100% Renewable is Doable

How we can repower Massachusetts with clean, renewable energy

ENVIRONMENT MASSACHUSETTS

Clean air. Clean water. Open space.

100% Renewable is Doable

How we can repower Massachusetts with clean, renewable energy

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Environment Massachusetts works for clean air, clean water, clean energy, wildlife and open spaces, and a livable climate. Our members across the state put grassroots support behind our research and advocacy. Environment Massachusetts is part of Environment America, a national network of 29 state environmental groups.

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Executive summary

Our reliance on fossil fuels like oil and gas is polluting our air and water, harming our health, and changing our climate in dangerous ways.

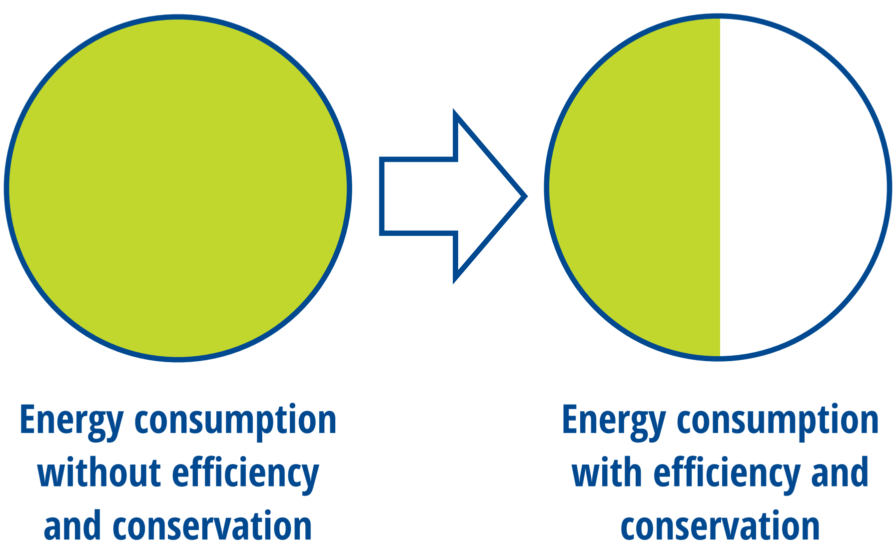
We can envision a future where 100% of the energy we use for electricity, heating, and transportation comes from clean and renewable sources, like solar and wind.

This report describes many of the resources and technologies that will make the transition to 100% renewable energy possible.

Massachusetts can transition to 100% renewable energy economy-wide by pursuing these three strategies:

1. Reducing our use of energy

Energy efficiency and conservation: We can significantly reduce the amount of energy we use by making our buildings and appliances more efficient, transitioning to less energy-intensive manufacturing processes, increasing the efficiency of our vehicles, and shifting trips from single-occupancy cars to transit, walking, and biking.[1]



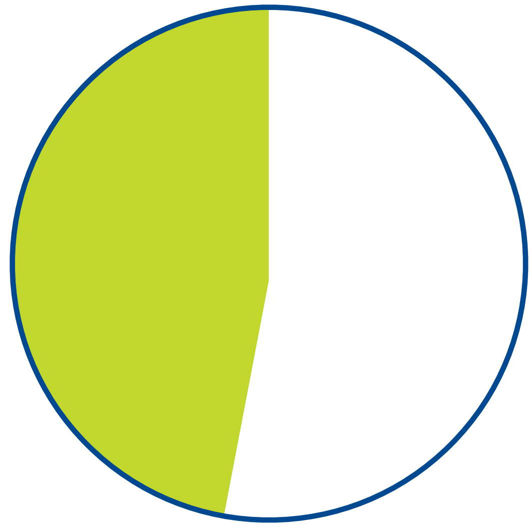
By 2050, we can reduce U.S. energy consumption by about 50% through efficiency and conservation.

2. Increasing renewable electricity generation from sources like the sun and the wind

Solar energy: The amount of solar energy capacity in Massachusetts has increased nearly 170-fold since 2009.[2]

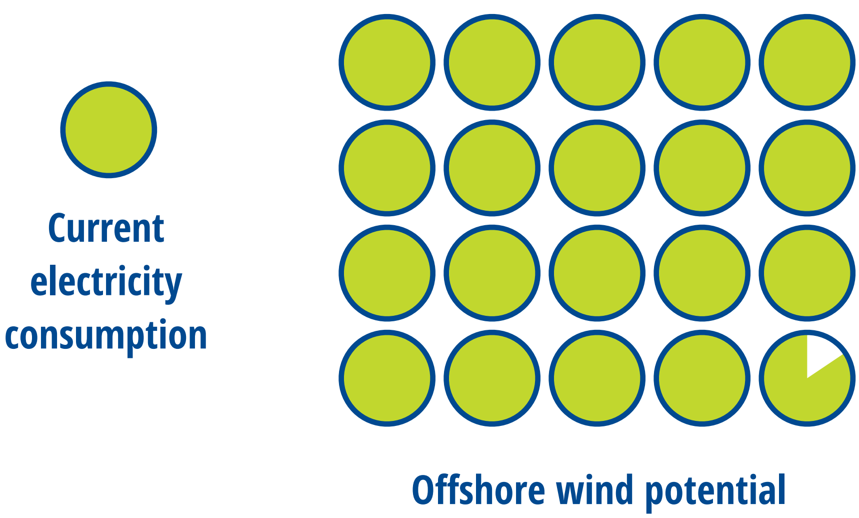
Offshore wind energy: Massachusetts has a greater potential for offshore wind energy than any other state in the country.[3]

Energy storage and demand management: We can ensure a reliable supply of electricity with a 100% renewable electric grid by using battery storage as well as other tools for matching generation and demand.



Rooftop solar panels could generate up to 47% of Massachusetts' electricity.

The cost of lithium ion batteries for energy storage has fallen by 85% since 2010.



Massachusetts could generate 19 times as much electricity from offshore wind as the state uses each year.

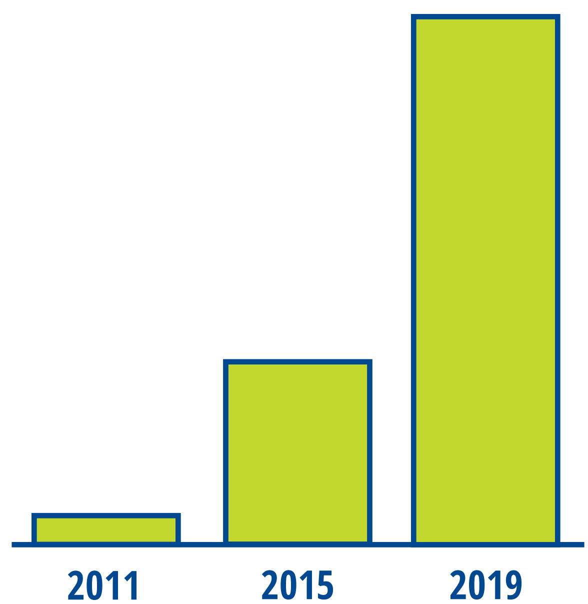
3. Repowering transportation and heating with clean electricity

Electric vehicles: There are more than 40 electric vehicle (EV) models on the market today, and more than 1.4 million EVs have been sold in the United States since 2011.[4]

All-electric buildings: Using heat pumps and other clean technologies instead of fossil fuel heating can be cost-effective in new construction and retrofits of existing buildings.[5]

Buildings with efficient, modern electric heating are being built today at a similar cost to buildings heated with fossil fuels.

Existing office buildings can be retrofitted to be zero energy with a payback period as low as 5–6 years.



Since 2011, annual sales of electric vehicles in the U.S. have increased from less than 20,000 to more than 330,000.

Studies affirm the feasibility of 100% renewable energy

Since 2004, at least 180 studies have examined the design of 100% renewable energy systems for electricity and other sectors.[6]

Studies of 100% renewable electricity scenarios, including hourly simulations of energy demand and production from renewable resources, have been completed for California, the PJM transmission region (serving parts of the Mid-Atlantic, Midwest, and South), and the United States as a whole, as well as many other countries. As two experts concluded after examining the relevant research, "the principal barriers to [100% renewable electricity] are neither technological nor economic, but instead are primarily political, institutional and cultural."[7]

One study found that powering Massachusetts with 100% renewable energy for electricity, heating and cooling, transportation, and industry would reduce health costs by $8.21 billion per year, while saving people an average of $26 on their energy bills.[8]

A recent study from the Center for Environmental Policy at the University of California, Berkeley found that the United States can achieve 90% carbon-free electricity by 2035 at no additional cost to consumers.[9]

States and cities are committing to 100% clean energy

So far, 13 states and territories have passed laws or issued executive orders to establish 100% renewable or 100% carbon-free electricity targets.[10]

In January 2020, Rhode Island Governor Gina Raimondo issued an executive order committing her state to achieve 100% renewable electricity by 2030.[11] In April, Virginia Governor Ralph Northam signed legislation establishing a commitment to 100% carbon-free electricity by 2050.[12]

179 U.S. cities and counties have committed to 100% renewable electricity, with 52 of those jurisdictions already obtaining 100% of their electricity from renewable sources.[13]

Some federal, state, and local officials are also taking a close look at how to transition heating and transportation to 100% renewable energy. Hawaii's county governments have jointly committed to transition all public and private vehicles to 100% renewable energy sources by 2045.[14] The U.S. House of Representatives Select Committee on the Climate Crisis recently released a report that, among other recommendations, called for federal policies to ensure that all light-duty vehicles sold by 2035 are EVs or other zero-emission vehicles.[15]

States and territories with commitments to 100% renewable or 100% carbon-free electricity

Name of state or territory	Law or exec. order	Commitment
California	Law	60% renewable electricity by 2030 100% carbon-free electricity by 2045
Connecticut	Executive Order	100% carbon-free electricity by 2040
District of Columbia	Law	100% renewable electricity by 2032
Hawaii	Law	100% renewable electricity by 2045
Maine	Law	80% renewable electricity by 2030 100% renewable electricity by 2050
New Jersey	Executive Order	50% renewable electricity by 2030 100% carbon-free electricity by 2050
New Mexico	Law	50% renewable electricity by 2030 80% renewable electricity by 2040 100% carbon-free electricity by 2045
New York	Law	70% renewable electricity by 2030 100% carbon-free electricity by 2040
Puerto Rico	Law	40% renewable electricity by 2025 100% renewable electricity by 2050
Rhode Island	Executive Order	100% renewable electricity by 2030
Virginia	Law	30% renewable electricity by 2030 100% carbon-free electricity by 2045/2050
Washington	Law	80% carbon-free electricity by 2030 100% carbon-free electricity by 2045
Wisconsin	Executive Order	100% carbon-free electricity by 2050

The 100% Renewable Energy Act

The 100% Renewable Energy Act (H.2836), filed by Representative Marjorie Decker and Representative Sean Garballey, will transition Massachusetts to 100% renewable electricity by 2035 and 100% renewable energy for heating and transportation by 2045.[16]

A majority of members of both legislative chambers have cosponsored this bill or similar legislation filed in the Senate by Senator Jamie Eldridge (S.1958).[17]

The Decker/Garballey 100% Renewable Energy Act would build on the example of the 100% renewable electric sector commitments adopted by other states, territories, cities, and counties, while going further by transitioning heating and transportation to 100% renewable sources of energy as well.

What is renewable energy?

(Adapted in part from We Have the Power: 100% Renewable Energy for a Clean, Thriving America, *Environment America Research & Policy Center and Frontier Group, Spring 2016.)*

Clean, renewable energy is:

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

Some forms of renewable energy are truly clean, including solar and wind energy. Energy efficiency technologies are nearly always clean. Other forms of renewable energy carry more significant environmental trade-offs, such as hydroelectric and biomass energy.

The term "carbon-free energy" includes the renewable energy technologies listed above, and may also include other technologies like nuclear power or fossil fuel power plants with carbon capture and sequestration.

The Decker/Garballey 100% Renewable Energy Act defines "renewable energy" to include truly clean technologies like wind, solar, and energy efficiency. It excludes nuclear power, fossil fuels, trash incineration, and wood biomass.

Energy efficiency and conservation

Efficiency is working

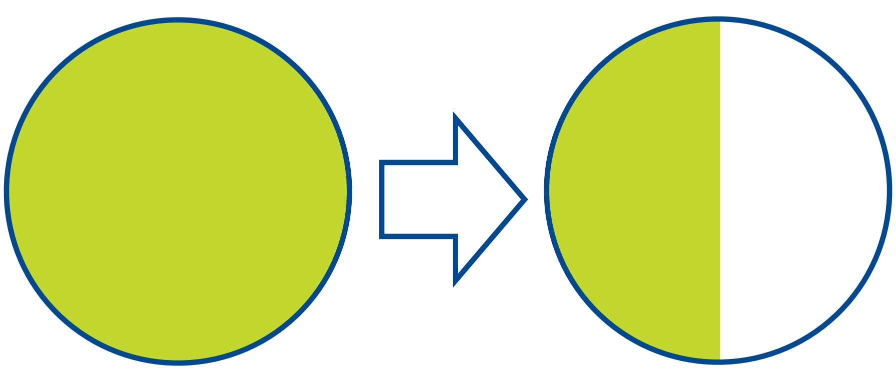
MassSave and other energy efficiency programs have significantly reduced the use of fossil fuels for electricity and heating. By 2020, energy efficiency programs are projected to cut Massachusetts' greenhouse gas emissions by 5.4 million metric tons — accounting for roughly 20% of all expected emissions reductions, more than any other category of policies.[18]

A 2015 report estimated that Massachusetts' energy efficiency investments through 2018 would yield $14.4 billion in benefits, mostly by reducing the need to purchase energy and expand electricity and gas infrastructure.[19]

Massachusetts' energy efficiency potential

In Massachusetts, energy efficiency improvements such as improved insulation and air sealing, smart thermostats, and LED lighting could reduce energy use for single-family homes by 27%, saving residents $1.5 billion per year on their utility bills.[20]

Even adopting a single energy efficiency measure can have a big impact. For example, setting efficiency standards for appliances, lamps, and other products would save Massachusetts ratepayers $282 million per year on their utility bills by 2035, while cutting carbon emissions as much as taking 57,000 cars off the road.[21]



Energy consumption without efficiency and conservation

Energy consumption with efficiency and conservation

By 2050, we can reduce U.S. energy consumption by about 50% through efficiency and conservation.

An analysis from the American Council for an Energy Efficient Economy found that we can reduce energy use across the United States by about 50% by 2050, through measures such as improving on existing programs to make our buildings and appliances more efficient, transitioning to less energy-intensive manufacturing processes, increasing the efficiency of our vehicles, and shifting trips from single-occupancy cars to transit, walking, and biking.[22]

Reducing transportation energy use

More than four-fifths of the trips taken in the United States in 2017 were taken by car.[23] We can reduce the amount of energy we use in our transportation system by making it easier for people to travel on buses and trains, which use less energy per passenger than cars, or to travel by foot or on a bike, which use no fossil fuels.

Doubling the number of miles traveled by walking, biking, or transit in the United States, if matched by an equivalent decrease in vehicle miles traveled, would reduce annual carbon emissions by approximately 32 million metric tons.[24]

Solar energy

Solar has grown rapidly

Between 2009 and 2018, the amount of electricity generated from the sun increased nearly 170-fold in Massachusetts.[25] Today, there are more than 2.5 gigawatts of solar energy capacity installed in Massachusetts, enough to generate 5.6% of our annual electricity consumption.[26]

The U.S. Energy Information Administration expects a record amount of solar capacity to come online across the country in 2020, accounting for nearly a third of all electricity generation capacity added this year.[27]

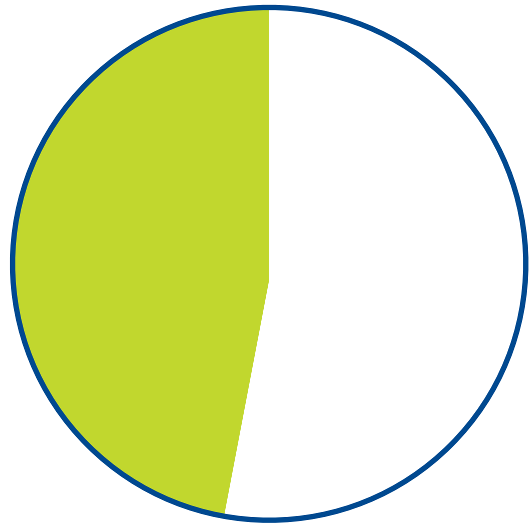
Prices are coming down

The cost of building a utility-scale solar farm in the United States fell by 77% between 2010–2018, while the cost of a typical residential rooftop solar installation decreased by 63%.[28] Globally, the cost of solar is predicted to decline by 71% by 2050.[29]

Massachusetts' solar energy potential

Rooftop solar panels could produce up to 47% of the electricity consumed in Massachusetts each year.[30] The potential to generate electricity from larger, ground-mounted solar installations is even greater.[31]

In order to reduce the region's carbon emissions by 80% by 2050, New England will need to add an average of 2–5 gigawatts of solar per year.[32]



Rooftop solar panels could generate up to 47% of Massachusetts' electricity.

Benefits of distributed solar energy

Solar panels can be installed on rooftops, on canopies over parking lots, on capped landfills, and even on floating structures on the surface of reservoirs. Increasing the amount of solar installed in our communities, close to the places where electricity is consumed, will bring several benefits:

- Improved grid resiliency and reliability.
- A reduction in the amount of energy lost when electricity is transmitted and distributed.
- The opportunity for homeowners and businesses to stabilize and reduce their energy costs.
- Investment in local businesses and jobs.[33]

Offshore wind energy

Massachusetts' offshore wind potential

Massachusetts has a greater potential for offshore wind energy than any other state in the country.[34]

Wind farms off the coast of Massachusetts could generate more than 19 times as much electricity as the state currently consumes each year, or 8.3 times as much electricity as Massachusetts is projected to use once heating and transportation are converted from fossil fuels to electric power — a necessary step to achieve 100% renewable energy economy-wide.[35]

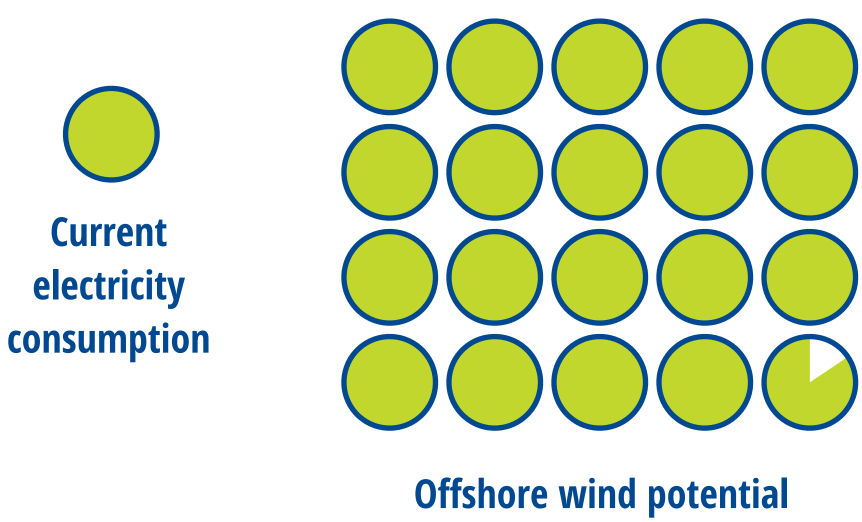
A proven technology

Today, there are more than 22 gigawatts of offshore wind capacity installed in Europe, including 5,000 turbines in 12 countries.[36]

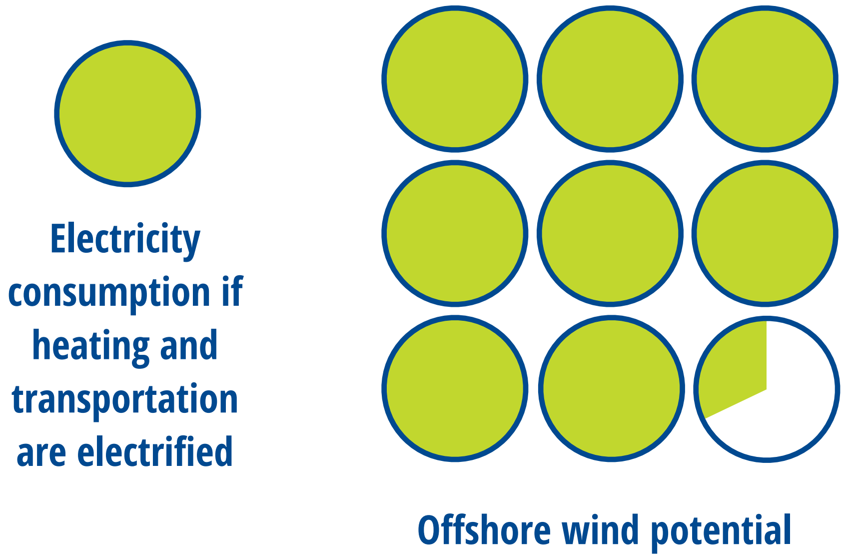
Offshore wind technology has improved dramatically over the last three decades. The first offshore wind turbines, installed in Denmark in 1991, had a capacity of 0.45 megawatts and a capacity factor (the average generation as a percentage of peak capacity over the course of a year) of 22%. The Block Island Wind Farm, the first offshore wind facility in the United States, has 6-megawatt wind turbines and a capacity factor of 47%.[37] Manufacturers are now offering turbines with a capacity of up to 10 megawatts.[38]

Commitments to offshore wind

In 2016 and 2018, the Legislature passed bills allowing for the procurement of up to 3,200 megawatts of offshore wind energy.[39] The first contract was awarded to the 800-megawatt Vineyard Wind project, which will produce enough electricity to meet 6% of Massachusetts' annual demand.[40]



Massachusetts could generate more than 19 times as much electricity from offshore wind as the state uses each year.



Once heating and transportation are converted to electric power, offshore wind could still power Massachusetts 8.3 times over.

Electricity from Vineyard Wind will cost 6.5 cents per kilowatt-hour, lower than many observers had expected.[41] Over 20 years, the Vineyard Wind project is expected to save Massachusetts ratepayers approximately $1.4 billion.[42]

Mayflower Wind was recently chosen to build Massachusetts' second 800-megawatt offshore wind farm, which will provide electricity at a cost even lower than Vineyard Wind.[43]

Offshore wind hub

Massachusetts is positioned to become a center of the offshore wind industry in the United States. The New Bedford Marine Commerce Terminal is the first facility of its kind in North America, designed for the construction and deployment of offshore wind turbines.[44] In Charlestown, the Wind Technology Testing Center conducts testing of wind turbine blades.[45]

The U.S. Department of Energy projects that the offshore wind industry could employ 76,000–80,000 people nationwide by 2030.[46]

Energy storage and demand management

Battery storage is scaling up

Utility-scale battery storage in the United States increased by 18 times between 2009 and 2018.[47]

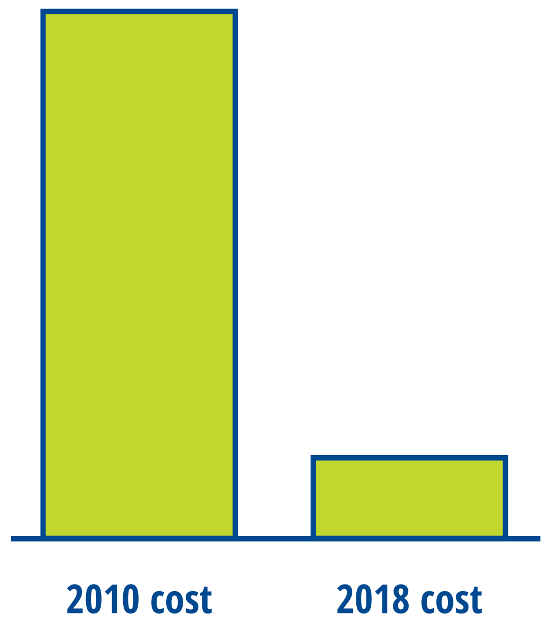
The cost of lithium ion batteries has fallen by 85% since 2010. A report from Bloomberg New Energy Finance predicts that battery costs in 2030 will be half of what they are today, leading to a 122-fold increase in battery storage globally by 2040.[48]

Utility-scale storage has arrived in Massachusetts

The Sterling Municipal Light Department installed Massachusetts' first utility-scale battery storage system in 2016. With projected savings of $400,000 for Sterling ratepayers, the battery system was also designed to provide backup power to the police station and dispatch center for up to 12 days in the event of a prolonged power outage.[49]

Sterling has since added a second battery storage system, and municipal utilities in North Reading and Ashburnham have also installed utility-scale storage.[50]

Investor-owned utilities like National Grid and Eversource are also installing storage. Battery storage systems have been installed or will soon be operating in Provincetown, Oak Bluffs, and Nantucket.[51]



The cost of lithium ion batteries has fallen by 85% since 2010.

Benefits of battery storage

Battery storage will play an important role in matching the supply of variable renewable electricity generation, from sources like wind and solar, with demand for electricity. Additionally, battery storage provides several benefits to Massachusetts residents and the environment:

- **Reduced electricity bills:** Between 2013 and 2015, 40% of annual electricity costs in Massachusetts came from the most expensive 10% of hours, typically when electricity demand is highest. Energy stored in batteries can help meet demand during these peak periods, bringing electricity prices down.[52] Energy storage can also reduce the need to build or replace transmission and distribution infrastructure, the costs of which are ultimately passed along to ratepayers.[53]

- **Reduced pollution:** When demand for electricity is highest, grid operators turn on "peaking plants," which are typically more polluting than other power plants. Energy storage can reduce the need to turn on these dirty plants.[54]

- **Resiliency:** Battery storage, when installed as part of a microgrid that can be disconnected from the rest of the power grid, can help ensure a reliable supply of electricity to critical facilities during power outages.[55]

Other approaches to match energy supply and demand

Utility-scale batteries are not the only way to store energy. Other storage options include behind-the-meter residential and commercial batteries, thermal storage, and compressed air storage, as well as emerging technologies like hydrogen.[56]

Additionally, other strategies can help ensure that electricity generation matches demand:

- Integrating renewable energy generation over a wide geographic area, with sufficient transmission infrastructure to bring electricity from one place to another.
- Using detailed weather forecasting to respond to dips in wind and solar availability.
- Using demand response to reduce the use of electricity when demand exceeds supply.
- Incentivizing electric vehicle owners to charge their vehicles when there is excess electricity generation.
- "Overbuilding" wind and solar plants to ensure that there is enough electricity produced even when they are not generating at their full capacity.[57]

Electric vehicles

Electric cars have become mainstream

While the first modern electric vehicles (EVs) only hit the road in the late 2000s, today there are more than 40 EV models on the market.[58] Since 2011, more than 1.4 million EVs have been sold in the United States.[59]

Lower cost, better performance

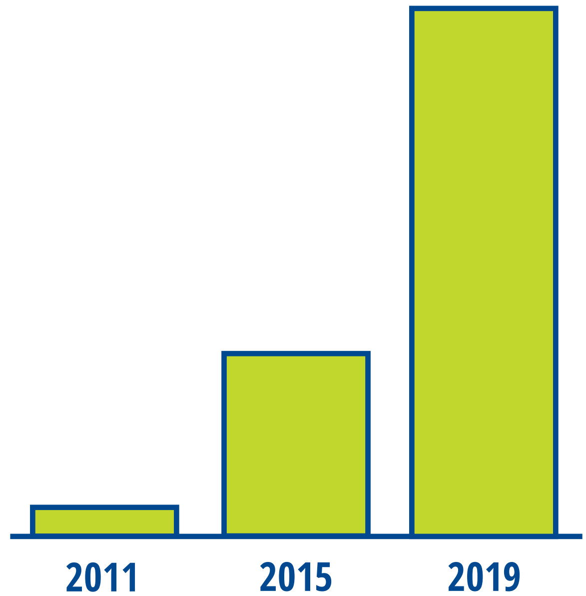
EVs have become more affordable in recent years, in part because the cost of batteries is dropping. In 2016, the cost of producing a lithium-ion battery for an EV was about a quarter of what it was in 2009, while providing six times as much energy for its size.[60]

Thanks to technological improvements, EVs are traveling farther on a charge — up to 300 miles — and reaching full charge in a shorter time.[61]

Cleaner and more efficient

Gas-powered vehicles are inefficient, making use of only 12–30% of the energy in gasoline, while electric vehicles convert over 77% of the energy from the electric grid into motion.[62]

Because they are more efficient, electric vehicles are cleaner than gas vehicles even when the electricity to charge their batteries comes primarily from fossil fuels. In 2018, emissions of greenhouse gases from the operation of an electric vehicle in New England were equivalent to the emissions from a gas-powered car getting 114 miles per gallon.[63] As the percentage of renewable electricity on the grid increases, electric vehicles will become even cleaner.



Since 2011, annual sales of electric vehicles in the U.S. have increased from less than 20,000 to more than 330,000.

Electric buses

By the end of 2018, 528 fully electric, battery-powered buses were in operation across the country. Major transit agencies, including LA Metro and New York's MTA, have committed to transition their entire fleets to zero-emission buses.[64] School districts are also adding electric school buses to their fleets. Pollution from diesel school buses is a significant contributor to lung inflammation and missed days of school.[65]

All-electric buildings

Electric heating technologies have improved

Most Massachusetts homes are heated with gas or oil, but clean heating technologies powered by electricity are an increasingly viable alternative.[66]

Air-source and geothermal heat pumps are several times more efficient than fossil fuel heating. Due to recent advances in technology, air-source heat pumps can operate in temperatures as low as –12 °F, making them a viable option in nearly every part of the United States.[67]

Cost-effective option

Using heat pumps in new construction is more cost-effective than fossil fuel heating, saving residents between $2,000 and $13,700 for space and water heating over 15 years.[68]

Retrofitting an existing building with heat pumps can also be cost-effective, particularly when switching from heating oil or propane.[69]

Buildings with efficient, modern electric heating are being built today in Massachusetts at a similar cost to buildings heated with fossil fuels.

Existing office buildings can be retrofitted to be zero energy with a payback period as low as 5–6 years.

Other technologies, such as solar thermal and district heating powered by renewable energy, can also provide efficient, clean heating and cooling.

Replacing other fossil fuel uses

Technologies to replace other uses of fossil fuels in homes are available. Heat pump water heaters are up to five times as efficient as gas-powered heaters, and generally save customers money over the long term.[70]

Induction stovetops use electricity to cook food, while providing greater temperature control and shorter cooking times than gas ranges.[71]

Health benefits

Moving to all-electric buildings can reduce indoor and outdoor pollution that is harmful to our health.[72]

A study in Southern California found that gas stoves add 21–39% to the level of indoor pollutants like nitrogen dioxide and carbon monoxide.[73]

All-electric buildings are cost-effective

By pairing clean heating technologies with renewable electricity, we can provide power, heating, and cooling for our homes and businesses without the use of fossil fuels. A zero energy building is a highly efficient building where on-site renewable electricity generation, from sources like rooftop solar panels, produces enough energy to power the building on an annual basis.[74]

A study from the Massachusetts Chapter of the U.S. Green Building Council found that zero energy buildings are being built in Massachusetts today at a comparable cost to conventional buildings, and that existing buildings can be retrofitted to be zero energy with a payback period of as little as 5–6 years.[75]

Notes

Notes for figures

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- Page 15, “Existing office buildings…”: see note 75.

Other notes

[1] *Halfway There: Energy Efficiency Can Cut Energy Use and Greenhouse Gas Emissions in Half by 2050*, Steven Nadel and Lowell Ungar, American Council for an Energy Efficient Economy, September 2019, <https://www.aceee.org/sites/default/files/publications/researchreports/u1907.pdf>.

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