Operating Your Business With Clean Energy

A Guidebook For Owners of Small and Mid-Sized Businesses

A Publication of the “On The Pathway To Clean Energy” Project

www.PathwayToCleanEnergy.org

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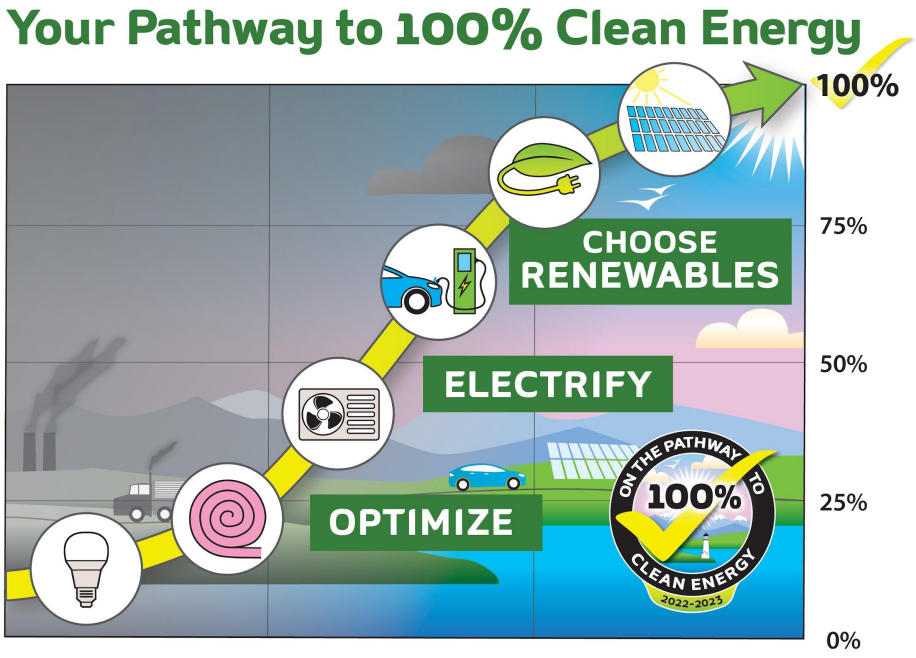
Introduction

Congratulations on deciding to build a better business with zero emissions from fossil fuel. You *can* power your company with clean energy! This guidebook shows you how.

- **Optimize** your efficiency so your company uses less energy and saves money.
- **Electrify** your equipment to use electric motors and heaters instead of fuel-burning engines and furnaces.
- **"Renewablize"** your energy supply to harness renewable sources instead of coal, oil or gas.

Your wise investments will pay dividends for years and generations to come.



This is version 1.5 of this guidebook, written by Fred Horch with contributions from John Gardner. Our aim is to record and share the current best practices of small business owners and contractors in Maine. This series is a work in progress, since knowledge, skills, technology, and priorities change over time—as do best practices. We welcome your contributions; please be in touch if you'd like to join our team as a volunteer author, contributor, editor, or reviewer.

We'd like to hear how these ideas and recommendations work for you! Please send your questions, comments and feedback to ***info@pathwaytocleanenergy.org****.*

Key Elements for Success

The "On the Pathway to Clean Energy" project helps you burn less fossil fuel and use more clean energy in ways that save money, improve cash flow, increase profitability, build goodwill and sustain value. Key elements for success are

- A **commitment letter** and the **pathway symbol** to announce to your stakeholders and community that you will stop burning fossil fuel for your business;
- An **emissions calculator** to track how much fossil fuel you are burning; and
- A **plan with milestones** to guide teamwork all the way to 100% clean energy.

But the most important element for success is *leadership* from *you*, the business owner.

Being small business owners ourselves, we know that your time is limited and your to-do list is long. We've gathered in one place everything you need to make good decisions and effectively lead your team to build a better business powered by clean energy.

Checklist for Achievement

1. Make a commitment by signing the Commitment Letter provided by the "On the Pathway to Clean Energy" campaign at www.PathwayToCleanEnergy.org.
2. Share and discuss your Commitment Letter with key members of your business.
3. Create a pathway team of employees and owners with the responsibility, authority and budget to achieve your commitment over time.
4. Calculate your emissions from fossil fuel to understand how and why you currently burn fossil fuel.
5. Outline your company's plan to stop burning fossil fuel, over time, describing key milestones to clean energy.
6. Choose key metrics to track your progress, such as total emissions per year, emissions per dollar of revenue, energy used per year, or energy used per unit of production.
7. Allocate the necessary resources to achieve your plan.
8. Assign the right person to be responsible for each milestone.
9. Review progress on a regular basis (quarterly to annually).
10. Announce and celebrate each milestone achieved.

Signing and Sharing Your Commitment Letter

Signing the letter to commit your company to being on the pathway to clean energy is an opportunity to announce and explain this bold goal to key stakeholders in your business and community. You might plan to achieve 100% clean energy quickly, or take several years. The important thing is to make a commitment, develop a plan, and start taking effective action now.

An open letter to all of our stakeholders and future generations of our community:

We, the owners of _____, commit our company to be on the pathway to 100% clean energy with zero emissions from fossil fuel, over time.

Securing our commitment, we have started to reduce our company's use of fossil fuel. We will achieve milestones, according to our own continuous improvement plan, further reducing our use of fossil fuel until we reach our goal of 100% clean energy, recognizing that success requires careful planning and long-term thinking.

Once we have reached our goal, we will continue to power our company with 100% clean energy with zero emissions from fossil fuel, leading by example to help create a carbon neutral economy and a sustainable energy future for everyone.

Our signatures below affirm our commitment.

_____ Date

_____ Owner Names

_____ Signatures

The Pathway To 100% Clean Energy campaign is a nonprofit, nonpartisan project initiated by and for business owners, managed by a volunteer Executive Director, overseen by a Steering Committee, and guided by an independent Advisory Board.

To learn more, please visit PathwayToCleanEnergy.org

- Consider who in your business needs to participate to achieve the goal of 100% clean energy.
- Explain why you are making this commitment now.
- Identify opportunities to reduce costs and grow your company.
- Listen and respond to ideas and concerns.
- Discuss what this commitment means for everyone involved.
- Create a pathway team.
- Assign responsibility for next steps: calculating your emissions and outlining your plan.

Calculating Your Emissions

Use the online emissions calculator on the "On the Pathway to Clean Energy" project website to understand how and why you burn fossil fuel for your business. Your own business records will reveal what percentage of your own emissions comes from each source.

Outlining Your Plan to End Your Emissions

Take the knowledge you gain from calculating your own emissions to establish milestones in your plan to end those emissions. For example, if you burn gasoline for company vehicles, milestones could be to upgrade to electric vehicles or to take vehicles off the road entirely.

The main purpose of this guidebook is to help you and your team develop a plan that makes good business sense for you. Once you have a plan with milestones, assign the right person in your organization to take responsibility for each milestone. For example, if you plan to purchase electric vehicles, assign a person to be responsible for making those purchases.

The Pathway's "Clean Energy" Destination

Once you electrify all of your equipment and then solarize your electricity supply, your business will be powered by 100% clean energy. For most businesses, solar-powered electrification is the most cost-effective plan. However, in some circumstances, full electrification may not be feasible. In that case your plan can be to replace fossil fuel with **renewable fuel**. Sunlight and plants (rather than coal, oil or gas) provide renewable fuel. Compared to fossil fuel, renewable fuel is clean energy. Whether your plan is to use renewable electricity or renewable fuel, either way you will be "On the Pathway to Clean Energy."

About This Guidebook

This guidebook shares best practices for eliminating emissions from coal, oil, kerosene, natural gas, propane, diesel or gasoline that you are buying and burning directly or indirectly (for your electricity supply). This version was written by Fred Horch with contributions from John Gardner, and reviewed by the On the Pathway to Clean Energy advisory board. Our project helps you follow the dollars to find your emissions. We guide you along four simple steps:

1) **Measure:** How much you're spending for energy may not be your highest priority, even though every penny of lower expenses is worth dozens of pennies of additional revenue. This guidebook helps you improve your operating margin by examining your energy use. On your profit and loss statement under expenses have your bookkeeper create separate line items for fossil fuel and electricity. You can then easily convert the dollars spent into units of energy (for example kWh of electricity, gallons of fuel oil, therms of natural gas). Combining that knowledge with the time of usage can uncover valuable opportunities to save money on the pathway to 100% clean energy.
2) **Optimize**: The most affordable unit of energy is the "negawatt"—one you don't use. In most facilities there are many ways to save energy without sacrificing comfort or productivity. This guide will help you investigate every obvious place to start saving.
3) **Electrify:** We're fortunate in New England that much of our electricity already comes from low-emissions sources like hydro power dams and wind turbines. The remaining fossil fuel-based generators are being phased out in favor of solar photovoltaic systems, backed up by grid level energy storage. This means that you can easily reduce your dependence on fuel by upgrading fuel-burning equipment to an electrical replacement.
4) **Solarize:** Once you have measured, optimized and electrified your energy use, the final step is to install your own rooftop, awning, canopy or ground-mount solar array. This guidebook helps you understand how much energy you might expect to generate on site, and explains other solar options like community solar farms, solar power purchase agreements, and renewable energy certificates.

This guidebook is not comprehensive. We focus on the energy you use directly in your business. Keep in mind that there might be other sources of environmental impact that are worthy of your attention but outside the scope of this guide. For example, leaks from refrigeration systems are very harmful to the environment and should be addressed immediately. Volatile organic compounds (VOCs) from paint, solvents, and other operations are directly implicated in the development of smog and other regional air quality issues. Also, wood-burning equipment is considered "clean" for purposes of our project, but must be maintained to ensure maximum efficiency and minimal particulate emissions, and may not be appropriate for all locations unless sophisticated filtration systems are used. Finally, upstream emissions from your supply chain and downstream emissions from your customers (also known as "scope 3 emission") lie outside the scope of this particular guidebook.

Measuring Consumption

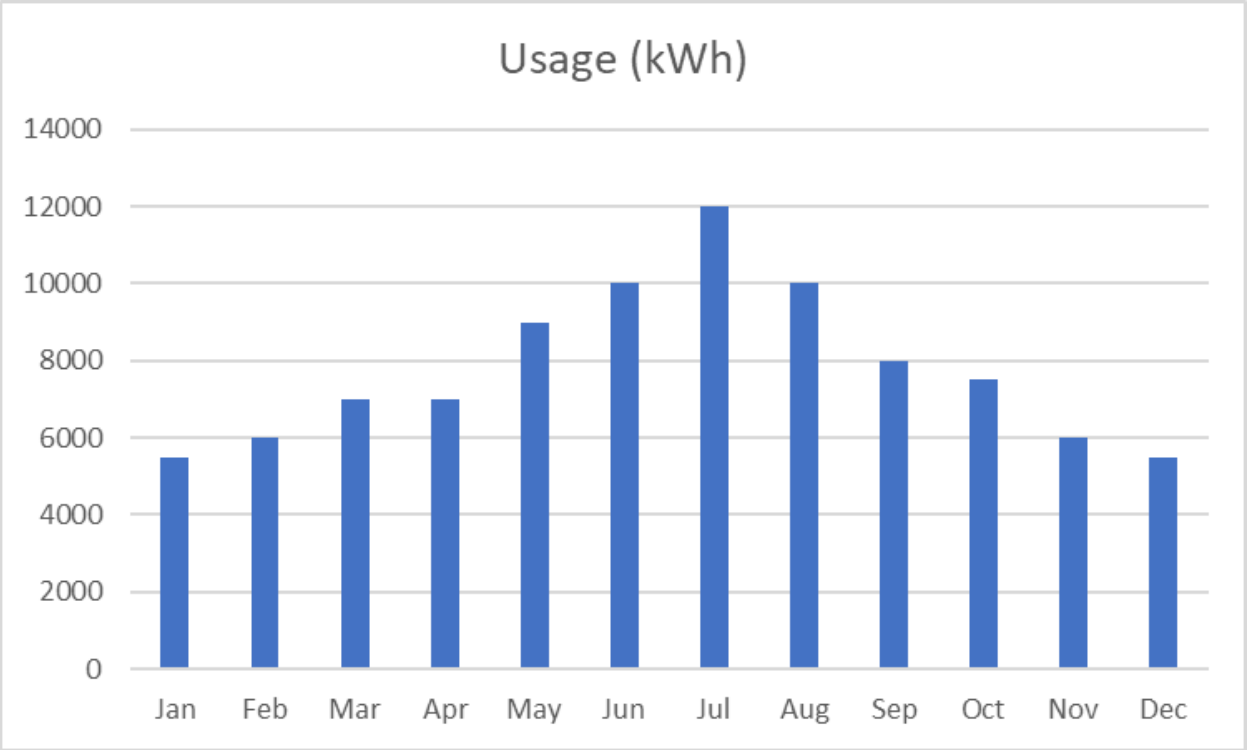
Like any good business, you're already tracking your energy costs, and lately those costs may have caught your attention. It is impossible to escape the impact of significant increases in the cost of fuel oil, propane, diesel and gasoline. Most electricity customers in Maine have seen sharp increases in their electricity rates. But price volatility is precisely why it's important to track energy consumption directly in the units it is delivered to you as well as the costs.

There are two simple things everyone can do that can give you insight into how you use energy and how you might optimize your operation. We'll call this the "When" and the "What".

When: Seasonal Variation

Electric utilities provide you with a bill every month in which they detail how much electricity you used, also known as consumption, measured in kilowatt-hours (kWh). For medium and large accounts, they also document the highest rate at which you used energy that month, called "demand," measured in kilowatts (kW). Just remember kWh measures "how much" and kW (without the "h") measures "how fast." Small users don't have to worry about the "how fast" (demand) portion but medium and large commercial accounts pay a demand charge for "how fast" they use electricity in addition to "how much" electricity they use.

Gather twelve months of electric bills (you can download these from your utility's online account portal if you don't keep your paper copies). Find the consumption portion of each bill and look at how they vary throughout the year. Spreadsheets are great tools for this. For example, your consumption may look like this:



This shows considerably higher usage in the summertime. The most likely cause is air conditioning. However, if you don't think you use much air conditioning, then you should probably look into other possible sources, such as insulation or seals around refrigerated coolers. If the consumption peaks in the cold weather months, then you can see that you use more energy to deal with colder outside temperatures.

Seasonal variations are to be expected, but if the differences are very large (such as in this example) it might point to problems with your building envelope. Consider your insulation, doorways and windows, as outlined in the next section of the guide.

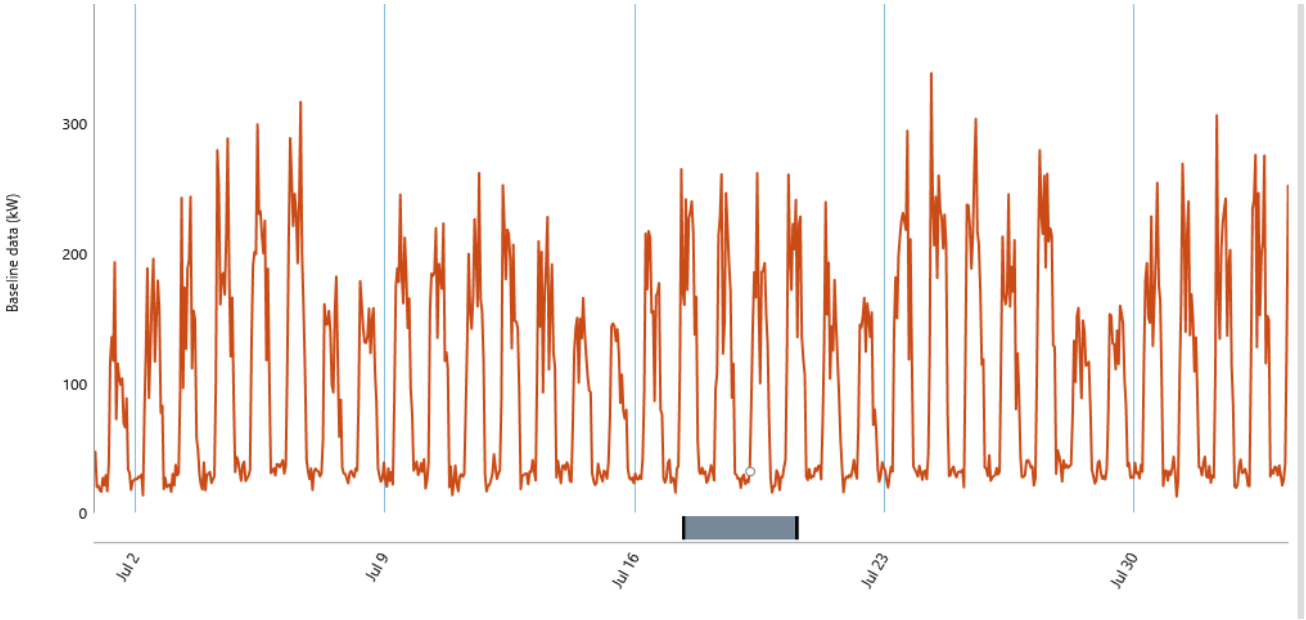
In addition, you should look at the months where very little heating or air conditioning is required. These so-called 'shoulder months' (typically mid-March to mid-May and mid-September to mid-October) tell you about energy uses for your operations that aren't directly linked to building heating, ventilation and air conditioning (HVAC).

You can perform the same operations with fuel oil or propane, but it's not quite as straightforward. Since these companies bill you upon delivery, not consumption, you need to figure out how much was actually consumed during a given month. If you always fill your tank to be 100% full, then you can get a rough sense how much fuel you use over different times of year by recording the amount delivered and the date of delivery. You may need to do a little sleuthing to figure out a good way to monitor how much fuel you're using each month.

When: Hourly Variation

Throughout Maine, electric utilities have installed “smart meters.” These meters are in radio communication with the utilities, which record the data. You can login to your online account to download a data set to see your energy consumption hour by hour. This level of resolution can help you monitor not just seasonal variations, but monitor the performance of systems and even individual pieces of equipment. You might be able to see when your refrigeration or AC systems turn on, for example, to determine whether your set-back thermostats are working correctly.

Once you download the data, you can graph it to see the hour-by-hour variations in usage. The figure below shows an example for a hypothetical commercial office building.



A few features are worth noting in this plot. First we see a clear 24-hour cycle of electricity use that roughly corresponds to the 9-5 work day. Not all days are the same, likely due to the fact that the outside temperature varies. Also, the work being carried out in the building might change day to day. Note also that the weekend days (the blue line corresponds to the midnight before Monday) show decidedly less usage, likely because the building systems were on an ‘unoccupied’ setting on those days and not working as hard to maintain specific temperatures.

When it comes to efficiency, there are two features you should focus on. One is the highest peak in any given billing month. If you are a medium or large electricity account, this peak sets the demand charge on your bill. The reason for this charge is that the utility must size its wires and transformers to meet that demand even if just for 15 minutes. Lower your peak to reduce your demand charge.

Second, look at the energy consumption when nothing is happening in the building. Assuming your operations don't run 24/7, ensure you don't have equipment running when it's not needed. The plot above shows a typical variation of 10-1 between occupied and unoccupied states. Finding ways to lower the unoccupied consumption can have really big pay-offs because these are 'always on' loads and really add up over time.

What

By "what" we mean – "what did you use the energy for?" Specifically: "What did you get for the money you spent on energy?" For example, if you're in the business of making donuts, you certainly track how many donuts you bake. If you divide your annual energy consumption by the number of donuts baked that year, you get the *energy intensity* of your donuts. This is a baseline for comparison as you make changes in your operation. Lowering your energy intensity will increase your profitability.

Of course, most operations are more complicated, making a variety of products, or maybe more service oriented. Another useful metric can be tracked by dividing the annual energy consumption by the total business in dollars for that year. Again, minimizing energy use per dollar of revenue will maximize your profitability.

Optimizing Your Efficiency

Start with efficiency to free up resources for the rest of your pathway plan. This section of our guidebook shares best practices to increase your profitability by eliminating waste, improving your productivity, *and* reducing your emissions from fossil fuel.

Here are two things to know about efficiency.

First, we are fortunate in Maine to have an organization called **Efficiency Maine**, which is devoted to helping you optimize your efficiency. On a quarterly basis, Efficiency Maine evaluates a wide range of efficiency measures, then offers financial incentives to encourage you to invest in those that provide the highest rate of return. For a current overview of the incentives on offer, visit the "Commercial and Industrial Sector" section of the Efficiency Maine website at https://www.efficiencymaine.com/at-work/

Second, most electric equipment is more efficient than most fuel-burning equipment. For example, the fuel efficiency rating of a Tesla Model 3 electric car is 150 miles per gallon (equivalent) in city driving and 133 mpg (equivalent) on the highway. Compared to gas vehicles getting 30 mpg, fully electric vehicles quintuple your efficiency. Electric heat pumps are many times more efficient than old-fashioned fuel-burning heating systems. Optimizing by electrifying moves you ahead two steps toward 100% clean energy.

The rest of this section of the guidebook takes a tour through optimizing all aspects of your facilities and operations.

Optimizing Your Building Envelope

Most likely the buildings you own or rent were not designed or built for high efficiency. That means improving your building envelope for greater efficiency will increase your free cash flow.

If you rent, have a conversation with your landlord about the fact that you have committed to being on the pathway to clean energy. Many commercial leases require tenants to pay all heating and cooling costs. A successful negotiation strategy is to identify critical building upgrades and offer to pay for half. If you can improve the value of the building and reduce your heating and cooling costs, you have a good opportunity to make money for both you and your landlord over time.

Your **building envelope** is your exterior walls, exterior doors, exterior windows, roof and floor. To maintain a comfortable indoor temperature and healthy indoor air quality, control how heat and air flow through your building envelope. In a modern, well-built commercial building in Maine that is designed to high standards, heating power equivalent to a hair dryer is sufficient to maintain comfort year round for thousands of square feet.

Once you've built your building envelope, there are limits to what you can easily or economically do to improve the performance. If you haven't thought at all about your building's energy performance, you might be surprised to find how much improvement is possible at relatively low cost. Conversely, if you feel you've done all you can with the existing envelope, it might be time to consider a larger investment such as a so-called "deep retrofit" or perhaps designing a new, high-efficiency building from scratch. The rest of this chapter is divided into these sections: Existing Buildings, Deep Retrofit, New Building Design

Existing Buildings

If any, or most, of the technical details of this section seem beyond your capability or capacity, you can hire a professional to do an efficiency evaluation or a full-blown energy audit. We recommend a 'virtual customer consultation' with Efficiency Maine's experts[1] to get the process started. There's no cost and no obligation. They can walk you through a few options, including some very attractive financial incentives.

All commercial buildings in Maine were required to meet the prevailing building codes in force at the time of construction. Building codes, and particularly the energy building codes, are constantly being updated. Most states, including Maine, reference the International Energy Conservation Code (IECC) as part of the building code.

If your building was built before 2015, there are two points you should consider. First, your building may be a good candidate for some simple upgrades (like additional insulation) that wasn't required when the building was built. Second, a large number of energy efficiency measures (like caulking and exterior insulation) degrade over time. Particularly in the harsh New England climate, buildings need constant care to maintain high performance.

The first step should be a building walkthrough and walk around. If you spend most of your working day in the building, you may be used to glossing over some of the more obvious problems. It helps to engage a trained professional at this point to perform an efficiency evaluation (also called a 'scoping audit') to identify the "low-hanging fruit" that can easily be addressed.

If you do the walkthrough yourself, it helps to choose a particularly cold (if heating is your big cost) or hot day (if you're concerned about your A/C bill). It also helps to have an inexpensive non-contact infrared (IR) temperature reader. These useful tools are available for under $50 and measure surface temperatures at a distance. Professionals use these to measure the temperatures of breakers in panels and to spot-check wall temperatures in areas where infiltration or insulation problems are suspected. More expensive IR cameras can record temperatures of entire walls or roof structures.

During your walkthrough, here are a few more pointers:

[1] https://www.efficiencymaine.com/business-customer-consultation/

On a cold day:

- Pay attention to the inside of the walls. The surfaces should be close to the inside temperature. If they're 5°F or more colder, more insulation may be required.
- Sometimes insulation settles in wall cavities leaving relatively uninsulated sections near the top of the wall. Spot check temperatures along the top of walls.
- Pay attention to the windows. Do you feel a draft? That may indicate two issues.
    - It may be that the sealing around the edge of the windows has failed allowing infiltration of the outside cold air. Replacing the caulking may fix this problem.
    - It may also be that the window surfaces themselves are so cold that the inside air in contact with the window cools down and hence drops toward the floor in a process known as natural convection. If this is the case, storm windows or window replacement may be indicated.
- Make sure your doors are sealing tightly. The weather stripping on doors wears quickly and needs to be replaced often. It's easy to miss the fact that doors are not tightly sealed. This is particularly true of the 'sweep' at the bottom of the door. If the door is rattling a bit in the frame when it's latched, that might be an indication that the weather stripping needs to be replaced. A visual inspection on your hands and knees can tell you the condition of the sweep.
- If you have a 'high-bay' building, assess the temperature near the ceiling relative to the floor where folks are working. Hot air rises, so it's likely that it will be considerably warmer at height and much of the money you're paying to heat the space isn't helping you. A ceiling fan, which moves air in large sweeps, or a specific-purpose 'destratification fan,' which moves air in a tight stream, can significantly decrease your heating costs in this situation.
- Remember that it's not just the physical condition of the building, but also how it's used that impacts energy consumption. Work with employees to ensure that doors are not left open (even cracked) and that large doors suitable for vehicles are not used for pedestrian traffic.
- Finally, remember that fluids like air and water flow from high pressure to low pressure. Cold and hot air both follow the path of least resistance. A small opening can let all of the hot air out of a building in the winter, and all the cool air out in the summer.

On a warm day:

- This walkthrough is very similar to the cold weather walk through described above.
- In this case, look to see if the windows present particularly significant solar loading. Is it hotter in the part of the office near a sunny window? If so, the effective solutions (in increasing effectiveness) are interior shading, exterior shading (e.g. awnings) or window replacement with highly efficient, 'high-e' windows.
- Inspect your air conditioning unit. Are the filters clean? Is the outside unit clear of debris?
- Make sure you have the AC unit serviced annually to ensure that you don't have refrigerant leaks or other potential problems.

In conjunction with the walkthrough, you can go down these bullet points as possible routes to improve your efficiency.

Insulation

- Properly install and insulate plumbing to use passive heat to keep all water pipes in your building above the minimum shallow groundwater temperature year round. You should never have to worry about burst pipes, even if your building loses power for an extended period in the dead of winter. Shallow groundwater in Maine varies between 37 and 47 degrees Fahrenheit depending on season, altitude and latitude.
- If you have a hydronic heating system (i.e., pressurized water pipes and circulator pumps) and you are worried about pipes freezing, add antifreeze to your distribution system. You won't need to run your heating system to prevent pipes from freezing.
- Carefully insulate water pipes near and around your building envelope. Pipes freeze from attic to basement, perimeter to interior, or in locations that are exposed to drafts.
- Add insulation to meet current building codes, which in Maine are now based on the 2015 International Energy Conservation Code. Use dense-packed cellulose or another type of high-performance insulation rather than low-performance fiberglass insulation. Insulation is rated by R-value (resistance to heat flow) per inch; the higher the R-value the better.
- Block airflow around insulation. It is ineffective if air flows around it. Poor craftsmanship by an insulation crew can open up holes in your building envelope, undoing any benefit. If you hire an insulation company, discuss how they will confirm that no unintended airflow is occurring through your building envelope after insulation has been installed. A blower door test is the most rigorous method.

Ventilation and Air Flow

- Before and after you have work done to improve your building envelope, hire a company to do a blower door test, which lowers air pressure inside your building. Taking measurements before and after shows how well the work was done.
- Verify that all air flow occurs in a controlled manner, through your building's ventilation system, rather through open ducts or gaps between your floor, walls, and ceiling, or around your exterior doors and windows.
- Ensure that you have adequate controlled air flow through occupied spaces. You should have windows that open and close securely or fans and ducting to move air in and out of your building. Consider installing an **energy recovery ventilator** so your building can efficiently bring in fresh outdoor air on demand.
- Add covers or one-way flaps on kitchen hoods, bathroom fans, and other ventilation systems so cold air does not enter your building when those systems are not in use.
- Close flues when not in use. Install a chimney pillow or a flue blocker for an open fireplace.
- Upgrade exterior doors and windows. For windows that you need to open, select an awning (hinged at top) or casement (hinger on the side) style, which form a tight seal when closed, rather than double-hung windows.

- Build an airlock for your main entrance. An airlock is an enclosed space with two sets of doors, designed so that both sets are not typically open at the same time. This reduces the amount of airflow when people enter and exit your building.

Shading and Windows

- Install awnings or plant deciduous trees to shade south-facing windows in the summer, reducing solar gain and reducing your air conditioning demand. Design this shading so it does not obstruct winter sun, when solar heat gain is a benefit.
- Add a white roof coating to reduce summer heat gain, lowering your air conditioning and refrigeration loads.
- Add interior insulating window shades or window films, or exterior storm windows, to minimize heat flow through windows.

Deep Retrofits

As the previous section points out, there's a lot you can do to improve the performance of your building and systems (and hence, lower your costs) by addressing issues one at a time. However, sometimes it makes more sense economically and logistically to take a more comprehensive approach and consider the entire building and systems at the same time. This comprehensive approach is known as a 'deep retrofit' and can often result in economic and performance improvements that exceed the results if taken one at a time.

Why Deep Retrofits?

Here's a prime example of how a comprehensive approach to retrofit can save money. Let's say your oil-fired boiler is nearing the end of useful life. Let's also assume that the building envelope has several problems including insufficient insulation and single pane windows. If you install a new boiler of similar capacity (but more efficient) your savings will be limited to what you realize with a 95% efficient boiler as opposed to the 70% efficient boiler you replaced. Likewise, if you simply replace your windows with double-glazed efficient windows, you'll notice a more comfortable workplace and your boiler won't have to work as hard since you're losing less heat through the windows. But that raises another problem. If you operate your boiler at a fraction of its rated output, it won't be as efficient. So the savings you realize from the better windows will be partially offset by a loss of overall efficiency in your boiler.

By taking a comprehensive approach, a better building envelope (including new windows) means that you can replace your boiler with a smaller (less expensive) unit to achieve the same level of comfort in the workplace. In fact, you may find that you can get rid of the oil (or gas) fired boiler altogether and replace it with one or more modern mini-split heat pumps. The end result is both a reduction in capital costs (since the boiler or heat pump will be cheaper than the larger unit you were replacing) but also a permanent reduction in operating costs.

New Building Design and Build for Efficiency

If you're fortunate enough to be in a position of planning a new construction project, then you're in a position to really maximize building performance. Whether you're considering custom architecture or a glorified pole barn, this is the best time to consider energy efficiency in design and construction.

Each building is different, so it's far beyond the scope of this guidebook to go into the details of energy efficient design for every situation. But here are some things to consider when choosing an architect and a construction firm.

- Ask your prospective designers and buildings to the IECC energy codes. Maine requires that new buildings adhere to the 2015 code, but ask them about compliance with the 2021 code instead. The IECC codes are continually adopting and codifying new measures and construction techniques that help ensure an efficient building.
- Consider having the design firm construct an energy model of the design. Energy models (using well-respected codes like Energy+) are excellent tools to assess the efficacy of various energy efficiency features. They can predict how much energy a given measure is likely to save over the life of the building which you can then compare to the incremental costs of that measure to make an informed decision.
- Ask prospective construction firms about their experience with high-performance buildings. While all firms are required to build to code, some firms have been able to deliver a superior product for less money up front.
- Look to incorporate passive solar features to retain solar heat in winter and reject it in summer. In general, this means awnings on southern windows that allow sunlight to penetrate deep into the building in the winter, but that are shaded in the summer. Design northern exposures to have few or no windows.
- Choose foam or dense cellulose insulation for better performance than fiberglass.
- Install high efficiency windows to allow visible light through but not heat.
- Eliminate problems from ice dams by installing standing-seam metal roofs on sloped pitches. Metal roofs can be coated for high solar reflectance and high thermal emittance (a "cool roof"), and provide excellent mounting points for solar panels.
- Make sure your builders will verify the building envelope by performing a blower door test that measures the actual rate of infiltration after all the trades have been through. Many times a plumber, electrician or HVAC crew will drill a hole in a building that undermines all the hard work of the insulation crew.

Optimizing Your Heating

A word of caution before you begin optimizing your heating system: Fumes from fuel-burning heating systems can sicken or kill people, and gas can explode. Electric heating systems that don't burn any fuel in or near your building and rooftop units that burn fuel outside are generally safer and more efficient than combustion systems inside your building envelope. The modern

‘sealed combustion’ boilers and burners alleviate some of these issues, but fortunately, there’s a better solution with all-electric HVAC equipment and induction ranges.

The first big question to ask is whether it is feasible for you to upgrade entirely to safe, high-efficiency electric heat. Modern cold-climate heat pump technology is effective in Maine's climate. Unless you have an exceptionally bad building you don't need a supplemental system: heat pumps by themselves are now powerful enough for Maine winters.

Converting entirely to efficient electric heat pumps eliminates the dangers and hassles of burning fuel. Continuing to operate fuel-burning equipment hampers efficiency and requires special care to prevent accidental poisoning from carbon monoxide and to prevent explosions from propane or natural gas leaks.

And heat pumps use about one third to one fourth of the energy equivalent compared to heating with combustion fuels. They just make more sense.

If your heating system burns fuel inside your building envelope, consider how air is supplied to and removed from the combustion chamber. Systems that burn fuel inside a building should be connected to an exhaust flue directly to the outdoors where carbon monoxide and other pollution you produce will be diluted and blown onto neighboring properties.

All exhaust leaving your building will be replaced by outdoor air coming into your building. If you do not have an intake duct connected to your combustion area, your heating system will pull air in through your building envelope in other ways. If you tighten up your building envelope and you do not have a fresh air supply to your heating system, you may reduce the effectiveness of your exhaust. Adding a dedicated intake air supply to a fuel-burning system can improve its efficiency and safety by ensuring a good draw through the exhaust flue.

If you do replace your combustion heating system, make sure you specify a ‘sealed combustion’ type which seals off the combustion gasses (both intake and exhaust) from the inside conditioned air. In addition, some manufacturers offer ‘condensing’ combustion systems which remove more heat from the exhaust combustion gasses to increase efficiency even further.

Programming Thermostats

In general, it requires less energy to let indoor temperatures fall and then raise them back up rather than to continually maintain a higher indoor temperature round the clock. For many heating systems, a cost-effective optimization is to install a programmable thermostat. Set back the target temperature when spaces are unoccupied.

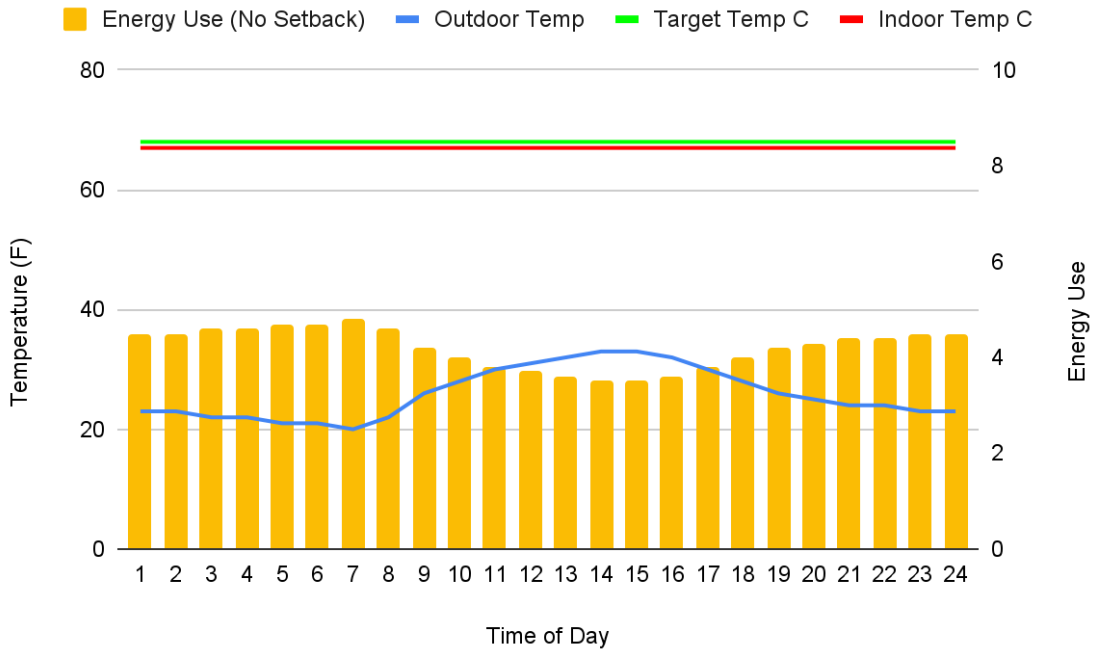


Figure 1. Heating energy use without setback. At night, the larger difference between target temperature and outdoor temperature requires more energy to maintain temperature.

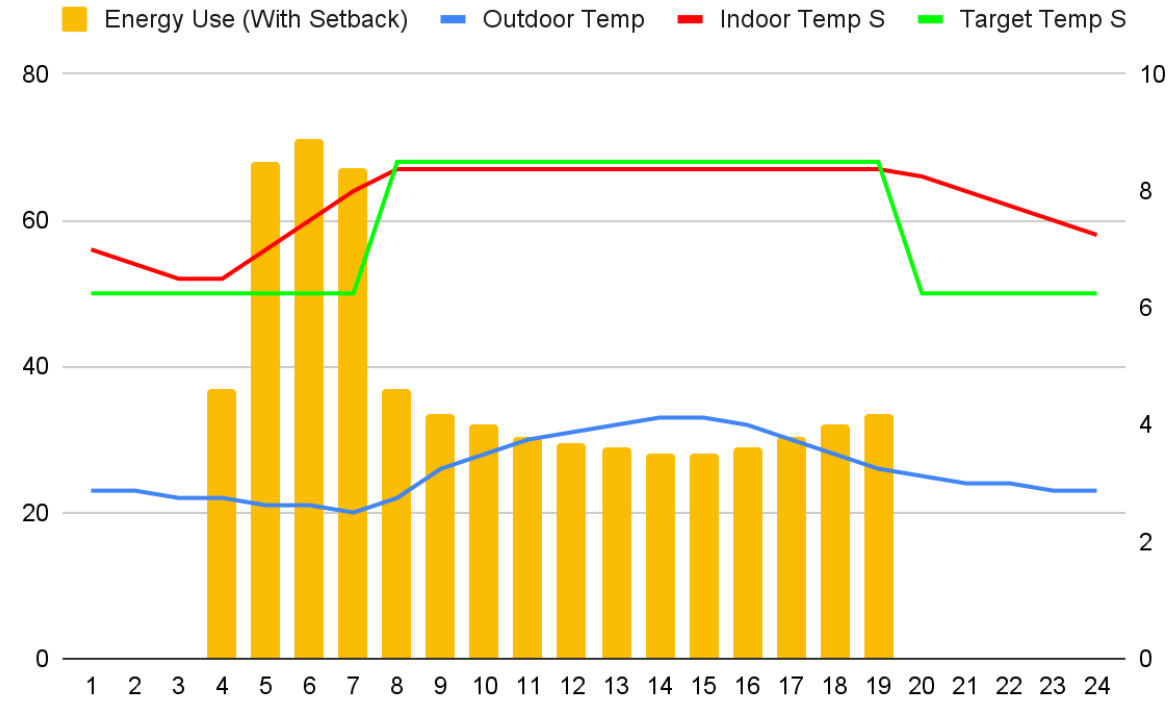


Figure 2. Heating energy use with setback. No energy is required when temperature is allowed to fall. For a short time early in the morning the heating system must work harder to recover.

Smart thermostats with outdoor temperature sensors can anticipate how far in advance they need to call for heat to bring a space back up to your target temperature. For example, if your target heating temperature is 68 degrees from 8 am to 6 pm, but your set back temperature is 50 degrees, a smart thermostat will let temperature fall as far as 50, but know that it needs to turn on the heating well in advance of 8 am to ensure that the building temperature is 68 degrees by 8 am. A smart system runs an algorithm that takes into account the current outdoor temperature, the power of your heating system, and the weather forecast for the day to decide when to start heating to reach the target temperature on time.

For fuel-burning heating systems, the more aggressive you are in your set back temperatures, the more fuel you will save. Combustion systems are more efficient with longer burn times, just like cars are more efficient on the highway than in city traffic. You will save energy and money by having your fuel-burning system burn once in the morning to bring your building back up to temperature, rather than burning in bursts all night long to maintain a high temperature.

Aggressive set back temperatures can also be extremely effective with some types of electric heating systems, such as resistance heat and infrared heat.

Controlling Heat Pumps

The set-back strategy might not work well for electric heat pump heating systems. Most cold climate heat pump designs do not benefit from setbacks. In 2021 the U.S. Department of Energy issued the Cold Climate Heat Pump Technology Challenge to improve the performance of future generations of heat pumps, which may allow heat pumps to benefit from setbacks.

In the meantime, if heat pumps are your only source of heat, the recommendation is to "set it and forget it." Don't worry about setbacks.

If you have both a fuel-burning heating system and heat pumps, an optimal control system will run heat pumps when they can satisfy your heating demand with greater efficiency than your fuel-burning system. For integrated systems that include both a fuel-burning component and a heat-pump component, your control system should already provide this optimization.

If you add mini-split heat pumps to an existing fuel-burning heating system, you will probably have separate thermostats controlling the different systems. Experiment to coordinate those controls to optimize your efficiency. Heat pump systems have an efficiency curve that drops off when the temperature is very cold. Each system has a different shape to its efficiency curve.

Note the inflection point on the curve when the efficiency of your heat pump drops off sharply. This is the "very cold" weather point where it makes sense to coordinate operation between the two systems. Above this temperature, you can just "set and forget" your heat pumps. Below this temperature, setting back can save money and energy, but only if you do it correctly.

Here's a recommended coordinated setback tactic for situations where heat pumps and a fuel-burning heating system are both in use on separate controls:

- Until temperatures become very cold, just use your heat pumps. Set the thermostat controlling your fuel-burning system very low so it won't come on unless there's a problem with your heat pumps. Set your heat pump controls to your desired room temperature so they maintain temperature. Simply "set and forget."
- On very cold nights when your building is unoccupied, turn off your heat pumps. Aggressively set back your fuel-burning system, allowing your indoor air temperature to fall. Set your thermostat's schedule so in the early morning your fuel-burning system does one long burn to raise the temperature back up before your building becomes occupied. Have your heat pumps come on after your building is back up to temperature.
- During very cold days, once your building is occupied and your fuel-burning system has brought up the temperature, then use heat pumps to maintain temperature. During occupied times, set your heat pumps to your comfort temperature and set your fuel-burning system a few degrees below your comfort target. Even in very cold weather your heat pumps might operate at higher efficiency than your fuel-burning system, which should only come on if your heat pumps cannot satisfy demand. Ideally, your fuel-burning system will only do one long burn in the early morning and your heat pumps will do the rest of the work when your building is occupied.
- During very cold weather, schedule your thermostats to turn off your heat pumps and then set back your fuel-burning heating system overnight to allow indoor temperatures to fall. It wastes energy and money to maintain high indoor temperatures on very cold nights when your building is unoccupied.

Controlling Ventilation

Ventilation is important for indoor air quality, but over-ventilating or ventilating unoccupied spaces wastes energy. Ideally, your building envelope should be tight so you can control air flow through your building rather than suffer from uncontrolled air flow.

- Understand how your building handles fresh air. Some heating systems include a fresh air intake, and some don't. Rooftop units usually have a fresh air intake, but often these are not controllable, simply fixed in place to bring in a constant amount of fresh air every time the unit fires. It's best to be able to control the amount of fresh air being brought into your building. If your heating system has a fixed-in-place fresh air intake, ask your HVAC service technicians to check it and adjust it every time you have your unit serviced.
- Consider installing both intake and exhaust ventilation. A balanced ventilation system, with the same volume of air flowing in and out, avoids over-pressurizing or under-pressurizing your building. An over-pressurized building brings in an excess amount of air from the outside, which inflates the building like a balloon. Air must then find a way back out through gaps in the building envelope. An under-pressurized building is the opposite: often a kitchen hood or bathroom fans will be blowing air out of a building. If there is no matching make-up air unit, replacement air gets sucked in around doors and through gaps in the building envelope. If your building envelope is

tight, in an over-pressurized or under-pressurized situation you'll notice exterior doors being hard to close or to open as air pressure pushes them open or sucks them shut. But in a poorly-constructed building, enough air might be able to flow through the building envelope that over- and under-pressurization doesn't occur, despite an unbalanced ventilation system.

- An energy recovery ventilator provides balanced ventilation and reduces the energy costs of bringing in fresh air. In this type of system, the incoming and outgoing air flows remain separate but both go through a heat and humidity exchanger. This tempers incoming fresh air so that it is cooler in the summer and warmer in the winter.
- Ventilation systems with carbon dioxide sensors can automatically bring in more air when a space is occupied. When a space is unoccupied, you save energy by not ventilating it unnecessarily.
- If your building has a commercial kitchen, smart demand controls on your hoods will optimize your efficiency. Smart controls, which sense whether a cooktop is in use and how much air is necessary to provide, ramp up and down the speed of your hood and make up air fans so you are not bringing in more air than necessary.

Destratifying Air

Gravity pulls down dense cold air, forcing hot air to rise. If you have high ceilings and little air movement in your building, near the ceiling will tend to be much warmer than near the floor. This temperature gradient is called "stratification." Destratification fans, typically mounted high up in areas with tall ceilings, mix air so it provides more warmth where needed.

Optimizing Your Air Conditioning

As Maine's climate warms, air conditioning will become a larger part of your energy budget.

- Have your air conditioning units thoroughly cleaned and inspected on a regular schedule. The current technology for commercial air conditioning equipment is vapor compression, which pressurizes and circulates a refrigerant between an outdoor condenser and an indoor evaporator. On a regular basis it's important to check the pressure of the refrigerant lines, to verify the motors and controls are working properly, and to clean the condenser and evaporator coils so they can transfer heat efficiently. In addition, it's important to inspect and clean the drains from your indoor evaporators.
- Ideally, the condensers for your air conditioning system will be located outside on the north side of your building, where they will be naturally shaded. The cooler the air around a condenser, the more efficiently it can reject waste heat from your building.
- Setting back the temperature for your air conditioners will save you money. If you have a ventilation system that allows you to bring in fresh air to your building, a good control strategy is to raise the temperature setting of your air conditioning overnight, and use your ventilation system to bring in outdoor air early in the morning, when it is the coolest. If you have rooftop units, make sure you have economizers installed and ensure that

they are operational. Economizers automatically bring in cool outside air if the conditions are right for ‘free cooling’.
- Besides maintaining a comfortable temperature, air conditioning maintains a healthy and comfortable relative humidity. Proper ventilation that removes moist air from kitchens, bathrooms, and occupied spaces reduces the need to run your air conditioning to lower indoor humidity levels.

Optimizing Your Hot Water

You have four basic ways to optimize your hot water system:

1. Reduce your use of hot water so you don't need to heat as much water.
2. Set your hot water temperature so you aren't heating your water hotter than necessary.
3. Heat water efficiently with electric heat pumps.
4. Retain the heat in your hot water from the heat source to point of use.

Reducing Hot Water Use

Pressurized hot water is one of the joys of modern life. You can make the most of this resource by buying efficient fixtures and appliances that qualify for the EPA's **WaterSense** standard. You can easily check the flow rate (gallons per minute) of your fixtures by filling up a bucket for 15 seconds, then multiplying the amount of water in it by four.

- Hand-washing sinks with low-flow aerators should use 0.5 gallons per minute.
- Pre-rinse spray valves (for pre-rinsing dishes before washing them) should use 1.6 gallons per minute.
- Showerheads should use 2.0 gallons per minute or less.

Setting Your Water Pressure

Your building's water pressure affects the flow rate through your fixtures: the higher the pressure, the higher the flow rate. Water pressure in commercial buildings often varies between 30 and 70 psi. Water pressure higher than 80 psi can be dangerous; a pressure reducing valve on your supply line may be necessary if your supply pressure exceeds 70 psi. If you have a pressure reducing valve or a check valve on your supply line, you should have a thermal expansion tank set to your desired water pressure. This tank ensures that your water pressure remains constant regardless of water temperature. Without a thermal expansion tank, heating your water will raise your water pressure.

Some water-using appliances, such as dishwashers, require pressure reducing valves. Verify that pressure reducing valves are installed and set correctly. Most commercial dishwashers require 20 psi or less. If your dishwasher allows for a range of pressures, setting its pressure reducing valve at the low end of the range will reduce your water consumption.

Circulating Your Hot Water Supply

If you have long runs for your hot water to travel, consider a recirculating system. According to Efficiency Maine, "Businesses can significantly reduce water heating and water costs with the installation of electronically commutated motors (ECM) recirculation pumps. These pumps use electronically commutated motors and smart controls to constantly circulate hot water from the water heater to the farthest fixture and back. This results in constant hot water in distribution pipes and at the faucets, cutting wait times for hot water and reducing water waste. ECM recirculation pumps operate at a fraction of the cost of traditional recirculation pumps. Efficiency Maine offers instant discounts on ECM recirculation pumps."

Setting the Temperature of Your Hot Water

When you turn on a hot faucet with the cold faucet completely off, the temperature of the water coming out should be no hotter than 120 degrees Fahrenheit. Water hotter than 125 F is hazardous; in a commercial setting you may be liable for any scalding injuries due to water that is too hot at its point of use. For safety and efficiency, set your hot water heater tank temperature to 120 degrees so that no faucet can deliver water hotter than 120 degrees. This simple step not only ensures the safety of your employees and customers but can also save hundreds of dollars annually according to the US Department of Energy.

Heating Water Efficiently

Upgrading from an old-fashioned electric water heater or a gas-fired water heater to a heat pump electric hot water heater allows you to benefit from hot air in your building to reduce your cost of making hot water. Efficiency Maine often offers rebates for qualifying heat pump water heaters. Check to see if rebates are currently available.

Years ago, solar hot water heating systems were used that circulated antifreeze through panels mounted in a sunny location. In recent years, overall system reliability, economics and efficiency has improved by using solar panels to produce electricity, and then using this electricity for high-efficiency heat pumps to heat water. Using solar energy to produce electricity allows higher overall utilization of the solar resource, since electricity can be used for many purposes and is easily shared with surrounding buildings through the distribution system. It is more difficult to put hot water to use at all times and to share it with surrounding buildings. As a result, much of the energy collected by a "circulating fluid" solar hot water heating system cannot be used effectively, and for this reason these types of solar energy systems are rarely installed today.

Insulating Your Hot Water Supply

The set point temperature of 120 degrees for your hot water is above the comfortable indoor temperature for your building. As a result, hot water tanks and pipes inside your building envelope will be constantly losing heat to the surrounding air. You can reduce this unwanted waste by insulating your hot water tanks and pipes. If your hot water heater is in an unconditioned space, you may be wasting energy heating the great outdoors with your hot water

tank. You can retain the energy that you are using to keep your water hot by creating an insulated room around your hot water tank.

Reducing "Standby Losses"

Keeping a tank of water hot all year long takes more energy if the tank is poorly insulated. Most of the time the tank is just "standing by," using energy to keep water hot just in case you need it. Upgrading to a tank with better insulation or wrapping insulation around a tank can reduce this waste.

Eliminating "Standby Losses"

Systems that provide hot water on demand eliminate standby losses. For low flow rates, such as for a bathroom sink, a point-of-use electric heater can heat water fast enough to provide warm water to wash your hands. These electric point-of-use systems can be extremely efficient, since they only use energy when the faucet is on.

For higher rates of flow, such as for showers, an electric heater might not be powerful enough to raise water temperature on demand. Infrequent high flow rates can be supplied by a fuel-burning on-demand water heater without standby losses.

Optimizing Your Refrigeration

In commercial settings, refrigeration is usually provided at two, three or four different temperature levels, all of which are below the comfortable temperature for an occupied building. Heat is constantly flowing into refrigerated spaces from occupied spaces.

The United States Food and Drug Administration (FDA) recommends that refrigerated food products be kept at 40 degrees Fahrenheit or lower. Bacteria become a significant health hazard at temperatures 41 F and above. To extend product shelf life and provide a margin of safety, most commercial refrigeration cases are set to 38 F. Most dairy, meat, produce and beverage display cases are set to alarm when temperatures rise above 40 F, indicating a refrigeration failure.

Some refrigerated products like fresh fish should be kept at 32 F. One strategy is to put ice in a display case that is set to 34 F or 38 F. This allows fresh fish placed on a bed of ice to remain near 32 F while the ice slowly melts. Setting the display case temperature higher than 32F prevents products from freezing and the ice from freezing into a solid block.

The FDA recommends that frozen food be kept at 0 F. Most commercial freezers are set to this temperature.

Some products require ultra-low temperatures, so in some cases a commercial facility will have freezers set to -10F or even colder depending on specific requirements.

When planning and operating your refrigeration, remember that heat is always flowing into your refrigerated spaces from the occupied areas of your building through convection (air movement), conduction (transmission through solid materials), and radiation (visible and invisible light waves).

You have many ways to improve the efficiency of your refrigeration systems:

- Have your refrigeration units thoroughly cleaned and inspected on a regular schedule. The current technology for commercial refrigeration equipment is vapor compression, which pressurizes and circulates a refrigerant between a condenser (often outdoors) and an evaporator (in the area being refrigerated or frozen). On a regular basis it's important to check the pressure of the refrigerant lines, to verify the motors and controls are working properly, and to clean the condenser and evaporator coils so they can transfer heat efficiently. In addition, it's important to inspect and clean the drains from your indoor evaporators. When air cools, it loses its abilities to hold moisture, which then condenses to liquid. Refrigeration systems must provide a way to handle this condensation. The amount of condensation produced varies depending on the humidity of the air being cooled.
- Whenever possible, place refrigeration equipment and refrigerated spaces in shade. Direct sun on a refrigerator or freezer wastes money and pushes equipment to work harder than necessary.
- Check gaskets and seals. Gravity pulls cold air out of a refrigerated space toward the floor while warm air flows into the refrigerated space near the ceiling to replace the cold air that leaks out.
- Add insulation around the refrigerated space. Newer refrigerator and freezer appliances have much better insulation than older models. An infrared thermometer can reveal areas where insulation is not performing properly.
- When buying a refrigerator or freezer appliance, look for the Energy Star symbol. According to the Environmental Protection Agency, an old refrigerator wastes 25% of the energy it uses compared to a new Energy Star model.
- For walk-in units, install a strip door curtain kit, which is a hanging set of clear plastic strips that keep air from flowing into or out of the unit even when the door is open.
- For warehouses that are serviced with fork lifts, install high-speed overhead doors that minimize infiltration and heat gain when vehicles enter and exit.
- Upgrade your door heater controls. Doors on coolers and freezers have heaters in them to eliminate fogging and condensation. Some older units run the heaters continuously, or on a timer. Efficient controls prevent fogging or condensation on doors while only running the heaters as needed. Some systems include a condensation sensor.
- Consider what you are refrigerating. Sodas and beer do not need to be kept at 38F. You can save money by raising the temperature of beverage coolers to 45F. But be sure not to place any perishable items in a beverage cooler set above 40F.
- Use the waste heat from your refrigeration system to pre-heat your hot water. Your refrigeration systems are constantly removing heat from inside your refrigerated spaces. Typically that heat is simply wasted by pumping it outside. By connecting your

refrigeration system to your hot water system, you can pump heat from your coolers and freezers into your hot water.
- Upgrade to scroll compressors. Scroll compressors are more efficient and quieter than reciprocating compressors.
- Match your compressor capacity to the desired load of coolers and freezers. By matching capacity, the compressors can reduce cycling rate and increase reliability.
- Upgrade to high-efficiency (ECM) evaporator fan motors. Evaporative fan motors work in refrigeration systems to direct air into the cooling units and then into the coolers or freezers. Not only do ECM motors use less electricity than comparable units, but in doing so, they add less heat to your refrigerated space, which eventually has to be removed.
- Upgrade to efficient evaporator fan motor controls. Evaporator fan motor controls are installed in walk-in coolers and freezers to monitor the refrigerant flow. These systems reduce the speed of an evaporator fan when the unit's compressor is turned off, reducing energy use.
- For large, walk-in spaces where frost builds up on the evaporator (cold) coils, take steps to minimize the energy used for defrost. The two biggest opportunities are to control humidity infiltration and to switch from a timed auto-defrost cycle to one that senses when defrost is needed.
- Upgrade to floating head pressure controls. Floating head pressure controls work to reduce energy used in refrigeration by decreasing the pressure exiting the compressor.

Optimizing Your Ventilation

Your ventilation system is closely tied to your building envelope and has important ramifications for your heating and cooling systems. Review the sections above for more information about how those systems interact with your ventilation system.

Efficient ventilation balances two competing goals: bringing in *more* air from outside for better air quality versus bringing in *less* air from outside for better efficiency. An active mechanical system such as a heat recovery ventilator or energy recovery ventilator along with passive ventilation systems like windows allows you to control your ventilation for best results.

A good place to start is to eliminate sources of indoor air pollution so the quality of your indoor air remains higher longer.

- Use "low" or "zero" VOC products whenever possible. Volatile organic compounds evaporate from products like paint and pollute indoor air.
- Grow indoor plants. They naturally consume carbon dioxide and release oxygen.

If you are designing a new ventilation system, your contractor should consult the detailed guidance provided by ASHRAE, the American Society of Heating, Refrigerating and Air-Conditioning Engineers. Many new recommendations have been developed as a result of the COVID-19 pandemic.

Traditionally, it has been assumed that outdoor air is healthier than indoor air. That is still generally the case. However, new filtration systems can remove allergens such as pollen and lung irritants such as particulate matter from outdoor air. In theory, with the elimination of combustion products inside a building envelope, filtration of air flow, maintenance of relative humidity between 30 and 45%, and the addition of oxygen and removal of carbon dioxide, indoor air could be healthier than outdoor air.

Several strategies can help you optimize your ventilation:

1. Control air flow through your building by sealing your building envelope so air is flowing intentionally through ducts and windows when opened, rather than unintentionally through walls and ceilings all the time.
2. Install equipment that is sized to provide the right amount of air flow.
3. Ensure a balanced air flow, so that incoming and outgoing air volumes are equivalent.
4. Install equipment with temperature, humidity and carbon dioxide sensors.
5. Install energy recovery ventilators with high-efficiency motors.
6. Use smart controls on your ventilation system to bring in outdoor air at the best time of day to satisfy heating, cooling and humidity requirements.
7. Ventilate according to occupancy using carbon dioxide sensors.
8. Inspect and clean ducts and clean and replace filters often to ensure air can flow unimpeded.

Optimizing Your Lighting

Probably the most effective way to optimize your lighting is to upgrade to light emitting diode (LED) technology. This type of lighting simply works better than older lighting technology in almost every situation and costs less to operate. Every type of lighting can now be retrofitted to use LED lamps.

Prior to the recent LED technology breakthrough and commercialization, for many decades fluorescent technology dominated in commercial spaces. Fluorescent lighting typically has two components: a ballast which is hardwired into the fixture, and a replaceable lamp (tube). LED lighting also has two components, but they are called a driver and a lamp (chip). When upgrading to LED lighting, you have three basic choices:

1. Replace the entire fixture.
2. Keep the fixture housing, but replace all of the components (lamp and ballast).
3. Keep the fixture housing and ballast, and just replace the lamp.

Fluorescent technology replaced an even older technology called incandescent lighting. The screw-in form factor for incandescent light bulbs has persisted throughout all of the technology evolution, so it is now possible to buy screw-in LED lamps that work in sockets that were designed in the early 1900s for incandescent light bulbs.

Efficiency Maine provides rebates for LED retrofit projects and instant discounts for screw-in LED lamps. Most hardware stores in Maine offer specials every week featuring the instant discounts available on LED lamps.

The only place it doesn't make sense to update to LED is in areas that experience high heat, such as lighting in a kitchen hood. The electronics in an LED circuit can be damaged by heat and humidity unless specifically designed to withstand those conditions. Many businesses have found that it is more cost effective to use incandescent lamps in hoods and ovens because that technology works well in high heat environments.

LED lighting is especially effective in freezers and other cold temperature environments. Unlike fluorescent lighting, which doesn't work well in cold temperatures, LED circuits are very happy to be cold. And unlike incandescent technology, LED lamps don't give off lots of heat.

LED lighting can instantly be turned off and on rapidly without issue, unlike fluorescent lamps and ballasts. Motion sensors work extremely well with LED fixtures.

LED chips can be dimmed, but require that the drivers that control the LED chips be designed to handle dimming. Some older and cheaper LED drivers were not designed to provide dimming. These "non-dimmable" drivers tend to strobe the LED chips if placed in a dimming circuit. Simply upgrading to dimmable drivers will solve the problem. (This often requires replacing the entire lamp, since most drivers and LED chipsets are soldered onto the same board.)

Other lighting optimization strategies include:

- Use daylight whenever possible. Windows, skylights, light tubes and fiber optics can all bring sunlight into a building to reduce the need for artificial light.
- Provide the correct amount of light for the task. The amount of light a fixture provides is measured in lumens. Choose lamps and lighting designs that provide just the right amount of lumens in the right places at the right times.
- Install dimmer circuits. Modern dimming controls that work with LED lighting reduce energy use, unlike older dimming technology.
- Use smart controls, including motion sensors and "daylight harvesting." The latter are light sensors connected to dimming controls that automatically adjust the light output of fixtures to provide the right amount of illumination.
- Install "astronomical" timers for outdoor lighting. These are affordable and reliable timers that automatically adjust the time outdoor lighting comes on based on latitude and day of year to correspond to sunset and sunrise.

Optimizing Your Compressed Air

Efficiency Maine provides incentives for the following optimizations for compressed air systems:

- **High-Efficiency Compressor Systems:** Multiple stage compressors vary their speed to match load. Switching to a variable speed compressor can result in significant energy savings.
- **High-Efficiency Dryers:** Dryers help remove the moisture in the air, increasing the efficiency of compressed air production and reducing energy load. Select the drying technology that gives you the maximum allowable pressure at dew point.
- **Compressor Controls:** Compressed air requirements may change over time or vary between shifts. Compressor controls allow compressor speed to vary to match need.
- **Air Compressor Receivers:** Air receivers are designed to provide a buffer capacity between the supply and the demand sides of a compressed air system. Having enough storage capacity near the compressor plant protects the compressors and dryers from sudden shifts in demand. They also prevent false loading of the compressors.
- **Low-Pressure Drop Filters:** The filter is a typical place where the air distribution system loses pressure; pressure drops can significantly reduce system performance. If you lose more than 0.5 psig at the filter, consider replacing the filter.
- **Air-Entraining Nozzles:** Air-entraining air nozzles draw in (or entrain) surrounding atmospheric air, reducing compressed air use at the nozzle.
- **Lower the Setpoint**: Be sure you have the compressor set point set to the pressure possible. If only one load on the system requires a high pressure (eg 90 psi) and the rest of the equipment only requires 50 or 60 psi, consider a dedicated high pressure compressor for that one load, then reduce the pressure of the system. As a rule of thumb, you reduce compressor energy consumption by 1% for every 2 psi you reduce the setpoint.
- **Optimize the Distribution:** If you find you need a pressure set point more than 10-15 psi above the highest required load, consider replumbing the distribution system to have larger pipes to reduce pressure drops at high flow rates.
- **Stop the Leaks**: It is imperative that you have a systematic and utilized program to identify and eliminate leaks in the compressed air distribution system. This is best done during breaks or between shifts since the operation of the plant often overwhelms the sound of air leaks. Consider the use of an ultrasonic leak detector to help identify leaks in hard-to access locations such as the ceiling spaces.

Optimizing Your Pumps, Fans and Compressors

Pumps and fans use electric motors to move liquids and gasses. Compressors use electric motors to pressurize gasses. They are not only used for compressed air systems, but they are also found in most air conditioning, refrigeration, and heat pump equipment, and are a critical part of a number of agricultural operations, particularly on dairy farms.

Three basic optimization strategies are

1. Improve your controls so you are running motors less frequently.
2. Upgrade to high-efficiency motors.
3. Upgrade from an "on-off" system to a variable-speed system.

Check if you have older reciprocating compressors and can upgrade to scroll compressors. According to Efficiency Maine, "Newer scroll compressor systems typically save 15 to 25 percent of electrical costs over reciprocating compressors, and are quieter and more reliable than traditional reciprocating compressors."

When you upgrade a compressor, be sure to match capacity to the load. By matching capacity, the compressor can reduce cycling rate and increase reliability.

Optimizing Your Vehicles

In the near future, the best way to optimize your vehicles will be to upgrade to battery electric vehicles. Electric vehicles are already up to five times more energy efficient than gas-burning vehicles, and announced improvements to battery technology will increase that ratio.

In the meantime, you can optimize your use of fuel-burning vehicles:

- Reduce unnecessary travel by adopting tools and procedures that facilitate remote work.
- Slow down and drive conservatively. A government study found, "Aggressive driving (speeding, rapid acceleration and braking) ... can lower your gas mileage by roughly 15% to 30% at highway speeds and 10% to 40% in stop-and-go traffic."
- Haul cargo inside vehicles whenever possible. According to the US Department of Energy, "Hauling cargo on your roof increases aerodynamic drag (wind resistance) and lowers fuel economy. A large, blunt roof-top cargo box, for example, can reduce fuel economy by around 2% to 8% in city driving, 6% to 17% on the highway, and 10% to 25% at Interstate speeds (65 mph to 75 mph). Rear-mount cargo boxes or trays reduce fuel economy by much less—only 1% or 2% in city driving and 1% to 5% on the highway. If you need to use an external cargo container, removing it when it's not in use will save fuel and money."
- Ensure all tires are inflated to the proper pressure. Another government study found, "With all four tires at 75% of the recommended pressure, a vehicle’s fuel economy is about 2-3% lower. Vehicles with tires inflated at 50% of the recommended pressure used 5–10% more fuel. It should be noted that underinflated tires not only waste fuel but also pose serious safety risks."
- Remove excess weight. For light-duty vehicles, an extra 100 pounds of unnecessary cargo wastes 1% of the fuel burned.

You can measure progress by calculating your average fuel economy across your fleet of company vehicles. Add up the total distance you drive by recording the starting and ending values of the odometers on your company vehicles, and add up the total amount of fuel you purchase. Your total miles divided by your total fuel consumption is your average fuel economy.

Electrifying Your Equipment

When you electrify all of your vehicles and equipment, you eliminate all of your direct emissions from fossil fuel, achieving a major milestone toward being powered by 100% clean energy. You simplify your operations by eliminating the need to buy, store and distribute fuel. Also, you improve the safety of your facilities by eliminating the risk of carbon monoxide poisoning and the risk of explosions from gas leaks.

In many cases, you will have electrified your equipment as you optimized your efficiency. Electric vehicles are four to five times more efficient than gasoline or diesel vehicles. Electric heat pump heating systems are two or three times more efficient than fuel-burning equipment. Electric equipment is usually more reliable, quieter and safer.

Electric Vehicles

Virtually all major vehicle manufacturers have announced plans to build electric vehicles for every vehicle type, up to and including class 8 heavy duty trucks weighing over 33,000 pounds. One reason is that electric motors can be extremely powerful and efficient. Very large turbo-electric propulsion systems, such as for locomotives and nuclear-powered ships, use electric drive systems.

When making the transition to electric vehicles, consider the following:

- The most convenient way to charge a vehicle is to plug it in overnight. Standard commercial electric power of 240 or 208 volts is sufficient for overnight charging. Higher voltage chargers are generally not necessary when vehicles can be charged every night.
- An electric vehicle that is plugged into a 240 or 208 volt outlet overnight will start the day fully charged. For most electric cars and light-duty vans built in 2020 or later, this means at least 200 miles of range.
- Rapid charging during the day is typically not necessary for most commercial vehicles. Rapid charging at a special high-voltage station is only necessary if an electric vehicle will be driven more than its range in one day.
- Electric vans and work trucks will be able to plug in at job sites to recharge. For job sites without power they can act as a giant battery to power and recharge electric tools.
- Electric vehicles deliver far better reliability with far less maintenance than internal combustion vehicles, but still require replacing window washer fluid, aligning and rotating wheels, and replacing cabin air filters.
- Solar panels on site can charge battery electric vehicles directly from sunlight. If you have a parking lot, you can cover it with a solar structure to provide shade, shelter from rain and snow, and energy to charge electric vehicles and power nearby buildings.
- Recent federal legislation has allocated money to further develop the chagrin infrastructure, which is already fairly robust throughout New England. In addition, there are more tax credits available for businesses to adopt electric vehicles, making them more affordable than ever.

In addition to electrification, most vehicle manufacturers are also working on autonomy, which allows electric vehicles to drive themselves. Once the software is developed, it will be possible for millions of vehicles to be updated overnight to drive themselves.

There are two major types of fully electric vehicles. The most prevalent are battery electric vehicles. Less prevalent are fuel cell electric vehicles, which combine hydrogen with oxygen to produce electric power. Fuel cells can be designed to use methane (natural gas) as a source of hydrogen, or pressurized hydrogen gas. All electric vehicles have a rechargeable battery and one or more motors. Fuel cell electric vehicles add an on-board fuel cell to recharge the battery. This adds weight, complexity and cost.

Toyota is the last major car manufacturer pursuing hydrogen fuel cell passenger electric vehicles in addition to battery electric passenger vehicles. Hydrogen fuel cell vehicles are not likely to be available in Maine in the next five years, unlike battery electric vehicles which are already here. According to the US Department of Energy's Alternative Fuels Data Center, of the 48 hydrogen fueling stations in the United States in 2021, forty-seven are in California and one is in Hawaii. The same source lists two hundred and seventy-three public electric vehicle charging stations currently available in Maine.

Hybrid vehicles are partially electric vehicles. They have a rechargeable battery and one or more electric motors plus a fuel tank and an engine that burns gasoline, diesel, natural gas or another fuel to recharge the battery, provide traction power, or both. Some hybrid vehicles can be plugged in like a battery electric vehicle. An advantage of hybrid vehicles is that they can be refueled quickly. The major disadvantage is the higher complexity and lower reliability compared to a battery electric vehicle.

Electric Heat Pumps

Cold-climate heat pumps have become practical in recent years. More progress is expected thanks to the U.S. Department of Energy's 2021 Cold Climate Heat Pump Technology Challenge to improve the performance of future generations of heat pumps. It is now possible to heat and cool most commercial buildings in Maine solely with heat pump systems and no fossil fuel. (A few very efficient buildings don't even need heat pumps; simple electric heaters are sufficient.)

For poorly constructed, drafty buildings, heat pumps may struggle to maintain temperatures in very cold or very windy conditions. While far more efficient, heat pumps are typically less powerful than fuel-burning heating systems, which means they take longer to reach setpoint temperatures in cold weather. (One more reason not to use setbacks with heat pumps.) Deficiencies in a building envelope are often masked by traditional fuel-burning systems, but become more obvious when using heat pumps. It was common practice among Maine's heating contractors to oversize boilers to avoid callbacks, rather than to weatherize or insulate buildings.

Vapor compression is currently the dominant technology used by heat pump systems. This type of system uses electricity to pressurize and circulate a refrigerant in a closed loop through four components: 1) a compressor, 2) a condenser, 3) an expansion valve, and 4) an evaporator. A compressor pressurizes vapor, heating it above ambient temperature, and pumps it through a condenser so it gives off heat and condenses to a liquid until the fluid reaches an expansion valve. On the cold side of that valve, a pressure drop cools the fluid below ambient temperature. The cold fluid gets sucked through an evaporator where it collects heat and evaporates back to vapor on its way back to the compressor.

Running a pump to circulate fluid in a loop moves heat that is absorbed by the cold side and released by the hot side. The phase change between vapor and liquid allows a relatively small amount of refrigerant to move a relatively large amount of energy. Each unit of energy used to pressurize and circulate the refrigerant can collect and release much more heat than if that energy were used directly for heating or cooling.

Air conditioners are heat pumps that permanently work in one direction only, collecting heat from inside a building and releasing it outside. Reversible heat pumps, such as mini-splits, can work in both directions. During the summer their cold side is indoors and their hot side is outdoors. Reversing the refrigerant flow in the winter makes the cold side outdoors and the hot side indoors. In a reversible heat pump unit, a condenser can serve double duty as an evaporator, and vice versa, depending on which way refrigerant is flowing through the system.

The most common type of reversible small heat pump system is called a "ductless mini-split." These systems have two main components: the indoor "head" which can mount on a floor, wall or ceiling, and the outdoor "compressor" which mounts on the ground, roof, or side of a building. Holes drilled through your building envelope connect the components with a "lineset" containing refrigerant tubes and power. Power and a cut-off switch is provided for the outdoor unit. A drain line is installed for the indoor head when it is operating in cooling mode. Condensate from the outdoor compressor typically simply drips onto the ground or roof.

Indoor units for mini-split heat pump systems have fans that blow air past coils which are heated or cooled depending on the direction of refrigerant flow. Sometimes more than one indoor head can be connected to each outdoor compressor. Usually in these multi-headed systems, all of the indoor units must be in the same mode, either heating or cooling.

Mini-split systems often have several modes of operation. When the systems are in cooling mode, an indoor fan blows air past cold coils in the indoor units, an outdoor fan blows air past hot coils in the outdoor unit, and the compressor pressurizes and circulates refrigerant between the two sets of coils to make one hot and the other cold. Condensation naturally forms on the cold coils, drips down and drains either by simple gravity or with the help of a drain pump.

In heating mode, the two sets of fans and compressor are all again in operation, but in this case the indoor coils are hot and the outdoor coils are very cold. When temperatures are below freezing, any condensation that forms on the outdoor coils can't simply drip down and drain

away. It freezes to the coils instead. Periodically the system must go through a defrost cycle to melt frozen condensate off the outdoor coils.

Some units have a ventilation mode that simply runs the fans on the indoor units to circulate air in the room.

Larger heat pump systems are often connected to ducting, so that fans can move warm and cool air from one central location to many areas throughout a building. There are also "air-to-water" heat pump systems that collect heat from outdoor air and release it to a hydronic heating distribution system, and "geothermal ground-source" heat pumps that collect heat from pipes underground.

Although virtually all heat pumps on the market today use vapor compression technology, there are many variations on the basic technology that can improve its efficiency. Most of these variations have to do with how the outdoor compressor unit operates, allowing it to move more heat using less electricity. In the future, "solid state" heating systems will likely replace today's vapor compression systems and deliver greater efficiency and reliability using a completely different process to move heat between source and sink. But for now, the solid state systems on the market are more expensive and less powerful than vapor compression systems.

Four different ratings can help you compare the efficiency of a heat pump system:

1. **SEER:** Seasonal Energy Efficiency Rating is the most commonly used efficiency rating for heat pumps in cooling mode and air conditioners. This focuses on cooling performance.
2. **HSPF:** Heating Seasonal Performance Ratio is used to measure a heat pump's heating efficiency. This rating does not apply to air conditioners.
3. **EER:** Energy Efficiency Ratio is the cooling efficiency for ductless mini-splits.
4. **COP:** Coefficient of Performance is a measure of the ratio between the amount of useful cooling or heating delivered and the energy usage of the compressor. A high COP value represents a high efficiency.

Efficiency Maine provides rebates for systems with high efficiencies. For current minimum HSPF standards to qualify for rebates, check the Efficiency Maine website at https://www.efficiencymaine.com/at-work/commercial-heat-pump-program/

Electric Hot Water Heat Pumps

If you currently operate equipment that burns fossil fuel to produce hot water, you can eliminate emissions by replacing that equipment. While conventional electric water heaters have been around almost as long as electricity, a number of other "fossil-fuel-free" approaches have been tried over the years, including solar hot water systems that circulate glycol through tubing and collectors on rooftops. Other approaches, such as tankless heaters that burn propane or natural

gas, reduce but do not eliminate emissions. The current best practice is to use a tank heated by an electric heat pump for hot water to eliminate all emissions from fossil fuel.

Electric hot water heat pumps use electricity more efficiently than conventional electric hot water heaters. They cool and dry the air surrounding a hot water tank, moving heat from ambient air to water inside a tank. If your building requires air conditioning, an electric hot water heat pump will help out your air conditioning units and use waste heat for a productive purpose.

Because heat pump hot water systems take heat from the surrounding air, they work best when the tank is in a heated space. The efficiency of the heat pump declines when ambient air temperature declines.

Rebates are available from Efficiency Maine. According to their website as of Q4 2021, "Each year, thousands of heat pump water heaters are installed in Maine. These high-efficiency units can save more than $3,000 over the life of the unit compared to electric water heaters. Heat pump water heaters typically have 10+ year warranties. Other benefits include a heat pump water heater's ability to dehumidify the space where it's located. Efficiency Maine offers a $850 rebate for qualifying heat pump water heaters."

Electric Induction Cooktops

Electric induction cooktops offer faster heating and better control than propane, natural gas, or conventional electric cooktops. These systems use rapidly reversing magnetic fields to directly heat metal pots and pans, allowing you to cook without burning any fossil fuel.

Electric induction cooktops do have some limitations, however:

- Only magnetic cookware becomes hot when placed on an induction pad.
- Cooking techniques that require open flame are not possible.
- Some flavor profiles related to the byproducts of combustion cannot be reproduced.

Manufacturers and distribution of induction cooking equipment for commercial kitchens point to five significant advantages compared to gas equipment:

1. **Faster**
   An electric induction range transfers energy directly to the pan metal. An electric current runs through the coil, generating a fluctuating magnetic field. There is no heat on the burner. Placing a pan in the magnetic field induces currents in the pan's metal. Faster cooking means greater profits in a commercial kitchen.
2. **Cooler**
   Traditional electric and gas ranges waste energy because they directly heat a burner and ambient air and only indirectly heat the vessel being used for cooking. With an electric induction range, heat is generated within the metal of the pan itself. No energy is wasted heating a burner or ambient air.

3. **Cleaner**
   Cleaning up an induction cooktop is simple. Just wipe it with a damp cloth. There are no grease or grates to worry about.
4. **Safer**
   The cooktop stays cool to the touch. There is no red hot coil or open flame that may burn exposed flesh, or ignite flammable materials or fumes. Without gas burning, the risk of carbon monoxide poisoning is eliminated. When a pan is removed from the cooking surface, the cooktop automatically goes into standby mode. You'll never have to worry about someone forgetting to turn off a burner or accidentally leaving the gas on.
5. **Cheaper**
   Compared to traditional electric or gas ranges, induction cooking is more energy efficient. Energy is transferred directly to the surface that does the actual cooking. Less energy is wasted as hot air coming off the burner. On top of that, automatically going into standby mode when a pan is removed from the cooking surface helps save energy.

Gas cooktop equipment can easily be replaced by electric induction equipment, but may require an additional electric circuit to be run. Codes almost always require hoods for gas-burning cooking equipment in commercial spaces. Your local code may or may not require a hood over an electric induction cooktop. Hoods are still a good idea in case of steam, smoke and grease fires (which are unlikely but possible).

Solarizing Your Energy Supply

Once you've optimized your use of energy, electrified your equipment, and completely "solarized" your energy supply, your business is powered by 100% clean energy. This handbook uses the term "solarize" in a broad sense to mean to harness renewable energy sources that rely on the sun for power. That includes solar power, wind power, hydropower and biofuel such as wood, biodiesel and renewable natural gas. All of those renewable energy sources stem from sunlight that reaches the Earth's lower atmosphere and surface.

Efficiently operating your business with electrified equipment eliminates all fossil fuel emissions on your property. But if your electricity supplier burns fossil fuel to generate electricity for you, that just shifts emissions from one place to another. Solarizing your energy supply eliminates those emissions, too.

Electricity Supply

Maine has deregulated our electricity market, which means companies can compete to supply electricity to the grid. You can choose who supplies electricity for you and how they generate that electricity. Selecting a 100% "green" electricity supply means no fossil fuel is burned to produce electricity for you.

Community Solar Farms

In addition to allowing electricity consumers to choose their own electricity supplier, Maine law provides for solar net metering electricity. Under this system, you can buy the output of a solar farm. For each kilowatt-hour the farm produces, you can deduct one kilowatt-hour from your electric bill. The effect of this is to pay a solar farm to produce electricity for the grid, reducing the amount of fossil fuel that would otherwise be burned to produce electricity.

Solar Panels On Site

One of the great things about electricity is that it's easy to generate using panels that directly convert sunlight into electricity. You can collect solar energy and produce electric power from panels on rooftops, window shades, awnings, carports and ground-mounted poles.

The most common type of solar electricity system uses photovoltaic panels to convert light to direct current (DC) electric power. An inverter then converts that DC power into alternating current (AC) power that is compatible with our electrical grid. The solar electricity you generate can be stored in a battery, used on location by your electric equipment, or shared with your neighbors.

Every kilowatt-hour of electricity you generate yourself from sunlight is one less kilowatt-hour you need to buy, and one less kilowatt-hour that needs to be generated from fossil fuel.

Renewable Fuel

Fuel is material that you can burn to release heat. If you electrify *all* of your equipment, you will not need to burn *any* fuel. But if you are unable to electrify all of your equipment you may need to substitute renewable fuel for fossil fuel.

Living systems use the sunlight that reaches the Earth's surface to combine atoms into carbohydrates and other molecules ("**biomass**") that can be processed into renewable fuel for distribution and storage, then later burned to release the stored energy. Replacing fossil fuel with renewable fuel is one way to solarize your business and reach the goal of 100% clean energy.

The typical reason most small business owners decide to switch to renewable fuel rather than to electrify their equipment to reach 100% clean energy is that they have made large capital investments in systems such as coffee roasters and paint drying systems that were designed to burn methane (natural gas). Although every system that burns fuel can be replaced by a system that uses electricity, it is sometimes not practical to make this switch after you have made a large investment in fuel-burning infrastructure.

Before making an investment in a fuel-burning system, carefully consider the electric alternatives. Every system that burns fuel can be re-engineered to use electricity. Once re-engineered, electric systems provide higher efficiency and better control. Very few fuel-burning technologies will remain cost competitive over the next decade, especially as our economy makes the transition away from fossil fuel. The fundamental reason for this is that all renewable fuels are derived from solar energy. Taking into account all costs, it will always be more affordable to use solar energy directly in the form of electricity, rather than to produce renewable fuel from solar energy and then burn it.

References

Campaign Definition of "Clean Energy"

Our campaign uses the term "clean energy" in a broad sense to mean all renewable energy sources that rely on the sun for power, plus a few additional sources of renewable energy. When you "solarize" your energy supply, your options include solar power, wind power, hydropower and renewable fuels. All of those renewable energy sources stem from sunlight that reaches the Earth's lower atmosphere and surface. Tidal power and geothermal power are additional clean energy sources that do not derive from solar energy, but are not expected to contribute much to Maine's energy supply in the next decade. In 2019 the use of nuclear power peaked in the United States. Unless we make dramatic technology and policy changes, nuclear power will not be a significant source of energy available in New England in time to help Maine achieve a carbon neutral economy by 2045.

Renewable fuels like wood and biogas do emit pollution when you burn them. But the carbon in those fuels comes from our atmosphere, because plants use energy from sunlight to capture carbon dioxide to grow. Burning renewable fuel releases that carbon back into our atmosphere. This cycle can be sustainable, if managed well; the overall renewable fuel **carbon cycle** can be in balance. Therefore, for the "On the Pathway to Clean Energy" project, renewable fuel is "clean" energy because it doesn't have the same carbon pollution forcing effect as fossil fuel.

Coal, oil and natural gas, found in limited quantities underground, cannot be burned in a sustainable way. Burning fossil fuel destroys finite resources and moves carbon from the ground to our air and water more rapidly than natural processes can sequester that carbon. Excess carbon is accumulating as carbon dioxide in our atmosphere and ocean.

Even if artificial carbon capture technology could mitigate carbon pollution from fossil fuel, it would still be smarter to use our limited coal, oil and gas resources to make steel, plastic, fertilizer, pharmaceuticals and other products rather than destroy these reserves by burning them. Being on the pathway to clean energy helps solve the serious and destructive problems associated with the fossil fuel cycle.

Directory

(This partial list will continue to be expanded in new editions of the Guidebook.)

- **Coastal Enterprises, Inc. (CEI)**
  Coastal Enterprises, Inc. (CEI) is a nonprofit community development financial institution with a mission to grow good jobs, environmentally sustainable enterprises and shared prosperity in Maine and rural regions throughout the United States. CEI provides loans, equity and tax credit financing.
  www.ceimaine.org

- **Efficiency Maine**
  The Efficiency Maine Trust is the independent administrator for programs to improve the efficiency of energy use and reduce greenhouse gases in Maine. The Trust does this primarily by delivering financial incentives on the purchase of high-efficiency equipment or changes to operations that help customers save electricity, natural gas and other fuels throughout the Maine economy.
  www.efficiencymaine.com

- **Maine Solar Solutions**
  Maine Solar Solutions designs, installs, and services solar electric systems throughout Maine. We help homeowners and business owners lower their utility costs and gain energy independence by switching to solar power.
  www.mainesolarsolutions.com

- **ReVision Energy**
  ReVision Energy is a full-service renewable energy contracting company that provides a full range of engineering, design, installation and equipment service for homes, businesses, municipal buildings and nonprofits.
  www.revisionenergy.com

- **Spark Applied Efficiency**
  Spark Applied Efficiency is a full-service electrical and mechanical contracting firm serving commercial clients in southern Maine. Services include HVAC and refrigeration design-build-maintain services, greenhouse construction, LED retrofits, heat pump installation and maintenance, electric vehicle charging stations, and more.
  www.sparkae.com

Electric Vehicles

Here are some of the battery electric vehicle models in production or pre-production for the North American market. Efficiency Maine currently offers rebates for certain electric vehicles, and there is a federal tax credit available for some models as well.

Hatchbacks

- Chevrolet Bolt EV
- Hyundai Ioniq Electric
- Mini Cooper Electric
- Nissan Leaf

Sedans

- Polestar 2
- Porsche Taycan
- Tesla Model S
- Tesla Model 3

SUVs and Crossovers

- Audi e-tron
- BMW iX
- Bollinger B1
- Chevrolet Bolt EUV
- Ford Mustang Mach-E
- Hyundai Kona Electric
- Kia Niro EV
- Rivian R1S
- Tesla Model X
- Tesla Model Y
- Volvo C40 Recharge
- Volvo XC40 Recharge
- VW ID.4

Commercial Vans

- Canoo MPDV
- Ford E-Transit
- GM BrightDrop EV600
- Mercedes-Benz eSprinter
- Rivian RCV

Light-Duty Trucks

- Bollinger B2
- Chevrolet Silverado EV
- Ford F-150 Lightning
- GMC Hummer EV
- Rivian R1T
- Tesla Cybertruck

Heavy-Duty Trucks

- Bollinger Commercial
- Freightliner eCascadia
- Freightliner eM2
- Kenworth T680E
- Peterbilt Models 220EV, 520EV, 579EV
- Tesla Semi

Funding and Free Advice

Coastal Enterprises, Inc. (CEI)

Financing/Loans

- CEI offers a range of loan products for both start-ups and established businesses:
    - Wicked Fast loans of up to $25k ($15k for start-ups) with a 3-business day decision window and a streamlined application process.
    - Microloans (<$50k) up to $1MM+ business loans.
    - Loans for predevelopment, construction and bridge financing, renewable energy projects, and financing for public facilities.
- Loan applications are available in English, Spanish, French, Portuguese, Somali and Arabic.

Business Advising

- CEI offers business and industry expertise to business owners through free one-on-one consultations, trainings, workshops, seminars, peer networks, and other services.
- In addition to general business assistance, CEI has specific programs for women, marine-related businesses, farms and food businesses, and refugees and immigrants.

Human Resources Strategies

- CEI's Workforce Solutions team can assist CEI loan/investment clients with free recruitment, training and retention strategies.
- CEI's workforce experts will work with you one on one at no cost – contact: workforce@ceimaine.org.

Sustainability Advising

- CEI can connect you to rebate programs, local installers, and technical assistance, as well as provide the financial expertise to help you save money and go green.
- Linnea Patterson <Linnea.Patterson@ceimaine.org>, CEI's environmental lending specialist, can help you assess the value of clean energy improvements (e.g., solar, heat pumps) for your business.

Efficiency Maine

Efficiency Maine has rebate programs for businesses of all sizes, including multifamily buildings with five units or more. It also has a loan program for small businesses.

Fixed Rebates

Efficiency Maine's Commercial & Industrial Prescriptive Program offers "prescriptive incentives" to reduce the cost of equipment and projects that help your business use energy more efficiently. *Note: Efficiency Maine's commercial & industrial rebate programs change every ninety days. Information is current as of December 2021.*

- **Electric Vehicles:** Instant and mail-in rebates for qualifying electric vehicles at participating dealers or purchased directly from the manufacturer.
- **Heating:** Rebates on heating equipment for central heating systems (including high-efficiency boilers and furnaces); supplemental or space heating systems (including heat pumps); and controls (including programmable thermostats). Systems can be fueled by natural gas, oil, and propane and can include ductless heat pumps and variable refrigerant flow systems.
- **Cooling:** Rebates on cooling equipment for certain types of air-to-air heat pumps and variable-frequency drive systems.
- **Heating and Cooling:** Rebates on heat pumps, including high-performance heat pumps, variable refrigerant flow systems, packaged terminal heat pumps, vertical packaged terminal heat pumps, and water source heat pumps.
- **Ventilation:** Rebates on energy recovery ventilator systems, including rotary heat exchangers, plate heat exchangers, heat pipe heat exchangers and runaround coil heat exchangers.
- **Refrigeration:** Rebates on refrigeration equipment, including scroll compressors, high-efficiency evaporator fan motors, strip curtains, door heater controls, evaporator fan motor controls, and floating head pressure controls.
- **Lighting:** Rebates on LED lighting and controls for retrofit projects that upgrade existing lighting, as well as instant rebates for new screw-in LED lamps.
- **Water Heating:** Rebates on heat pump water heaters and electronically commutated motors for recirculation pumps.
- **Compressed Air:** Rebates on compressed air solutions, including high-efficiency compressor systems, high-efficiency dryers, compressor controls, air compressor receivers, low-pressure drop filters, and air-entraining nozzles.
- **Commercial Kitchens:** Rebates on commercial kitchen solutions, including demand control kitchen ventilation.
- **Agriculture:** Rebates on agricultural solutions, including indoor horticultural lighting, milk scroll compressors, milk vacuum pumps with adjustable speed drives, and potato ventilation fans with adjustable speed drives.

Small Business Energy Loans

Financing is available for eligible small business owners upgrading to high-performance heat pumps and variable refrigerant flow (VRF) systems. Any business that is registered as a "Small

General Service" (SGS) or "General Service" (GS) electricity customer may be eligible for these loans.

- Loans may only be used for costs of purchasing and installing qualifying heat pumps and variable refrigerant flow systems approved through, and consistent with, Efficiency Maine's Small Business Initiative.
- Amount of loans may be as low as $2,000 or as high as $10,000 per customer location.
- The interest rate for financing through this initiative is 4.99%, requiring no money down and no closing fees.
- The term of the loan may be either 12 months, 24 months, or 36 months.
- There is no pre-payment penalty.

Custom Rebates

The Efficiency Maine Commercial & Industrial Custom Program incentivizes tailored energy efficiency and distributed generation projects that require site-specific engineering analyses and/or projects with energy conservation measures that are not otherwise covered by fixed rebates. Funding levels range from a minimum of $10,000 to a maximum of $1 million per customer. Additional restrictions apply.

Glossary

The **2015 International Energy Conservation Code** has been adopted as the Maine Uniform Building and Energy Code Board. Some municipalities, such as Portland, have adopted the 2021 version of this code. According to Mainebiz, "The United States Department of Energy has determined that the 2015 IECC is 20% to 25% more efficient than the 2009 code, and the 2021 IECC is 10% to 15% more efficient than the 2015 Code." These building codes specify requirements such as minimum standards for heating system efficiencies, minimum performance requirements for insulation and windows, and methods for testing the air tightness of a building.

Biomass is material that comes from plants and animals. According to the United States Energy Information Administration, "Biomass contains stored chemical energy from the sun. Plants produce biomass through photosynthesis. Biomass can be burned directly for heat or converted to renewable liquid and gaseous fuels through various processes."

Carbon credits are a way to offset your carbon footprint. The core idea is that you pay someone else to do something that you believe will reduce carbon emissions. You can claim to be **net zero** by subtracting enough carbon credits from your own carbon footprint.

Carbon footprint is a measure of how much carbon dioxide emissions you are responsible for. This includes **scope 1** direct emissions from fuel you burn yourself, **scope 2** indirect emissions from fuel burned to produce electricity for you, and **scope 3** emissions from fuel other people burn in order to do business with you. Often, emissions of gasses other than carbon dioxide are converted to a global warming equivalent in terms of carbon dioxide, and all of these emissions are considered part of your carbon footprint.

Carbon emissions are pollution from burning fuel and other activities that release carbon dioxide into the atmosphere. The main products of burning fossil fuel are water and carbon dioxide.

Clean energy is defined by our campaign as all renewable energy sources that rely on the sun for power, plus a few additional sources such as tidal and geothermal power.

Fossil fuel is coal, petroleum (and refined derivatives such as kerosene, diesel, gasoline and propane), and natural gas from very old deposits of biomass that have accumulated over millions of years in the Earth's crust.

An **energy recovery ventilator** is a type of air-to-air heat exchanger that transfers sensible heat as well as latent heat from humidity in the air. A stream of outgoing air passes next to a stream of incoming air in a way that allows both temperature and moisture to transfer between the air streams. The main advantage to this type of ventilation is energy savings, because the outgoing airstream tempers the incoming air, reducing the amount of heating, cooling, and dehumidifying that other systems must do to maintain indoor comfort.

A **heat recovery ventilator** is an air-to-air heat exchange that transfers sensible heat only, not latent heat in moisture. In this type of ventilator, streams of outgoing and incoming air can exchange heat but not moisture content.

LED (light emitting diode) lighting is lighting that is based on chips that directly convert electricity to light. It is much more efficient and rugged than other lighting technologies.

Scope 1 emissions are direct emissions from fossil fuel you burn yourself.

Scope 2 emissions are indirect emissions from fossil fuel burned to produce electricity for you.

Scope 3 emissions are indirect emissions from fossil fuel by other people to do business with you.

Renewable Fuel

Most of the discussion below is taken from the United States Department of Energy's Alternative Fuels Data Center website at https://afdc.energy.gov/

Biogas

Biogas is produced from various biomass sources through a biochemical process, such as anaerobic digestion, or through thermochemical means, such as gasification. With minor cleanup, biogas can be used to generate electricity and heat. To fuel vehicles, biogas must be processed to a higher purity standard. Processed biogas is called renewable natural gas.

Biogas from Landfills

Landfills are the third-largest source of human-related methane emissions in the United States, according to the U.S. Environmental Protection Agency (EPA). Biogas from landfills is also called landfill gas (LFG), as the digestion process takes place in the ground rather than in an anaerobic digester. As of June 2020, there were about 564 operational LFG projects in the United States. Most of these projects use biogas to produce electricity rather than to power natural gas vehicles or to supply natural gas pipelines.

Biogas from Livestock Operations

Biogas recovery systems at livestock operations can be used to produce renewable natural gas. Animal manure is collected and delivered to an anaerobic digester to stabilize and optimize methane production. The resulting biogas can be burned for electricity or processed into renewable natural gas and used to fuel natural gas vehicles or supply a natural gas pipeline.

Biogas from Wastewater Treatment

Biogas can be produced during the digestion of solids removed in the wastewater treatment process. According to EPA estimates, this biogas potential is about 1 cubic foot of digester gas per 100 gallons of wastewater. Energy generated at U.S. wastewater treatment plants could potentially meet 12% of the national electricity demand, according to a study released by the National Association of Clean Water Agencies and the Water Environment Federation.

Other Sources of Biogas

Other sources of biogas include organic waste from industrial, institutional, and commercial entities, such as food manufacturing and wholesalers, supermarkets, restaurants, hospitals, and educational facilities. Biogas can also be produced from lignocellulosic material (such as crop residues, woody biomass, and dedicated energy crops) via thermochemical conversions, co-digestion, and dry fermentation. These technologies are underway in Europe, with limited applications in the United States.

Biodiesel

Biodiesel is a domestically produced, renewable fuel that can be manufactured from vegetable oils, animal fats, or recycled restaurant grease for use in diesel vehicles or any equipment that operates on diesel fuel. Biodiesel's physical properties are similar to those of petroleum diesel, but different enough that it can cause some problems in cold weather and in some equipment. A particular concern is that biodiesel can dissolve certain types of rubber and plastic components.

Biodiesel and renewable diesel are not the same fuel. Biodiesel is a mono-alkyl ester produced via transesterification. Biodiesel meets ASTM D6751 and is approved for blending with petroleum diesel. Renewable diesel is a hydrocarbon produced through various processes such as hydrotreating, gasification, pyrolysis, and other biochemical and thermochemical technologies. It meets the ASTM D975 specification for petroleum diesel and is approved to completely replace petroleum diesel.

Ethanol

Ethanol is a renewable fuel made from corn and other plant materials. Ethanol use is widespread, and more than 98% of gasoline in the U.S. contains some ethanol. The most common blend of ethanol is E10 (10% ethanol, 90% gasoline). E15, another blend, is increasing its market presence. Ethanol is also available as E85—a high-level ethanol blend containing 51% to 83% ethanol, depending on geography and season—for use in flexible fuel vehicles.

Renewable hydrocarbon biofuels

Renewable hydrocarbon biofuels can be produced from various biomass sources. These include lipids (such as vegetable oils, animal fats, greases, and algae) and cellulosic material (such as crop residues, woody biomass, and dedicated energy crops). Currently, the United States has limited commercial-scale production of renewable hydrocarbon biofuels. Where production is occurring, commercial facilities largely focus on renewable diesel production.

Renewable Natural Gas

Renewable natural gas (RNG) is a pipeline-quality gas that is fully interchangeable with conventional natural gas and thus can be used in natural gas vehicles and natural gas appliances. RNG is essentially biogas (the gaseous product of the decomposition of organic matter) that has been processed to purity standards. Like conventional natural gas, RNG can be used as a transportation fuel in the form of compressed natural gas or liquefied natural gas. RNG qualifies as an advanced biofuel under the Renewable Fuel Standard.

Renewable Diesel

Renewable diesel is a biomass-derived transportation fuel suitable for use in diesel engines. It meets the ASTM D975 specification for petroleum in the United States and EN 590 in Europe. It is a commercial fuel produced in the United States and imported from Asia. Five plants produce renewable diesel in the United States, with a combined capacity of nearly 400 million gallons

per year. Nearly all domestically produced and imported renewable diesel is used in California due to economic benefits under the Low Carbon Fuel Standard.

Biobutanol

Butanol, a 4-carbon alcohol (butyl alcohol), is produced from the same feedstocks as ethanol, including corn grain and other biomass. The term biobutanol refers to butanol made from biomass feedstocks. The benefits of biobutanol, when compared with ethanol, are that biobutanol is immiscible in water, has a higher energy content, and has a lower Reid vapor pressure. Under the Renewable Fuel Standard, corn grain butanol meets the renewable fuel 20% greenhouse gas emission reduction threshold.

Renewable Gasoline

Also known as biogasoline or "green" gasoline, renewable gasoline is a biomass-derived transportation fuel suitable for use in spark-ignition engines. It meets the ASTM D4814 specification in the United States and EN 228 in Europe.

Sustainable Aviation Fuel

Sustainable Aviation Fuel (SAF) is a fuel derived from renewable resources that enables a reduction in net life cycle carbon dioxide emissions compared to conventional fuels. SAF is the preferred, now commonly used term for non-petroleum synthesized jet fuel components produced to the definitions in ASTM D7566. These fuels were previously referred to as renewable jet fuel, alternative jet fuel, renewable aviation fuel, alternative aviation fuel, aviation biofuel, biojet fuel, or sustainable alternative jet fuel. When SAF is blended with conventional jet fuel, it meets ASTM D1655, which allows it to be used in existing aircraft and infrastructure. SAF is commercially available and has been used by United Airlines at Los Angeles International Airport since 2016 and San Francisco International Airport since 2018.

Renewable Propane

Propane is a by-product of natural gas processing and crude oil refining, with almost equal amounts of production derived from each of these sources. Most of the propane consumed in the United States is produced in North America. In addition to conventional propane, renewable propane—which is produced from renewable feedstocks—is also being explored. Chemically identical to conventional propane, renewable propane is produced from biomass-based feedstocks, including used cooking oil, animal fats, or 20% dimethyl ether. Although the number of producers is small, renewable propane is currently produced in biodiesel refineries.

Wood

Wood was the main source of energy for Maine and the rest of the world until the mid-1800s. Heating with wood has several advantages and disadvantages. The advantages of wood heat include:

- Wood can be stored for long periods of time.
- Wood can provide heat during power outages.
- Wood can be easily procured from sustainable sources in Maine.
- Maine has a large community of people who heat with wood.

Disadvantages of wood heat include:

- Wood is bulky to store.
- Burning wood produces smoke containing particulate matter.
- Wood-burning systems produce ash which must be removed and disposed of.
- Per unit of energy, wood is more expensive than solar power.

As solar power has decreased in cost, the competitive economics of producing heat and power from burning wood have deteriorated. It is now more affordable to harness solar energy directly through passive solar building design and solar electricity generation rather than indirectly through harvesting, drying, distributing and burning wood.

Cordwood

Cordwood is wood that has been cut into pieces small enough to be conveniently handled but not otherwise processed. Cordwood heating value per unit of volume and per unit of mass varies widely depending on the species of tree and the moisture content.

Biobricks

Biobricks are blocks of compressed sawdust the size of a large brick. With a low moisture content, they can deliver a more consistent and higher amount of energy per volume, with less ash residue, compared to cordwood.

Pellets

Pellets are small pieces of compressed sawdust that can be stored in a hopper and fed into a firebox by augur to allow wood-burning systems to be automated, reducing the amount of labor required to operate.

Websites

- Alternative Fuels Data Center
  https://afdc.energy.gov/

- Coastal Enterprises, Inc. (CEI)
  https://www.ceimaine.org/

- Database of State Incentives for Renewables & Efficiency
  https://www.dsireusa.org/

- Efficiency Maine
  https://www.efficiencymaine.com/

- Energy Star
  https://www.energystar.gov/

- Maine Public Utilities Commission - Electricity
  https://www.maine.gov/mpuc/regulated-utilities/electricity

- On the Pathway to Clean Energy
  https://www.pathwaytocleanenergy.org/

- WaterSense
  https://www.epa.gov/watersense