North Carolina	4,022	3%	32
North Dakota	8,080	45%	1
Ohio	1,448	1%	42
Oklahoma	19,924	33%	3
Oregon	7,346	16%	11
Pennsylvania	3,855	3%	34
Rhode Island	74	1%	41
South Carolina	35	0%	49
South Dakota	3,147	26%	5
Tennessee	189	0%	47
Texas	58,659	15%	14
United States	283,093	8%	22
Utah	1,850	6%	24
Vermont	448	8%	20
Virginia	1,503	1%	40
Washington	8,131	9%	18
West Virginia	1,438	4%	28
Wisconsin	1,559	2%	36
Wyoming	4,366	26%	4

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