Why Go Solar?

An 8 Part Guide to Beginning Your Solar Journey

REVISION ENERGY

ReVision Energy has been helping homes, businesses, and institutions in Maine, New Hampshire, and Massachusetts switch to clean, renewable, solar power for over 10 years. Now, the pace of that transition is accelerating rapidly as product costs have gone down and solar efficiency has gone up. So, "Why go solar?" The goal of this guide is to answer that question for you in thorough, bite-sized chunks. What are we waiting for? The answer to our energy crisis rises every morning, so let's shine some light on the subject!

So, why go solar? Because solar offers a suite of benefits no other technology offers, empowering New England's 100% clean energy transition:

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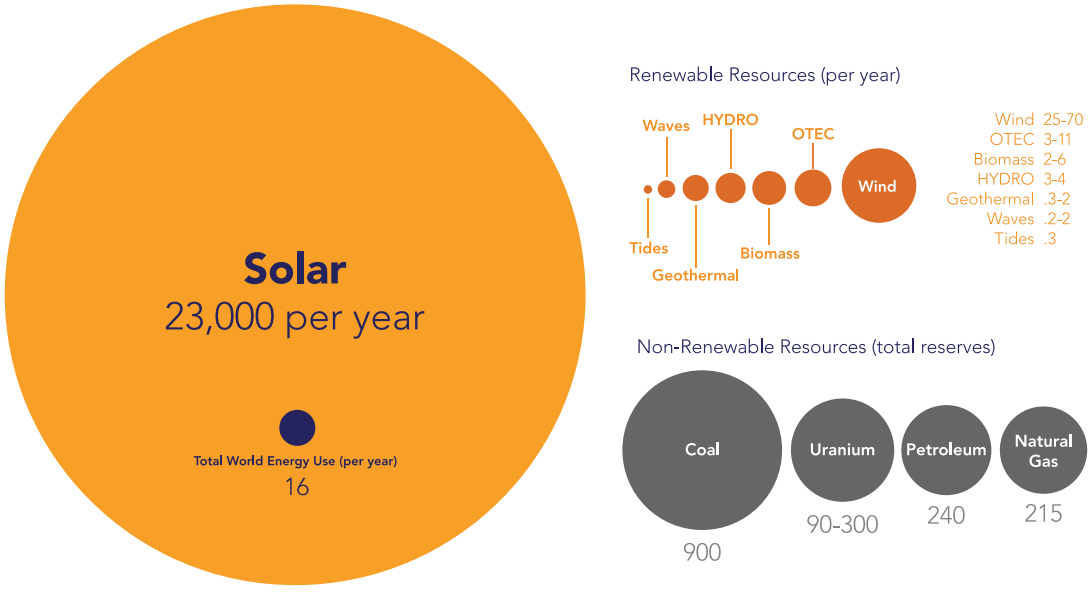
Solar Is An Abundant Resource

So, why solar? Out of all of the available renewable energy options (including wind, biomass, ocean power, etc.) and, for that matter, conventional options (natural gas, oil, coal, nuclear) why is ReVision Energy in the business of solar and why should Northern New England implement solar as the solution to our energy insecurity?

Because *solar is plentiful*. See the chart below:



All energy outputs in terawatts (TW)
Data Source: Perez, R. and M. Perez, *A Fundamental Look At Energy Reserves For The Plane*

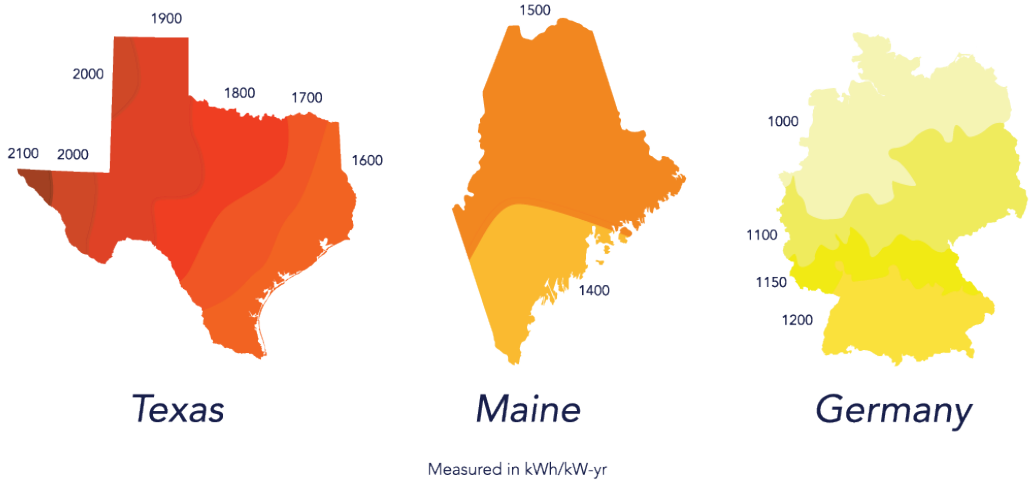
Traditional methods of energy generation through the use of fossil fuels are limited, as the resources—such as coal, uranium, and natural gas—are finite. On the other hand, sustainable energy resources—such as solar, wind, and geothermal are renewable. Of the many sustainable options, the amount of solar energy that the earth receives each year dwarfs all of the other resources. In fact, enough solar energy falls on the earth's surface each minute to meet world energy demand for an entire year (DOE).

OK, so – there is a lot of solar energy that hits the earth. But is there really enough available sunshine in *New England* for solar to offset my energy needs?

The answer is absolutely yes! Here's why...

Maine, New Hampshire, and Massachusetts have very favorable solar energy resources (also called 'solar insolation').

Insolation is the amount of solar energy hitting the earth's surface and is measured in kilowatt-hours per meter-squared per day (kW-hr/m2/day). The National Renewable Energy Lab has assembled worldwide insolation data to learn how much sun falls in a particular location so that one can draw a reasonably accurate conclusion as to the amount of solar energy that can be harvested on an annual basis. So about how much solar energy does New England receive? Take a look at the chart below. The map shows how the available solar insolation in Maine compares to both Texas and Germany:



What we can learn from the chart is that Maine has a similar amount of solar insolation as Texas, a very sunny state and a 30% greater resource than Germany, a world leader in solar energy.

Though Germany's solar resource is on par with Alaska, they have a much higher level of solar adoption than New England thanks to making it a national priority and creating policies that drove market investment in solar energy. Ironically, it is Germany's deep investments in solar that spurred the growth of the modern solar electricity as we know it, and resulted in the reduction of costs that has made solar more cost-effective globally (SEIA). At times during the year, Germany may be running as high as 95% on renewable energy!

It's important to understand that when we're talking about solar energy as a resource, we are talking about annual potential, not monthly potential. Yes, in December, a solar panel in Austin, Texas will beat the pants out of one installed in Maine. But, our summers have longer days and our cooler climate allows the equipment to produce more power than it would the Southwest (more detail in the "Solar Works in Winter" chapter), making up for the lower energy production experienced in winter.

Harnessing Solar Energy in New England

When we started installing solar electric systems in the early 2000s, prices were well north of $9/watt installed. A typical home needs roughly 5,000 watts of installed solar electricity to meet all its needs, so that meant a typical system for the home was $45,000. By Spring 2017, that price had declined to roughly $3/watt in most places where ReVision Energy does business, meaning the same system would be only $15,000!

Over that same period of time, grid electricity rates have gone up across the board, making solar significantly more affordable.

Now that we've established that solar is abundant in New England (Despite what a bleak day in January would lead you to believe) in the next chapter, SOLAR CAN OFFSET FOSSIL FUEL USE, we can talk about the core concepts of electricity generation - how it's measured, how you're billed for it, and how adding solar electricity can change both your electricity bill and even how much fossil fuels you use in other parts of your home.

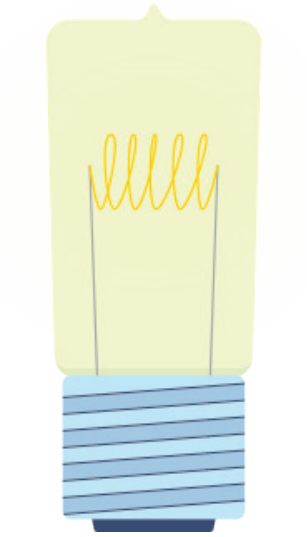
Solar Can Offset Fossil Fuel Use

Before we go too far, to really understand and appreciate solar electricity and how it can offset your fossil fuel use, you first should understand some basic concepts of electricity, and how that electricity is billed to you.

All electrical appliances tell you the number of amps, volts, and watts that they use. Their relationship is simple: Watts = Volts * Amps (W = V *A). Many battery systems run on 12V, so for example, a 12V cell phone charger might be 0.9 amps, or, 12 * 0.9 = 10.8 watts. That's about as much electricity as can be pumped into a smartphone battery at one time.

Most devices in your home consume a *lot* more power than a smartphone, however. Your home (if it's in the US) is wired at 120V Alternating Current (AC) and some appliances (dryers, water pumps) are wired in at 240V. A washing machine may have a peak load of around 12 amps at 240 volts, or, close to 2,880 watts. That's as much current as can charge 160 smartphones!

1,000 watts = 1 kilowatt. However, you are billed for electricity in kilowatt-*hours*, the product of a certain amount of electricity over a period of time. So for instance, that washing machine, pulling 2,880 watts, for 5 minutes, would consume 240 watt-hours (0.24 kilowatt-hours) of electricity. At today's rate (around 15.5 cents) that amount of electricity would cost you about 4 cents.



The accumulation of ALL of the electric loads in your household, times the amount of time that you run them, culminates in your total electric bill from the utility. The energy loads that end up being big hogs can be deceiving. For example, a 100-watt incandescent light bulb, left on 24 hours a day, 365 days a year, will consume 876 kilowatt-hours each year, at a cost of over $130 (now you know why you should switch over to LEDs)!

How Solar Electricity Fits In

Solar panels are the opposite of electric loads, they generate a certain amount of electricity for every minute they are exposed to the sunshine. Solar panels are rated in watts (typically 265 to 320 watts) and collections of them for homes are rated in kilowatts (1,000 watts). For example, 20 solar electric panels rated at 250 watts results in a 5-kilowatt solar electric array (5,000 watts = 5 kilowatts).

An oversimplification is to say that a 5-kilowatt solar electric system will generate 5 kilowatt-hours (kWH) for each hour that they are exposed to sunlight. Realistically, some amount of the solar energy is lost in the wiring process and conversion from the direct current (DC) electricity generated by sunshine into the 120V alternating current (AC) electricity consumed in your home. Also, the sun is rarely constant for a full hour; any clouds or changes in sun intensity will affect the real-time performance of a solar array.

So to predict how much electricity a 5-kilowatt solar array will generate, we take the data on regional solar insolation that we saw in the last chapter and build out a model of expected solar generation. The National Renewable Energy Labs (NREL) has an excellent calculator, PV Watts, which uses 25 years of weather data to assess expected solar insolation for a location.

A full analysis of a solar array's expected production based on climate, adjusted for the angle of the solar array, and orientation (azimuth) towards the sun, and adjusted again for any shading, results in a prediction of a system's output over the course of the year. As a rule of thumb, each 1-kilowatt of installed grid-tied solar, on a good site will generate around 1,250 kWh/year in New England. A typical 5 kw array for a home will generate about 6,250 kWh/year. In the next chapter when we get into talking about the economics of solar, we will also talk about how to convert a solar energy system's potential output into dollars saved on your electric bill, and how that savings justifies investing in the project.

Negawatts

Energy efficiency enthusiasts make the claim that the easiest kilowatt-hour to create is the one you don't have to use, hence, "Negawatts!"

When we start designing a solar electric array for a system, our first step is to figure out exactly how much electricity they are using, and how much solar resource is available at their location. A homeowner with a very tight roof, who can only fit 16 panels, for instance, has a different set of decisions to make than a homeowner who has a vast south-facing barn where they could potentially install much more solar electric generation than they actually need.

Most of our customers see solar as part of a road towards energy independence, and taking reasonable aims to reduce energy consumption in tandem with a solar installation is a highly recommended strategy. It can work out to be much more expensive to produce electricity that is used relatively inefficiently – for example, powering old refrigerators and water heaters. Generally, it is cost-effective to make some (not all) energy efficiency upgrades as a path towards meeting all of your needs with solar electricity.

Using Solar Electricity to Offset Fossil Fuel Use

There are, however, "good" reasons to increase your electric bill! With heat pumps, electric cars, and electric water heating solutions available, a home can essentially eliminate oil, propane, or natural gas completely and be fully electric powered. Many of our customers add enough solar electricity to meet all of their needs initially, then upgrade the system over time to supply power for an air-source heat pump, an electric water heater, or an electric car. Solar energy can also heat your water directly with solar hot water panels.

As you can see, there are quite a few options that exist in the world of renewable, solar power. The next section, SOLAR IS AN ECONOMIC OPPORTUNITY, takes a look at the economic benefits of solar electricity and the paths that we offer to owning solar power.

Solar Is An Economic Opportunity

While it's well known that solar is clean and helps the environment, what has opened up solar to vastly more people — and lead it to become the fastest growing new electricity source in the United States is that **solar is now the least expensive source of electricity on the planet.**

Wait, what? Let's repeat it, to be clear: *Solar is the least expensive source of electricity on the planet.*

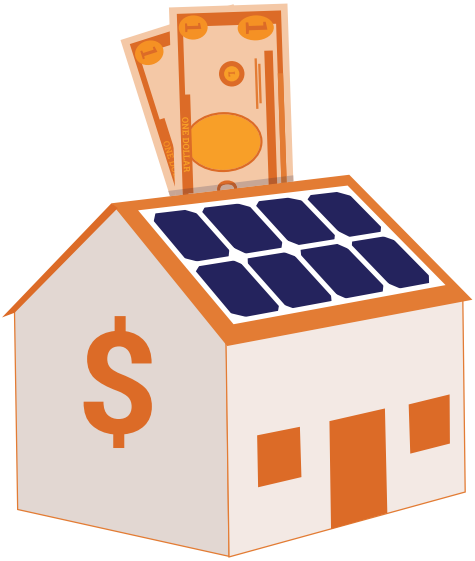
What that means is that solar electricity is an impressive economic opportunity. Not only is solar electric equipment incredibly inexpensive, but it is extremely *reliable.* By making the upfront investment to go solar, you gain a system that produces electricity (worth money!) for decades, with little to no maintenance required.

Solar is a Solid Investment

People are surprised to learn that in Maine, New Hampshire, or Massachusetts, the economics of solar energy outperform traditional investment products.

Sound crazy? It's true!

Compare solar to an annuity, for instance. An annuity works by offering you a monthly payment for a fixed period of time-based on a pre-determined interest rate, around 2% right now. A solar electric system also requires an up-front investment, and offers a monthly "payment," so to speak, in the form of reduced utility bills for the life of the system.



Start "paying" yourself for electricity!

However, the solar electric investment is pegged to a commodity – electricity – which increases in the order of 2.5-3% each year.

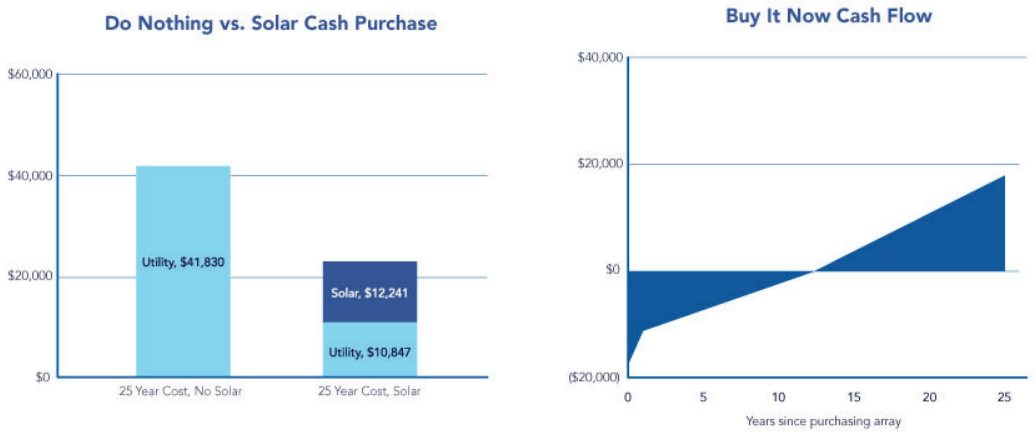
Consider a $15,000 investment:

Option A: With a 2%, 20-year, fixed rate annuity, you could expect a $67 dividend each month.

Option B: With a 5 kilowatt solar electric array, you would receive $4,500 back in the first tax year as part of the 30% federal tax credit, plus other state incentives or SREC revenue if applicable, and a 'dividend' of around $85 per month, in the value TODAY it provides against your current electric bill. The solar will earn you roughly $4,080 *more* than the dividend, even if the price in electricity does not change!

Solar Cash Purchase: Reliable Savings Over Time

Every solar project we design includes graphs like the following, which compare (Left) the cost of doing nothing versus investing in a solar array, and (Right) the relative cash flow of an upfront cash purchase versus the ROI in terms of energy savings over time.

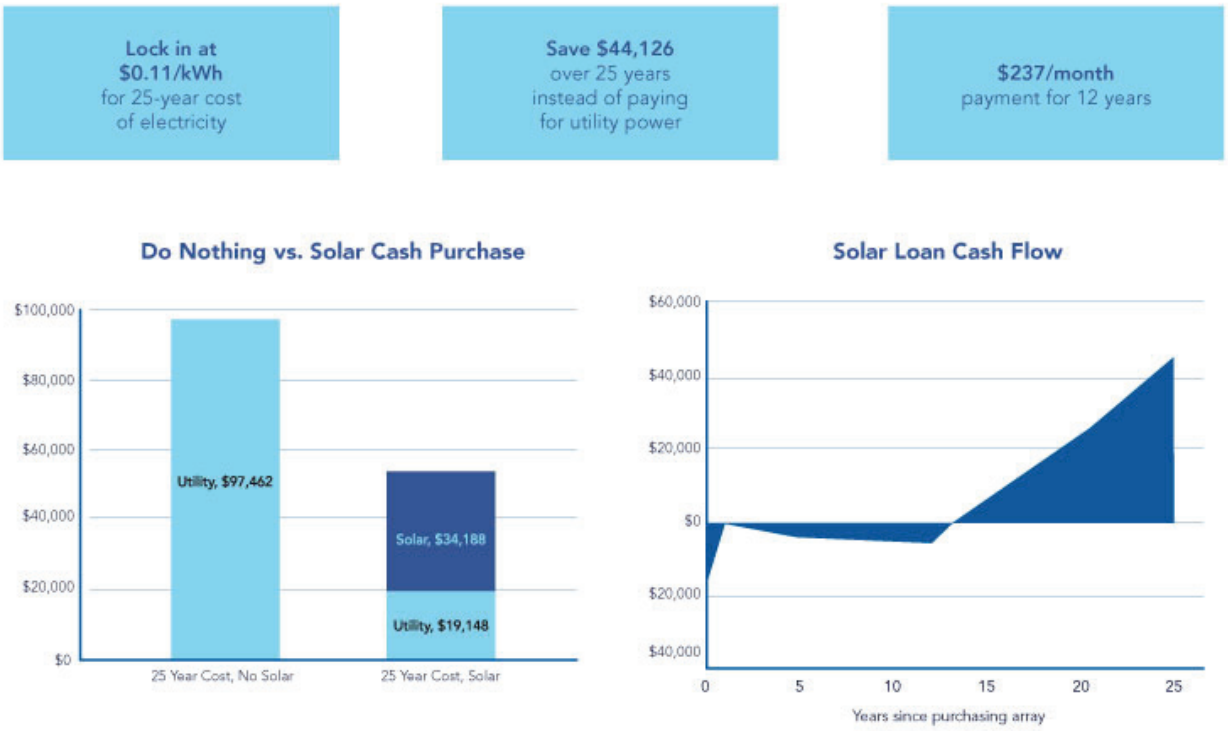


The exact Internal Rate of Return (or IRR) of a solar investment will vary based on a number of conditions, including a site's solar access, the local rate for electricity, and available state incentives. However, most solar investors see a 25-year IRR of 8-12%, vastly superior to any other risk-free investment. See our profile of a customer who 'did the math' for his Falmouth, ME installation to see this modeling backed up with real data.

For businesses and institutions, the math is a little different, as the incentive structures are a bit different, and larger electricity consumers are usually billed on demand profiles rather than a fixed rate for kilowatt-hour consumption. However, the business case is quite solid and especially with financing solar is an excellent choice for businesses who are keen to reduce their long-term operating expenditures.

Solar Loans: An Affordable Way to Get Fixed-Price Power

Buying solar using a loan product makes for a slightly different decision-making process. For those who are choosing to finance, usually it is a way to go solar earlier than would be possible if an upfront cash purchase was required. One of the biggest reasons to choose to finance a solar array (beyond simply wanting to have solar on your roof) is to enjoy the peace-of-mind and security of a fixed payment for electricity that will not fluctuate with local electricity prices.



Simulated economics of a solar project financed by a loan. There is a small premium (vs current electric bill) paid in the 1st 12 years, but once the loan is paid off there is quick payback and overall vast savings. Compare this to a solar lease where you would continue paying for the system for a full 20 years.

Exact economics vary (and are displayed in great detail in one of our solar system proposals), but with our Own Your Power solar loan product, we can offer a fixed rate of 2.99% over 12 years. After the system is paid off, the solar owner enjoys 100% of the benefits for the remaining 20+ year life of the system. Compare this to a solar lease, where for the same array you would continue paying for 8 more years!

Massachusetts homeowners are also able to take advantage of a loan product sponsored by the Mass CEC, the Mass Solar Loan Program.

Solar Increases Property Value

As solar has become mainstream, a number of recent studies have sought to help homeowners, appraisers, and real estate professionals through the process of assessing the appropriate value for a solar energy system on a home in the event of a sale.

A solar photovoltaic installation, such as this one for a customer in Maine, will raise the value of the home roughly $20,000 (based on a 4-5 kW solar electric system)

Their findings:

- The Berkeley National Laboratory ("Exploring California PV Home Premiums") found that "each 1-kW increase in size equates to a $5,911 higher Premium"
- The National Bureau of Economic Research ("Understanding the Solar Home Price Premium: Electricity Generation and 'Green' Social Status") found that PV systems "add 3.6% to the sales price of a home … [which] corresponds to a predicted $22,554 increase in price for the average sale with solar panels installed"
- The Colorado Energy Office ("The Impact of Photovoltaic Systems on Market Value and Marketability") found that "owned PV systems typically increase market value and almost always decrease marketing time." Leased PV systems caused problems with the sales transaction in a number of cases

We appreciate that market research proves what to us seems obvious: solar is an excellent investment, whether you are staying in the home long-term or need to sell. Solar provides a powerful suite of benefits not seen in any other home improvement:

1. Proven ROI in the form of reduced energy costs for the life of the home
2. Environmental ROI in the form of reduced carbon emissions
3. Long-lived and durable equipment increases in value over time as costs of traditional energy rise

Standing Out in a Crowd

While the actual dollar value of PV improvements is still an area of study, what is more easily observed is how solar helps sell homes more quickly. In addition to findings in the Colorado report (with realtors reporting feedback like "PV was a major marketing factor," "Sold very fast," and "Listing agent liked the system so much, he had it installed in his own personal home after this sale").

A 2008 Ryness study found that "homes with solar systems were outselling others by as much as 2:1 in 13 California communities" (Businessweek).

In the Northeast, there is little data, but anecdotally several of our customers have said that they are very happy in their solar homes, but feel confident that their solar investment will be recouped should they need to sell it.

Chris Rhoda of Belgrade told us that "My wife and I were talking about what might happen in 20 years when we're empty nesters and want to downsize—but we can't imagine finding a home that's more efficient than ours already is. The realtors we have talked to have told us they would love to sell a 'green home.' They have very few green homes to sell yet people are asking for them all the time."

More Data Needed

One of the tricky parts with the current solar valuation of solar is the lack of data for appraisers to use when comparing like homes. To help with this, the Sandia National Laboratories has developed a new tool, PV Value, which uses the income capitalization approach when assigning a value to PV systems. This approach factors in the anticipated production of the PV system, along with estimated maintenance costs, to determine a fair market value of the energy savings. This approach is discussed in detail in their paper, "Standardizing Appraisals for PV Installations."

This approach, properly called the "Income Approach using a Discount Cash Flow," more fairly assesses solar compared to the cost approach (looking at costs to have the equipment replaced) or comparable sales (looking at similar homes that have sold, which are often scarce with solar improvements). Sandia Labs reports that there have been over 2,500 downloads of their tool and early feedback from appraisers is very positive.

The next section, SOLAR WORKS ON THE ROOF, GROUND, OR FAR AFIELD, examines the many solar options that exist to see what may be perfect for your home or business.

Solar Works On the Roof, Ground, or Far Afield

The 75% decline in the cost of solar electric panels over the past 10 years has turned solar into a practical investment that is accelerating New England's transition to clean energy. Whether purchased upfront or financed, whether you own your home or rent, whether it's installed on the roof, on the ground, or across the state, solar technology can help your household, business, or institution save money and the environment.

This section of the guide covers many of the solar options available today. The great news is that there is viable a way to go solar for everyone!

Rooftop Solar Basics

Rooftop solar installations are ReVision Energy's most common installation and the form of solar people are most familiar with. But even so, there have been some advancements in the way we approach rooftop solar as equipment prices decline and electrical/fire codes become more rigorous.

Any roof facing between southeast and southwest makes a great solar roof. If you want to get scientific, use a compass or compass smartphone app to see which direction your roof faces. The perfect solar orientation in New England is 195 degrees (15 degrees west of due magnetic south on a compass, also known as 'true south') but any orientation between 150 and 240 degrees is within 10% of perfect.

With that said, as equipment costs have dropped, our tolerance for off-axis systems has increased somewhat. For example, a solar array that is positioned due west may (depending on the roof slope) harvest within 20% of its ideal annual production.

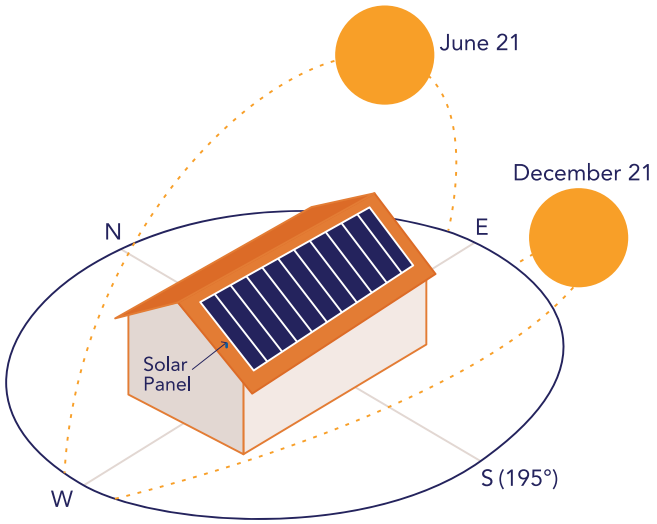
Since much of a solar project's total project cost is fixed overhead (electrical connections, inverter, permitting, getting a crew on-site, etc.) it may be possible to simply add extra solar panels to make up for the production loss on a strongly east or west facing roof and still see a very strong ROI for your solar project.

The actual solar panels have become 'cheap' – relatively speaking – so there is a certain cost curve where adding additional solar panels does not significantly impact the fixed costs of the project but allows you to generate more power (and, accordingly, more savings) for a modest increase in the project budget.

What about the slope of the roof? Most common roof pitches, e.g. 4/12 to 12/12 are just fine for solar and do not significantly impact the overall yearly solar harvest. More extreme angles (mounting on a flat roof or an awning mount) require special hardware but are also good options in many cases.

Want to understand how this all fits together? See the graphic below, which compares the relative height of the sun in the skyline, to its orientation, at various times during the year.

Shading (Solar Access)



Ideally, we like to see a shade-free solar 'window' between 9am-3pm, year-round. When evaluating your site, a solar professional will use a tool such as a SunEye or Solar Pathfinder. These tools take a fish-eye photo of the open sky and then super-impose the sun's arc (adjusted for longitude) onto the open sky photo. The results can be interpreted by software to develop a percentage figure of available solar access at a site; generally greater than 80% is required but we prefer to see access that is 90% or more.

Any significant shading during the 'peak' hours of the day will affect solar production and reduce the system's ROI. That said, because ReVision Energy employs module level optimizers on most of our residential projects, solar systems are more tolerant of partial shading than ever before. We use the industry's best site survey tools when conducting solar evaluations so we can generate an accurate analysis of potential shade issues and advise potential customers accordingly.

Ground-Mounted Solar Arrays (and solar trackers)

For all those situations where a roof-mounted system is not viable or wanted, another option is simply to install solar panels on the ground.

Solar homeowners Lauren and Nate Zike in front of their 5.83 kW solar electric array. Their solar array will meet close to 100% of their energy needs, allowing them to control their energy costs, all while helping to reduce strain on the local energy grid and reducing pollution from fossil fuel sources.

Due to the need to survive decades of punishment from harsh winters, ground-mounted solar arrays must be built particularly tough in the Northeast. The footings and wire management system must be able to handle hundreds of freeze/thaws, and the panels must be able to withstand uplift from the wind, multiple feet of snow, and pummeling from rain and hail.

Historically, that has meant that ground-mounted systems in the northeast involve heavy excavation to pour large concrete footers to support the solar array. The concrete work is not only CO_2 intensive and disruptive to the site, it is costly as well. As a result, ground-mounted solutions have historically commanded a significant premium over roof-mounted projects of a similar size.

Our engineering team, not to be deterred by the challenge of marrying absolutely perfect product performance with a need to reduce costs and gain efficiency, has evaluated hundreds of racking and foundation solutions over the years. In 2016, we made an investment that significantly improves our ability to install ground-mounted arrays: a Pauselli 900 solar pile driver, which allows us to install pile-driven posts or ground screws for solar arrays without the need for any concrete.

What used to take hours can now be done in a matter of minutes, and with far less disruption to the site!

With the new equipment in play, our premium for installing a ground-mounted solar array has dropped by over 30%, to the point where in some instances the ground mount solution will be comparable or cost-competitive with roof mounted installations.

Some advantages of ground-mounted arrays compared to roof mounts are:

- System can be oriented at perfect angle and shade-free area, no need to accept however the home was built
- Array can be located in less conspicuous area than on the roof
- Array not hindered with on-roof obstructions like dormers, skylights, and plumbing vents
- No rooftop work required, so certain parts of the installation go much more quickly

A member of our newly-formed Solar Foundations Division driving a groundscrew into place with our Pauselli 900 pile driver.

We also are still fans of and installers of AllSun Solar Trackers, a dual-axis, GPS-driven tracking system that allows a solar array to harvest roughly 40% more electricity in a given location than a traditional, fixed-axis system.

Community Solar / Solar Gardens

ReVision Energy's approach to Community Solar Farms, or CSFs, is a member-ownership model that follows the concept of community supported agriculture (CSAs). Rather than building the solar array on site at their own home (growing a garden), a CSF shareholder invests in a solar project somewhere offsite (at the solar 'Farm'). A certain minimum number of people are needed to make the farm possible—in Maine, there is a current arbitrary cap of 10 participants—and when the project is built, each shareholder gets the benefit of an amount of solar production relative to their percentage of ownership in the Farm.

Billing-wise, a CSF share works identically to having solar production at your home. 100% of the solar electricity generated by the solar farm is sent back to the grid. Each shareholder gets a credit—based on their percentage share—that is automatically applied to their utility account, which can accumulate for up to a year and be used for any electric load, whether that be heating water, heating the home, or powering an electric car. The CSF share is utility-specific. Should you move within your region and stay with the same electric utility, your CSF share simply transfers with you. Should you need to move out of the region, your CSF share can be transferred to a new owner. ReVision Energy maintains a long wait list of people eager to buy out existing CSF shares and can help set up the transaction.

Practical Considerations

In addition to the hard and fast physics, it's impossible to close a section on the many options of solar electric system design without talking about the 'real world.' In the real world, homeowners and businesses face choices about where to purchase their energy and what kind of solar array makes sense. So when we discuss solar with a prospective customer, we need to know a lot about them in order to design a system. For example:

- Is a rooftop array feasible? If so, how much roof space is there? If not, is a ground mount feasible?
- Beyond pure production economics, what other factors are important? Aesthetics? Carbon reduction?
- What is the rate currently paid for electricity? How much electricity is used per month?
- Has this building had efficiency improvements? Is there room to decrease their need for energy inputs?
- How many people live in the home? How much hot water do they use? How is that hot water heated?

In addition to offsetting household electric bills, we look to every opportunity to leverage affordable solar to reduce dependence on oil or gas by converting water heating and space heating equipment to solar, as we'll discuss in the next section, SOLAR CAN HEAT AND COOL YOUR HOME.

Solar Can Heat and Cool Your Home

Since the early 2000s, our clients have asked us how to use solar to heat their homes. For years, that solution involved literally trapping the sun's heat using solar thermal collectors and transferring it to water, which could then circulate using a radiant loop. No more!

Today, efficient air source heat pumps are the system of choice for both new construction and existing homes to heat and cool, with or without solar.

An air source heat pump uses the same technology as a geothermal heat pump, but since it uses ambient air as its source (hence 'air source') it is a much simpler project, and as a result, a smaller upfront investment. Heat pumps used to mainly be seen in the Mid-Atlantic or Southern States, but thanks to dramatic improvements in their low-temperature performance, they are being rapidly adopted in the Northeast. The latest generation of heat pumps can provide heating to temps as low as -17° Fahrenheit.

The vast majority of the systems we install are ductless, consisting of an outside compressor/evaporator and an inside air handler. The units are connected using copper refrigerant line and we triple evacuate the lines with a deep vacuum and dry nitrogen purge, before charging them with an advanced refrigerant for the most efficient and reliable installation.

Based on current electricity prices, it costs the equivalent of around $1.5/gallon of oil to heat with a heat pump, and using solar, as little as $1/gallon! In cooling mode, a modern heat pump is roughly 1/2 the operating cost of a window unit air conditioner.

Fuel Source	Cost Per Unit	Cost Per Million BTUs	Cost to Heat Typical Home
Resistive Electric Powered by Grid	$0.14 / kWh	$44	$4,489
Heating Oil (2010 prices)	$3.70 / gallon	$41	$3,938
Heating Oil (2016 prices)	$2.70 / gallon	$30	$2,790
Propane	$2.50 / gallon	$35	$3,404
Natural Gas	$2.00 / therm	$26	$2,587
Resistive Electric Powered by Solar	$0.09 / kWh	$26	$2,418
Heat Pump Powered by Grid	$0.14 / kWh	$18	$1,706
Heat Pump Powered by Solar	$0.09 / kWh	$11	$1,023

Based on fuel data and pricing from: Maine Energy Office. Assumes typical oil boiler operating at 65% efficiency, propane and natural gas at 85% efficiency, resistive electric at 95% efficiency and heat pump at 250% efficiency (COP of 2.5). Solar PV kilowatt-hour cost of 9 cents per kilowatt-hour over 25-year time frame based on typical pricing economics of a 4kw + system. Economics are roughly the same in New Hampshire or Massachusetts, subject to the local cost of oil, propane, and electricity.

Learn more about heat pumps on our dedicated page: Solar-Powered Heat Pumps

Water Heating with Solar

Water heating may not be the 'sexiest' application of solar technology, but it is one of the most cost-effective and powerful. For a home heating domestic hot water with an oil-fired boiler, you can save more than 300 gallons of oil per year for an average family of four by switching to solar hot water!

Like with air source heat pumps, the preferred way to get solar hot water in 2017 is to install a solar electric system, and then generate electricity which can be used to power an electric water heater. However, instead of any big-box store water heater, we strongly recommend a well-made Heat Pump Water Heater (HPWH) which offers an incredible combination of efficiency and convenience.

Some facts about Heat Pump Water Heaters

- Instead of *making* heat, they simply move it from one place to another, making them much more efficient than conventional electric water heaters, or other ways to make hot water.
- While they make heat, they also help dehumidify the room they are in.
- Highly insulated, meaning the energy you do use for hot water is not wasted in 'standby losses' as the tank sits idle.
- Available in large tank sizes, which means that you can easily meet the needs of a 4+ person household with a heat pump water heater.
- Many states have cash rebates for installing them.
- One of the only water heating systems that can be solar powered!

Solar + Heat = Economic Powerhouse

We spoke earlier about the great economic opportunity of going solar. Well, when you combine the good economics of solar electricity, with added benefits by reducing fossil fuel use, the effect is even more powerful! Combine solar electricity with efficient electric heating and cooling equipment, to be both more comfortable in your home, and more comfortable with your wallet.

The next chapter, SOLAR POWER CAN BE STORED FOR LATER USE, goes over the advances in energy storage technologies and pricing that have made battery storage a viable option for backing up your home in case the grid goes down.

Solar Power Can Be Stored For Later Use

Like we mentioned in the previous chapter, a lot of progress has been made in the technologies that are involved in solar electric power production. The area of batteries is no different. Just a few years ago, the cost and challenge to integrate battery systems with a solar electric array meant that unless there was a specific use case—remote location, critical 24/7 electric loads—we would often advise a customer against adding battery storage. Simply put, a grid-tied solar array (dependent on the grid with no on-site battery backup) was simpler, more reliable, and a better overall investment.

Chip Means from Pika Energy (left) and Gifford Jenkins-Davis of ReVision Energy (right) in front of a battery-ready solar home in Durham, Maine, powered by Maine-made Pika Energy electronics installed by ReVision Energy.

But, technology changes quickly! Elon Musk's 2015 announcement of the Tesla Powerwall—and more recently, the Powerwall 2—has invigorated consumer demand in solar + storage products. Currently there is a technology 'arms' race going on, as many vendors compete to develop the energy storage solutions of the future.

As of 2016, every solar electric system we are designing and installing is 'forward compatible' with storage, whether or not a battery pack is installed at the time of the solar installation. Not only can batteries keep the lights on when the sun or grid is down, but they can also support the utility grid by filling intermittent gaps in renewable energy production when clouds pass over or the wind subsides.

This article features a general overview; for the full story, don't miss our three part feature published in 2015:

- Part 1 – Is Tesla's PowerWall the iPhone of Battery Storage?
- Part 2 – Solar + Batteries: The Right Thing to Power my Home?
- Part 3 – Solar + Batteries: Technologies on the Bleeding Edge

Batteries and Solar Energy Systems: A Short History

Before the popularization of the grid-tied inverter in the late 1990s, ALL solar energy systems were independent of the grid; this is what it means to be 'off the grid' – literally not connected to the utility grid. In this era, if you wanted to have power after the sun had set, you had to have a battery of some kind to store the energy, usually a big bank of 'golf cart type' lead acid batteries.

Fast forward twenty years and, at least in the US, the vast majority of solar energy systems no longer use batteries at all; instead taking advantage of the utility grid and net metering to export excess electricity when the solar production exceeds the load, and to import electricity back from the grid when the loads exceed production.

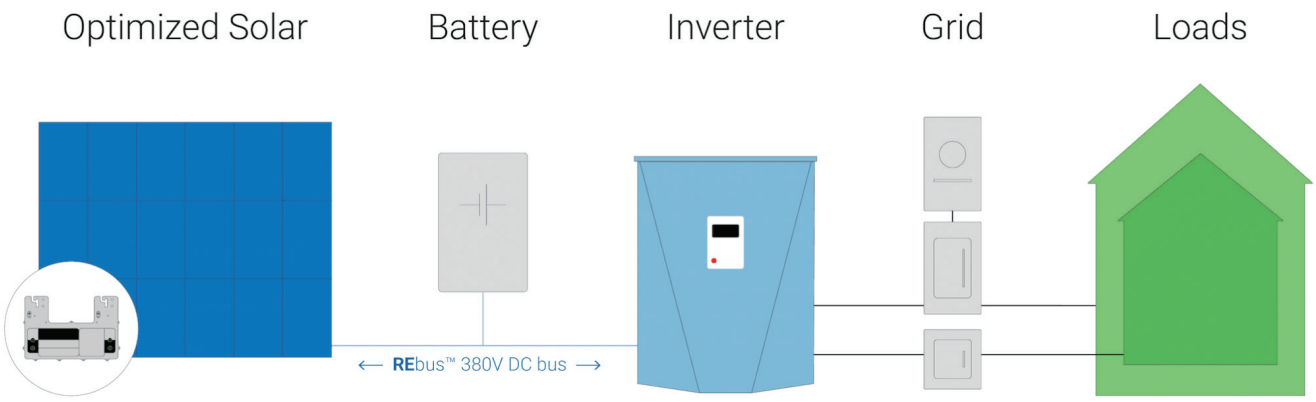
Grid-tied solar electric systems work great and are a real win-win for both the solar customer and society at large. The solar customer benefits by having the advantage of using the grid as storage. Society benefits because solar customers typically export excess electricity to the grid at periods of high wholesale prices and peak demand, and import power at periods of low wholesale prices and low grid demand. This is a market benefit above and beyond the obvious environmental benefits of solar (documented in studies such as Maine's own Value of Solar).

Grid-tied solar energy's rapid growth has been fueled by staggering drops in equipment cost, roughly 75% over the past 10 years. And though batteries have not experienced the same meteoric progress in performance and cost, many industry observers think it is only a matter of time. Investment in battery R&D is growing worldwide, thanks largely to surging popularity of hybrid and plug in electric vehicles, and the distributed solar industry is well poised to benefit from those investments and economies of scale created by that market.

How Batteries + Solar Work

Whether it's the Tesla PowerWall, cell phone, cordless drill power-pack or golf cart battery, the basic concept is the same: a charged battery stores electrical energy in chemical form for someone to use later.

In most renewable energy applications, a special class of battery, deep cycle batteries, are required, as the constant discharge and recharge of the battery requires more durable construction (in contrast to your car's battery, which is used for a short burst of energy before it is quickly re-charged by your alternator).



Schematic of the Pika Energy Island system. Getting technical, there are 'DC coupled' systems where the electronics talk to the solar using Direct Current (DC) power, vs other options in which conversion between DC — AC — AC — DC is required.

In addition to being able to survive the wear and tear of frequent use and deep cycles, a renewable energy battery will also have a number of other important performance characteristics that determines how well it works in a particular application. Among those are:

- Energy Capacity: Maximum electric usable energy (kWh) stored in a battery.
- Maximum Discharge and Charge Rates: The peak power—usually given as maximum current—the battery can either provide or accept without damage.
- Depth of Discharge: What % of the battery's capacity may be used before it needs to be recharged.
- Cycle Life: How many recharge cycles a battery can undergo before it reaches end of life.
- Calendar Life: How long, in time, a battery can be expected to last before it reaches end of life.
- Energy Density: How much energy is stored per unit of volume.
- Specific Energy: How much energy stored per unit of mass. Energy density and specific energy are related, but distinct. For example, a battery with the same energy capacity may be large and heavy (low energy density and low specific energy), large and light (low energy density but high specific energy), small and heavy (high energy density and low specific energy), or small and light (high energy density and high specific energy).
- Temperature Limitations: The acceptable operating temperature range of a battery. Some battery chemistries may not operate below freezing temperatures, or at very high temperatures, for example. Others generate significant heat either while charging or discharging and thus may need an active thermal management system to keep them from overheating.
- Self Discharge Rates: The rate at which a battery loses charge while not producing energy.

There is no one single battery which optimizes all these characteristics, and in fact even within a particular battery chemistry (Lithium Ion or Lead Acid, for example), battery designers constantly have to make tradeoffs between different characteristics; for example sacrificing maximum discharge rate to increase overall capacity, or trading off cycle life against calendar life. Or trading any of the above against cost. Clearly there is no such thing as 'the best battery', there is only 'the best battery for a particular application.'

Can I Use a Solar Powered Battery Pack instead of a Generator?

The increased frequency of extreme weather events in New England (which scientists link to the effects of increasing carbon pollution in our atmosphere), together with our increasing reliance on electronics in the home has led many New England homeowners to install fossil fuel powered backup generators to provide assured power in the case of a grid outage.

Many homeowners also are concerned about the threats of cyber attacks or terrorism on grid infrastructure (e.g. 60 Minutes). Hundreds of thousands of generators are sold across the United States each year, the majority of them dirty, inefficient, gas-burning portable backup generators sold at big box stores.

Power outages due to extreme weather events are increasingly common across New England.

For the homeowner seriously considering a propane or gas powered standby generator, the economics and power properties of a solar-powered storage solution can be quite attractive. While a generator can provide power for everything, for a limited period of time, a solar and battery solution can provide power for the essentials, for a near unlimited period of time.

Battery Vs Generator

	Advanced battery energy storage system	Fossil Fuel Generator
Maximum peak power (kW)	4-8 kW	7-10 kW
Energy Storage	6-10 kWhr	Depends on tank size
Duration	Forever, if solar is available	Until the fuel runs out
Backup the whole house	Probably not, unless consumption is very low	Yes
Backup critical loads forever	Yes	No, limited by the fuel tank
Noise	Silent	70-80 dB (As loud as a city street)
Service required	None	Annual service: oil change and filters
Warranty	10 years	0-2 years
Internet-enabled	Yes, included in cost	No
Future smart home ready	Yes	No
Future smart grid ready	Yes	No
Provides protection against solar regulatory changes	Yes[1]	No
Requires weekly 'exercise' to be available	No	Yes
Net Installed Cost	12k[2]	7k
Plus gas install	N/A	$500
Annual service cost (est)	None	$200
Annual fuel cost (est)	None	$300[3]
Expected system life	15 years	12 years
Total cost per year	~$800	$1,125
Total cost for 10 years	$12,000[2]	$18,250

Footnotes:

[1] Installing energy storage provides some mitigation of risk associated with future Net Metering uncertainty and other rate design risk by allowing a customer to maximize self consumption, minimize demand charges or optimize energy use patterns for a possible Time of Use rate.

[2] Net Cost: Assumes storage is charged by a solar energy system and so is eligible for the 30% federal tax credit

[3] Assumes 100 G a year at $3/G propane

While there are some limits to its power output capabilities, the battery pack is infinitely cleaner, can run indefinitely under proper design circumstances, has no recurring maintenance needs, and offers a range of capabilities—such as 'self-consumption' of solar power and grid support services—not offered by generators. As technological evolution and fierce competition pushes down the sticker price of battery backup units, we expect the next 3-5 years will show a seismic acceleration in the adoption of home-based battery systems.

Solar Works in Winter

So far we have examined the amount of solar insolation that we receive here in New England, the viability of that solar energy as a positive investment, the options that prospective customers have for types of solar arrays they can invest in, and the increases in the technologies that surround solar production and energy storage. This is a good time to examine a few questions we receive a lot here in New England that pertain to our extreme seasons.

Solar panels working efficiently throughout the winter in an array for the City of Belfast in Maine. Low temperatures don't stop panels from converting available sunlight to power.

Do solar panels even work in the winter?

The short answer is, yes they do!
The longer answer of course is, yes but for obvious reasons their output is lower than during the height of summer—days are shorter and snow will reduce or shut down output completely. That said, we at ReVision Energy have been installing solar arrays in New England for over 10 years and have plenty of experience with designing solar arrays to endure everything winter can throw at them, from incredible cold to stacks of snow.

During our free site evaluation we use sophisticated solar path modeling equipment to estimate how much solar energy your roof or yard receives. Depending on your exact location, we 'de-rate' the predicted annual output based on the amount of snow your region receives on average. While there are always seasonal variations, over the course of your 40+ year solar investment, your system should produce very close to our estimate.

We should note that technical excellence is a key value at our company. Though some solar installers are tempted to be, er, optimistic with their production numbers, we prefer to give honest and conservative figures, such that your solar array will be more likely to outperform, rather than underperform, what we think it will do for you.

Note that because solar energy output is tracked on an annual basis (thanks to net metering), you stand to benefit from the higher overall summer output vs. winter. Since you always have the grid for a back-up, real-time 100% solar power to your home from your panels in winter is not critical.

Do solar panels work in the snow?

When a solar panel is covered with snow, it cannot produce electricity. However, solar arrays tend to shed snow pretty well—the panels themselves absorb the sun's heat as well as it's light, they are mounted to face the sun, and are often on a slope. While it's true that solar panels drop in production when they're covered with snow, the percentage of overall yearly production lost is actually very small, which still makes them a good investment for prospective customers (see Chapter 3). We do not recommend that owners of solar systems clear the snow from their arrays as this could damage the array and is not covered under the warranty. Additionally, the panels themselves tend to be in difficult or even dangerous areas to access on the roof.

Do solar panels work in the cold?

Many people are surprised to learn that winter conditions can actually improve the performance of solar panels, further minimizing the drop in production due to snow on the panel or the loss of daylight hours. The photovoltaic (PV) technology in solar panels is actually able to more efficiently convert sunlight to power when they are colder. Further still, the panels are also able to catch the sunlight that reflects off the snow, adding to what the panels themselves could receive throughout the day.

What if I want to clear the snow from my panels?

Now, some customers have solar arrays that are easier to access and are willing to put in some effort to optimize their system for every possible ounce of performance. If you fall into this camp, there are a few tips we've received over the years we can share. If you have a roof rake, use it to clear the area beneath the panels so that snow has a place to slide to when it sheds from the panels. Without being raked, the sun will hit the snow and cause it shed from the panels and onto your roof, but with a little extra help this process will speed up. If you have flat plate solar hot water collectors, or solar photovoltaic modules, you can also attach a piece of foam pipe insulation on the edge of your roof rake and use it to gently clear snow from the actual panels (we've also heard that a few strips of duct tape to dull the edge of the roof rake works).

Be careful! While customers have reported success using this technique, any damage caused to your panels will not be covered under warranty. Absolutely do not try to clear the snow from collectors with the sharp edge of a metal roof rake (and never use any type of rake on evacuated tube collectors). Also, be mindful of your safety—a few extra hours of production in the shortest daylight times of year are not worth you injuring yourself.

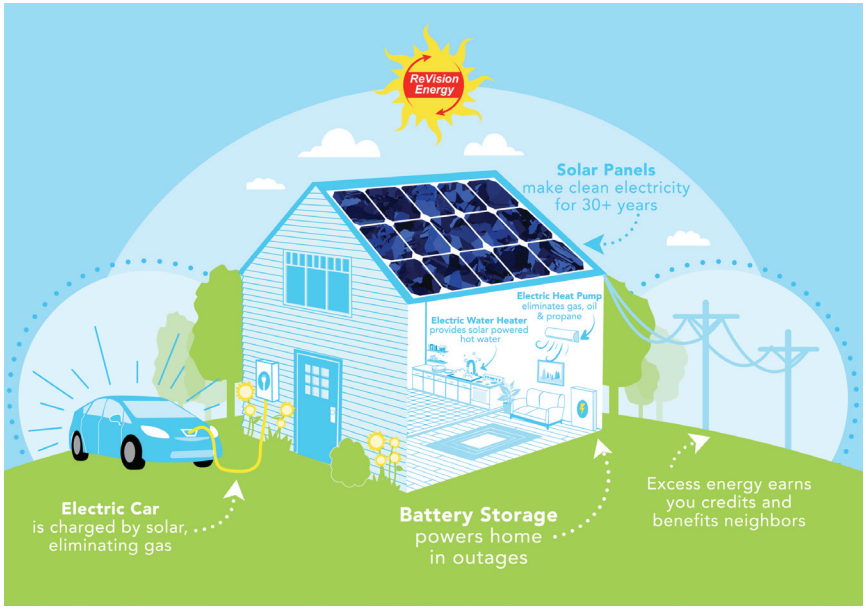
We think your time is better spent indoors enjoying a cup of hot chocolate and looking forward to the next sunny day!

We've seen that solar is a solid investment, an abundant resource with many different implementations, and one that heats and cools your home and even works in the winter. In the next chapter, SOLAR IS AN ENVIRONMENTAL SOLUTION, we put it all together to take a look at not only the vast environmental benefits of switching to solar energy, but how solar can truly power your lifestyle.

Solar Is An Environmental Solution

The 100% Renewable Household. It's not an option for everyone, sure, but it's the ultimate goal in "going solar." After everything else we have covered in this guide, this is the logical conclusion. Combining the benefits of year-round reliable solar energy, the efficiency of heating and cooling pumps, and the fossil fuel savings of electric vehicles, the 100% Renewable Household is not a far off possibility from the future, but a very real possibility for homes and businesses today.

More than 60% of the electricity generated in New England comes from natural gas and oil, followed by nuclear (14%) and coal (9%). Maine and New Hampshire emit over 10,000,000 metric tons of carbon pollution annually, a result of burning over 50,000,000 gallons of oil and 2,800,000,000 lbs. of coal. What's more, is that the use of these fuels exports more than $5 billion annually out of the local economies.



Our region's over-reliance on fossil fuels and the resulting carbon pollution is threatening to our tourism industry, our marine fisheries industries and our way of life. As a region, nation, and planet, we face stunning environmental challenges over the next 25 years, yet, the sunny news is that for all of the doom and gloom, there is a solution out there... *In fact, that solution rises every morning!*

The team at the Solutions Project recently crunched the numbers to figure out what a carbon-free future would look like. Their research supported our own, which suggests that converting just 1.5% of our region's land mass to renewable energy generation would be able to meet all of our energy needs now and forever.

This initiative is mandatory should we hope to stop the worst effects of climate change; however, for the climate skeptics, there are vast benefits beyond saving the planet. This initiative is also the fix for our economic woes, as the work needing to be done to integrate a renewable energy economy requires skilled workers, and somewhere in the order of 500,000 new jobs would be created were we to full transition to renewable energy in the next 25 years.

The technology is here and throughout this guide, we have explained how it works, and the powerful economic and environmental benefits. While State and National leadership leaves a lot to be desired in this major initiative (which truly should be a national effort, of the same order as the Space Race), we are excited and energized that the grassroots growth of solar is fast, and rapidly growing, thanks to conscientious, and financially-savvy solar enthusiasts throughout Northern New England.

More Than Just a Dream

The 100% Solar Household is here today! At ReVision Energy we have had a number of customers eventually complete the transition to living fully off of the sun's power and more on the path to doing just that. So, whether you are just Solar Curious or already committed to making the switch to the solar power, there are plenty of options available and the solar professionals at ReVision Energy are ready to advise you.

The 100% Solar Household of Solar Champion Mark Boren

Next Steps

This guide provides some general information about what going solar looks like, but everyone's situation is different. Legislation and incentives differ from state to state, nor are any two houses the same. Want to know more about your individual situation? Contact us for a FREE Solar Evaluation to see what options are available to you and which ones make the most sense.