SAMPLE CHAPTERS

Live in a Home that PAYS YOU BACK

ANNA DESIMONE

A COMPLETE GUIDE TO NET ZERO AND ENERGY-EFFICIENT HOMES

Live in a Home that

PAYS YOU BACK

ANNA DESIMONE

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First Edition — 2021

ISBN
978-1-03-912349-6 (Hardcover)
978-1-03-912348-9 (Paperback)
978-1-03-912350-2 (eBook)

1. BUSINESS & ECONOMICS, REAL ESTATE

Distributed to the trade by The Ingram Book Company

Acknowledgments

Special thanks to Jim Nostedt, P. Eng. from SEEFAR Building Analytics Inc. in Winnipeg, Manitoba, for his valuable technical review services. Thanks to the absolute best copy editor, Doris Castagno. Thanks to Joanna Breen, the production team at FriesenPress, the Jenkins Group, and Jane Reilly at Smith Publicity.

Special thanks to the environmental visionaries and industry leaders who shared their time and expertise: Sam Rashkin, TruHome Facts; Joe Emerson, Zero Energy Project; Robert J. Pierson, ECOHome; Wayne Cole, SEEFAR Building Analytics Inc.; Brett Cass, Canadian Home Builders Association; Donna Peak, Log &Timber Home Living Magazine; Dan Mitchell, Eagle CDI Builders; and Andrew Morrison, DMI AccuSystems.

Cover design: Yvonne Fetig Roehler, Jenkins Group, Inc.
Cover photo: Shutterstock
Infographics: Shutterstock
Author photo: NYC Portraits

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CHAPTER 1

Why Invest in an Energy-efficient Home?

WHAT IS THE PAYBACK? When we think about payback, we tend to think in financial terms, such as the break-even point, or return on investment. These are meaningful questions when you're exploring mortgage options. However, with an energy-efficient home, payback is quantified a number of different ways.

Today's homebuyers want sustainability—not just for home construction features, but to maintain long-term affordability as well. The best part about investing in "the home of the future" is that it will sustain your plan for the future.

With an energy-efficient home, your "true cost of homeownership" will be lower. Monthly utility bills are lower, construction materials are more durable, and appliances require fewer repairs and maintenance. Expanded mortgage programs will boost your buying power, and you will have access to many rebates and financial incentives. Energy-efficient homes increase in value at a faster rate than traditional homes, adding more dollars to your retirement nest egg.

In this chapter we take a look at five types of payback, and begin with a type of payback that is immeasurable—***your family's health.***

1. Your Home Will Be Healthier.

Scientific advancements in ventilation systems are now able to capture far greater levels of bacteria, allergens, and airborne pollutants. Your family can benefit from a continuous supply of fresh, filtered air. Energy-efficient homes are constructed with non-toxic materials and include built-in protections from mold and other environmental contaminants.

Research completed by the Joint Center for Housing Studies at Harvard University found that consumers are increasingly worried about the link between health and everyday environmental exposures. In its study, *Healthy Home Remodeling: Consumer Trends and Contractor Preparedness,*[1] the Joint Center found that "indoor air quality" ranked as the leading source of concern. Other pressing concerns included moisture, mold, water quality, and harmful chemicals such as radon.

Data from the study showed that 30% of households expressed concerns about some aspect of their home negatively impacting or posing a risk to their health. Among homeowners surveyed, the most common reason cited for exploring remediation steps was that a household member had developed physical symptoms.[2]

> As of 2019, web searches on Google for the term "non-toxic" marginally outpaced even those for the term "energy efficient."
>
> —Harvard University Joint Center for Housing Studies

According to a report completed by the U.S. Department of Energy (DOE), *Home R_X: The Health Benefits of Home Performance*,[3] energy-efficient enhancements can change the physical environment of homes by stabilizing temperatures, enhancing indoor air quality, and improving environmental conditions.

The DOE report analyzed data from 300 technical articles and a total of 44 studies conducted in the United States, Canada, and other countries around the world. The report identified that energy-efficient enhancements typically completed by builders and home improvement contractors have proven to directly impact health.

The DOE study examined variables from homes with occupants who had pre-existing health conditions, as well as adults and children with asthma. Results showed improvements in overall physical and mental health, respiratory health, and reduced injuries for homes that were constructed or renovated in accordance with "green building" standards.[4]

A report completed by the International Energy Agency (IEA), *Capturing the Multiple Benefits of Energy Efficiency,*[5] examined health outcomes resulting from energy-efficient measures.

A number of efficiency measures were studied, including insulation, air sealing, improved heating systems, improved cooking systems, and ventilation. Each measure was analyzed for its primary housing effect, secondary housing effect, and expected health outcomes.

Results from every type of measure indicated "reduced symptoms of respiratory disease." Examples of other health outcomes were telling. For example, in addition to a reduced risk of respiratory disease, the "ventilation" efficiency measure also indicated a reduced risk of cancer, cardiovascular disease, arthritis, and depression.[6]

2. Your Home Will Be More Comfortable.

Efficient lighting systems improve light distribution, reduce eyestrain, and offer a more calming atmosphere. High-performance heating and cooling systems deliver more consistent heating and cooling temperatures throughout every room in the house. Newer systems are quieter and available with programmable thermostats so that you can schedule temperature changes that fit your daily routine.

Maximum thermal insulation, along with high-performance windows, keep your home warmer in the winter and cooler in the summer. Thermal insulation and weatherization techniques keep those surprise drafts away when you're trying to relax. Sometimes comfort is simply a peace of mind, as expressed by the Yale Center for Environmental Communication at Yale University based on a study by the Urban Green Council.[7]

> Even during a winter blackout, you can expect a high-efficiency home to stay warm for several days.
>
> —Yale Climate Connections

3. Your Home Will Use Less Energy.

A home's energy efficiency is based on a whole-house assessment. Known as an "energy score," the efficiency rating of a home is based on measurable performance factors of individual appliances or operating systems. As upgrades or other efficiencies are integrated into the home, energy requirements will continue to drop.

According to Energy Star, Energy Star certified homes are at least 15% more energy efficient than standard homes; however, due to additional energy-saving features, homes are typically 20–30% more efficient.[8]

Energy consumption in residential homes has continued to increase even though there are many new technologies to conserve energy. The size of homes in the U.S. has increased 41 percent since the 1970s, while the average number of occupants has decreased 15 percent during the same period.[9]

Wasteful energy consumption includes heating and cooling of unoccupied homes and rooms, and accounts for at least 45% of total energy use in the residential sector, as reported in the *2020 Annual Energy Outlook* prepared by the U.S. Energy Information Administration (EIA).[10]

The Consumer Technology Association estimates the average household owns 24 home electronics products. Typically, a home includes at least three televisions, a cable box, a game console, a DVR, three home audio devices, and lots of chargers.[11]

> In 2019, electricity for miscellaneous household devices consumed more electricity than the core requirements for heating, water-heating, cooling, and refrigeration.[12]
>
> —Center for Sustainable Systems, University of Michigan

Residential energy use in the United States in 2019 averaged 33.91% for space heating and 11.04% for cooling, according to the Center for Sustainable Systems at the University of Michigan.[13]

Natural Resources Canada reports that 61.6% of residential energy consumption in Canadian households is used for space heating, and 1.9% for cooling.[14]

4. You Will Reduce Greenhouse Gas Emissions.

Most primary sources of energy are non-sustainable. About 80% of energy sources in North America come from "fossil fuels." Coal, crude oil, and natural gas are considered fossil fuels because they were formed from the fossilized, buried remains of plants and animals that lived millions of years ago.

Because of their origins, fossil fuels have a high carbon content. Fossil fuels are now being replaced with "renewable" sources, also referred to as "clean energy." Renewable energy comes from Earth's natural sources that are constantly being replenished.[15]

The "greenhouse effect" is a natural phenomenon that insulates Earth from the cold of space. Greenhouse gas (GHG) emissions are comprised of atmospheric GHGs, and emissions that are caused by humans, known as "anthropogenic" emissions. Greenhouse gas emissions consist of carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O).

Human-caused emissions are modifying Earth's energy balance between incoming solar radiation and the heat released back into space, which amplifies the greenhouse effect and results in climate change.[16]

According to the U.S. Environmental Protection Agency (EPA), the largest source of human-caused greenhouse gas emissions is from burning fossil fuels for electricity, heat, and transportation.[17]

> The global warming potential (GWP) of GHG emissions is calculated as carbon dioxide equivalents (CO_2e) as a single unit for measurement. This measurement unit is known as a carbon footprint.[18]
>
> —Center for Sustainable Systems, University of Michigan

The EPA defines a carbon footprint as: "The total amount of greenhouse gases that are emitted into the atmosphere each year by a person, family, building, organization, or company."

The EPA's *Household Carbon Footprint Calculator* establishes a household's carbon footprint based on geographic location, automobile miles driven, type of heating fuel, electricity use, and recycling or composting activity.[19]

According to the Center for Sustainable Systems at the University of Michigan, as of September 2020 the typical U.S. household had a carbon footprint of 48 metric tons of carbon dioxide (CO_2), and an "individual carbon footprint" of 20.4 metric tons per year.[20]

The "Paris Agreement" is a landmark environmental accord that was adopted in 2015 by nearly every nation in the world. The Agreement aims to limit the global temperature increase in this century to 2 degrees Celsius above pre-industrial levels, and to pursue efforts to limit the temperature rise to 1.5 degrees Celsius.[21]

On November 19, 2020, the House of Commons of Canada passed a bill to achieve "net-zero" greenhouse gas emissions by the year 2050. The purpose of the Act is to set national targets for the reduction of greenhouse gas emissions based on the best scientific information available and to promote transparency.[22] As of November 2020, net-zero targets had been pledged by ten countries around the world.[23]

Homeowners today have a number of options to offset grid-connected utilities with a renewable source of energy. More than 2 million Americans have installed solar energy systems in their homes.[24] The United States generates the most geothermal electricity in the world.[25]

In Canada, 67% of electricity comes from renewable sources, and 82% from non-GHG emitting sources.[26] Canada is the world's third-largest producer of hydroelectricity,[27] and nearly 3.5 million Canadian homeowners are powering their homes with wind turbines.[28]

5. You Will Have Greater Financial Rewards.

According to the U.S. Department of Energy, the typical household can save 25% on utility bills with efficiency measures, which amounts to over $2,200 annually.[29]

Across the United States and Canada, there are more than 2,000 incentives available to residential homeowners to help cover the cost of efficient appliances and energy-efficiency measures. Many utility companies offer free energy assessments and discounts to complete recommended measures.

Cash rebates are available from numerous appliance manufacturers. Incentives are available to support all types of efficiency improvements, including measures such as air-sealing and weatherization.

Should you choose to install a renewable energy system such as solar photovoltaic (PV) panels, you may be eligible for federal tax credits, as well as state and local tax credits or deductions. Many cities and towns have issued property tax waivers so that you are not taxed for the increase in value after installing a renewable energy system.

When you apply for a mortgage, the projected savings in utility costs will be added to your income if you apply for an "energy-efficient mortgage" program, which eases loan qualification. If you plan to upgrade your home with additional energy features in the future, there are many zero-interest energy improvement loans and grants from housing partnership agencies.

Your long-term investment will be more secure. A study completed by the North Carolina Building Performance Association revealed that homes with green certification programs such as Energy Star sold for 9.5% more than non-certified homes.[30]

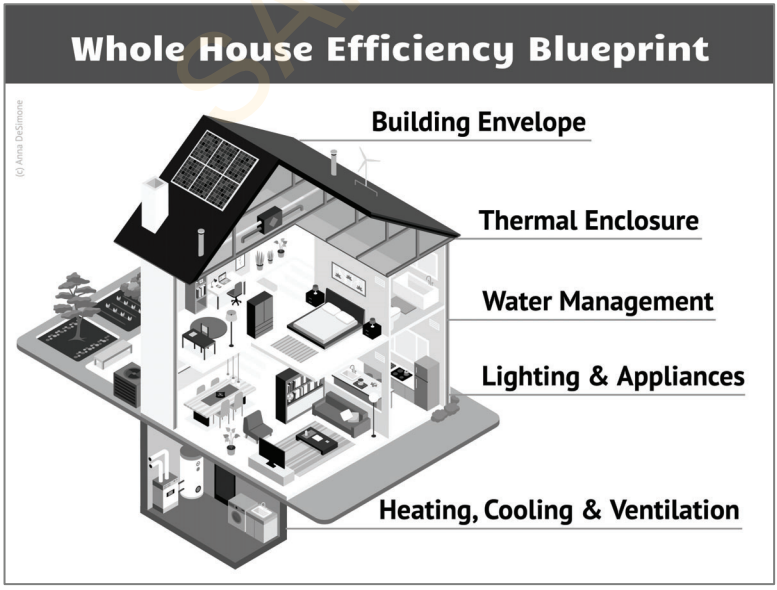
SEEFAR Building Analytics Inc., based in Winnipeg, Manitoba, has developed a software tool that monetizes building sustainability. The SEEFAR valuation tool incorporates a 60-year life-cycle analysis, which is used in home appraisals to support energy features, determine long-term investment value, and supports access to mortgage financing. Sustainable homes are constructed with more long-lasting materials. Due to fewer replacements of materials and appliances, homeowners are also reducing their greenhouse gas emissions.[31]

> Making a home more durable reduces carbon. Making a home more energy efficient reduces cost.
>
> —Wayne Cole, SEEFAR Building Analytics Inc.

CHAPTER 2

Whole House Efficiency Blueprint

THINK LIKE A BUILDING CONTRACTOR. This chapter examines five main parts of the house—the building envelope; thermal enclosure; heating, cooling, and ventilation; lighting and appliances; and water management. You'll have a close look at how some high-performance systems work and discover some new trends along the way.



BLUEPRINT #1

Building Envelope

The building envelope represents the outer layer of a home. Think of your home as a six-sided box, encompassing the four walls, roof, and foundation level. Sometimes the building envelope is called a "building enclosure."

The building envelope serves as a physical separator between the conditioned and unconditioned environment. It provides resistance to air, water, heat, light, and noise. The builder's objective is to make your home airtight and well insulated so that the energy that comes into the home stays within the envelope.

The building envelope protects exterior materials from deteriorating in bad weather. Homes are designed so that rain and melting snow are directed away from the roof, walls, and foundation. "Drainage planes," which are made from moisture-resistant material, are installed in continuous overlapping layers. The area around the home is graded so that water flows away from the foundation and is directed to underground drains. "Flashing" is a second layer of protection that is installed at roof-to-wall intersections and around windows and doors.

Exterior Siding

According to Building Science, *Innovative Solutions for High-Performance Homes,* the three major exterior options have traditionally consisted of brick, stucco, or wood. Choices generally conform to the local climate. Wood has remained the most common exterior siding, and there are several organizations which certify that wood was sourced from a sustainably managed forest. Such groups include the Forest Stewardship Council (FSC), Western Red Cedar Lumber Association (WRCLA) and the Cedar Shake and Shingle Bureau (CSSB).[32]

According to the Brick Industry Association, manufacturing brick today requires 70% less energy than it did in 1970. Because brick is made from clay and sand, it is non-toxic, fireproof, impact resistant, 100% recyclable, and provides thermal mass.

Brick and stone can be applied as a veneer rather than structural material. "Stucco" is a versatile material that can be directly applied to solid masonry, concrete, or "insulated concrete forms" known as ICFs.[33]

"Fiber cement" is made from a mixture of sand, wood fibers, cement, and water. Products are fire resistant, low maintenance, long lasting, and can mimic wood siding, clapboard, shingle, and board and batten. Fiber cement siding was first engineered by James Hardie Building Products, which manufacture *Hardie Plank, Hardie Shingle*, *Artisan*, and others. The Hardie companies are committed to a *Zero Harm Initiative*.[34]

KWP is an ecologically conscious manufacturer of engineered wood products. Siding and trim board are available in a variety of colors, styles, and textures, including a product with the look of authentic cedar shakes. KWP's *Eco-Side* collection uses 100% recycled post-industrial content.

Innovations in sustainable siding materials include architectural panels under the brand *Allura*, manufactured by Plycem. Other products such as *SmartSide* and *Progressive Foam* combine exterior siding with insulation.

"Steel siding" is a coated, long-lasting option available in many colors and textures. Other options include *Satinwood* and *Kynar*, which have special coatings similar to Teflon.

"Acetylated wood products" offer improved thermal insulation, longer life span, and better dimensional stability. Products resist decay and are considered an alternative to using toxic pressure-treated wood. "Structured Insulated Panels," known as SIPs, are airtight, insulated building systems that provide thermal resistance.

"Mass timber" is an alternative to steel or concrete and offers a very high strength-to-weight ratio. Layering methods include cross-laminated timber and glue-laminated timber. "Rammed Earth" is made from soil that is bound, placed in layers, and pressurized to create a hard surface for floors and walls. The finished look is very smooth and resembles sedimentary rock.

"Bamboo" is one of the world's fastest growing plants and is considered an excellent alternative to wood. Bamboo is often used for decks, floors, and cabinetry. "Straw bales" are made from agricultural industry vegetation waste. When straw bales are used for exterior walls, the walls are thicker and keep the home well-insulated.

Roofs

According to Green Builder, wood is the only renewable product available; products are also available from reclaimed wood sources. Wood is popular in areas where wood is harvested, such as the Pacific Northwest, Midwest, New England, and most Canadian provinces. There are certain geographical areas where building codes restrict wood use due to dry weather conditions.[35]

Asphalt shingles remain the popular choice, and in certain geographic regions, tiles made from clay, ceramic, or concrete are widely used. The latest sustainable trend is "metal roofs," which are considered highly efficient and low maintenance. Types of metal used in roofing include steel, copper, aluminum, and zinc. Products are available in a wide assortment of colors and architectural styles, including some that resemble shingles or slate. According to the U.S. Green Building Council, metal roofing typically contains a minimum of 25% recycled materials.[36]

Solar Roof Shingles

Scientific advancements in solar energy products continue to deliver new and exciting products to the home building industry. Solar shingles resemble conventional roofing materials while also producing electricity. Manufacturers include Tesla, CertainTeed, SolarCity, and RGS Energy.

Green Roofs

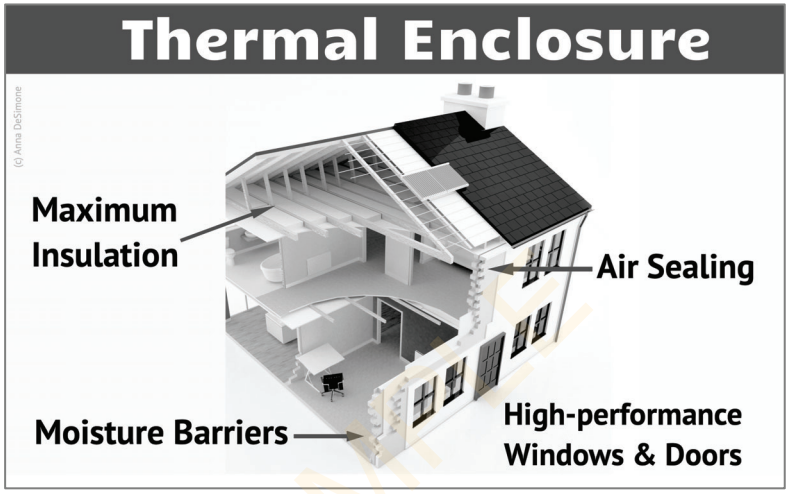
A green roof is a layer of vegetation that is planted over a waterproofing system installed on top of a flat or slightly sloped roof. Green roofs, also known as vegetative or eco-roofs, can support a diverse range of plants, including small trees. Green roofs absorb carbon dioxide, help insulate the building, and can increase the life expectancy of the roofing system.[37]

"Thatched" roofs, which are made from hay, straw, reed, sedge, and other dry vegetation, have been used for centuries and are most widely seen in the English countryside and Europe. Thatching works well in tropical climates and is used by builders in developing countries. The densely packed materials trap air, which insulates the home. Thatch is now becoming a popular trend in high-end, custom-built homes.

BLUEPRINT #2

Thermal Enclosure

There are four imperatives required to optimize the thermal enclosure of a home: maximum insulation, efficient air sealing, strong moisture barriers, and high-performance windows and doors.



Insulation

R-value means "resistance to heat flow." The higher the R-value, the more resistance is being provided by the insulation. R-value requirements vary based on geographical area and the part of the home that is being insulated. Typical recommendations for exterior walls range from R-13 to R-23, and the range is R-30 to R-49 for an attic and the space above ceilings.

"Thermal bridging" is a term that is used to describe targeted insulation applied to areas surrounding the support beams and studs. When structural bridging areas between floors and walls remain uninsulated, they will lower the R-value in that part of the house.

According to Home Innovation Research Labs, as of 2019 fiberglass remained the number one insulation for home builders.[38] Fiberglass insulation is available in a wide number of forms—long rolls, blankets (or batts), concrete blocks, rigid foam, and boards. Some insulation products are delivered through spraying devices, such as "loose-fill" and "foam."

Eco-friendly Insulation

Many different types of insulation are considered sustainable, however, there are some eco-friendly products worth mentioning.

"Denim cotton" is blue-colored insulation made from recycled blue jeans and denim cotton. Unlike fiberglass, handling the insulation does not irritate skin.

"Cellulose" insulation products are made from 85% recycled content, primarily newsprint. Other materials used in cellulose insulation include cardboard, cotton, straw, and sawdust.

"Sheep's wool" is considered one of the most natural and renewable sources of insulation, and products are available with an R-19 value.

Insulation Cautions

Certain types of insulation have been found to be unsafe. Older homes sometimes contain hazardous insulation, some of which require "safe removal" procedures. There are licensed professionals who specialize in safe removal of asbestos and other hazardous materials.

"Asbestos insulation" is highly toxic when fibers become airborne. Asbestos has not been produced in the United States since 1978.

"Vermiculite" was a popular form of insulation for many years. Prior to 1990, however, about 70% of vermiculite was contaminated with asbestos due to shared manufacturing facilities.

"Urea Formaldehyde Foam Insulation (UFFI)" was used in homes during the 1970s and early 1980s. The product has been discredited for its toxic emissions and is used only for industrial applications or in commercial buildings.

"Fiberglass" is made from extremely fine glass fibers and can be hazardous when improperly handled. In addition to skin irritations, fibers can be absorbed into airborne dust and irritate the eyes, nose, and throat.

"Mineral wool," which is often used for insulation in the form of "rock wool," requires the same handling precautions as fiberglass.

The following chart provides a brief description of various types of home insulation, based on information from the U.S. Department of Energy.[39]

Types of Insulation	
Cellulose	Made from 85% recycled paper products, primarily newsprint. Generally loose-fill in open attic areas, and dense-packed in building cavities and between walls.
Cementitious Foam	Cement-based foam, known as Krete or Airkrete. Non-toxic, nonflammable, and made from minerals extracted from seawater.
Cotton & Denim Cotton	Natural fiber consisting of 85% recycled cotton and 15% plastic fibers. Available in batts; includes flame-retardant and insect-repellent treatments.
Fiberglass	Made from fiber-reinforced plastic materials embedded with microscopic glass filaments. Available as blown insulation, in various sizes of batts and rolls with a variety of facings.
Insulation Facings	Fastened to insulation materials during the manufacturing process. Some types act as a vapor barrier, a radiant barrier, or a barrier to air.
Phenolic Foam	Currently available only as foamed-in-place insulation. May be found in older homes as rigid board.
Polyiso	Scientific name is polyisocyanurate, and available as liquid and sprayed foam and rigid foam board. Can be laminated for use in structural insulated panels (SIPs).
Polystyrene	Colorless, transparent thermoplastic that is commonly used to make foam board, beadboard, or concrete block insulation. Molded expanded polystyrene is used for foam insulation.
Polyurethane	Foam insulation available in liquid sprayed foam or rigid foam board. Can also be made into laminated panels with a variety of facings.
Rock Wool	Rock wool is fibrous material that is made by spinning mineral rock and slag. Used for structural and pipe insulation and soundproofing.
Sheep's Wool	Treated to resist pests, fire, and mold. Can hold large quantities of water. Batts available up to R-19 value.
Straw	Straw is fused into boards without adhesives and has effective sound-absorbing properties.

Air Sealing

The uninvited guest that leaks into the house starts out as air—and later becomes moisture. Air likes to move by the easiest path available. Air naturally moves from high-pressure areas to low-pressure areas through a hole or crack in the house.

The integrity of the exterior walls is the first line of defense for preventing damage to building materials and impairing indoor air quality. Air sealing controls the movement of air and guards the home against heat loss.

"Uncontrolled moisture" can enter the home through window and door openings, seams, footings, roofs, or other openings. An exterior weather barrier is installed to prevent moisture from entering construction cavities.

Water can also enter construction cavities through a process called "moisture migration," which can cause mold in any type of climate. Air sealing steps can reduce condensation, leaks, and drafts. Techniques include the application of caulk, foams, specialty tapes, and adhesives.

> A typical home contains a half-mile of cracks and gaps behind walls and around windows and doors, along with dozens of holes for pipes, vents, ducts, lighting, and wiring.[40]
>
> —Energy Star

Moisture Barriers

"Foundation moisture control" is a strategy to ensure potential moisture problems do not occur in the basement, crawlspace, or slab-on-grade foundation. Such areas need to be insulated to properly control moisture.

"Vapor barriers" are placed in strategic locations depending upon the climate. Vapor-impermeable membranes called "sill gaskets," also known as termite shields, are generally placed on top of the foundation to prevent moisture from wicking into the framed wall.

Rain, especially wind-driven rain, can cause moisture problems in walls. To control moisture, builders and contractors generally incorporate control measures such as flashing, caulking, and weatherstripping around windows, doors, and bottom plates.[41]

Mold

Excess moisture in the home can result in the growth of mold. Molds are part of the natural environment—and in the outdoors, molds break down organic matter such as fallen leaves and dead trees. Indoors, however, mold growth should be avoided. Molds reproduce by means of tiny spores that are invisible to the naked eye and float through both outdoor and indoor air. When mold spores land on indoor surfaces that are wet, mold begins growing indoors.

There are many types of mold, and none of them will grow without water or moisture. Allergic reactions to mold are common and can occur immediately or be delayed. Mold exposure can be harmful to people with asthma, and can irritate the eyes, skin, nose, throat, and lungs of both mold-allergic and non-allergic people.[42]

Windows

Energy-efficient windows, also called high-performance windows, are necessary for optimum thermal enclosure. Energy-efficient windows protect the inside of the home from the sun's heat and ultraviolet (UV) rays in the summer, and they prevent heat from escaping during the winter. Windows must be properly installed, and any spaces between the window frame and wall framing must be sealed.

Double-paned windows are made with two layers of glass and are also known as double-glazed. The glass panes are spaced apart and hermetically sealed, leaving an insulating air space. Triple-paned windows are recommended in areas with extreme climates, and windows are now available with as many as four of five panes.

Gas-filled spacers minimize heat transfer. "Low-emissivity" coatings, referred to as "low-e," are microscopically thin, virtually invisible, metal or metallic oxide layers that are deposited directly on the surface of one or more panes of glass in a window. Vacuum-insulated glass is also available.

> "Heat gain" and "heat loss" through windows are responsible for 25 to 30% of residential heating and cooling energy use.[43]
>
> —U.S. Department of Energy

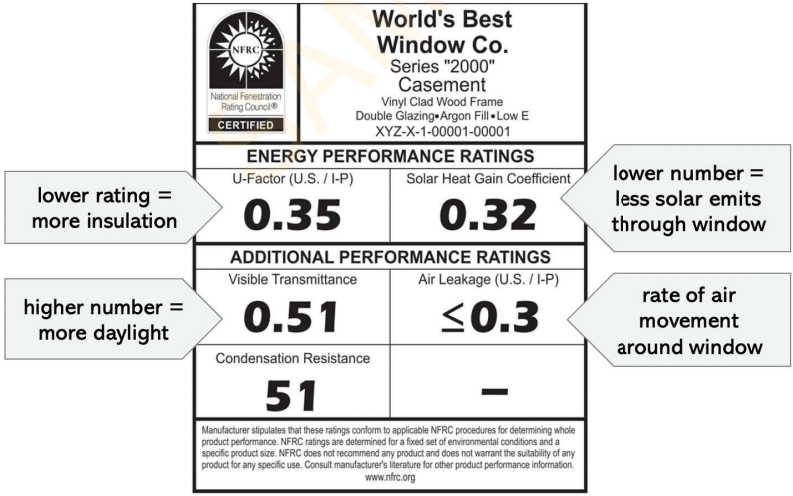
U-Factor

U-Factor measures the rate of heat transfer through a product, and is a criterion used for measuring the energy performance of a window. The U-Factor represents two things—heat loss during cold weather, and heat gain during warm weather. U-Factor values range from 0.20 to 1.20. The lower the number, the better the window is able to provide insulation.

The National Fenestration Rating Council (NFRC) operates a voluntary program that tests, certifies, and labels windows, doors, and skylights based on their energy performance ratings.[44]

The Solar Heat Gain Coefficient (SHGC) measures how much of the sun's heat comes through a window. Values range from 0 to 1. The lower the number, the less solar heat that comes through the window.

"Visible transmittance" (VT) is the amount of light emitted. A high VT number will maximize daylight. "Air leakage" is the rate of air movement around a window. The NFRC label is shown below, along with infographics added by the author.



Awnings

Awnings can be installed to shade a window from the sun's heat and glare. According to the U.S. Department of Energy, window awnings can reduce solar heat gain in the summer by up to 65% on south-facing windows and 77% on west-facing windows.[45] Awnings require ventilation to keep hot air from becoming trapped around the window, generally controlled by vents. Retractable awnings can be closed during the winter, which saves energy since sunlight will emit through the window and help warm the house. Conversely, non-retractable awnings can increase energy use in the winter, unless they are positioned in such a way to allow sunlight.

Solar Screens

Solar screens can reduce solar heat gain, ultraviolet (UV) damage, and glare. Screens can be installed on the interior or exterior as roller shades or fixed panels, and they typically allow for a view out the window as well as light transmission. Solar screens look similar to traditional window screens but provide more efficiency benefits. Benefits vary based on the level of openness, visibility, and light transmission.[46]

Doors

Exterior doors are available with energy-efficient features. Common types include doors with a steel skin with a polyurethane foam insulation core. Generally, there is a magnetic strip that serves as weatherstripping. Doors also have R-values, typically ranging from R-5 to R-6 without a window. High-performance doors are available with triple-weather seals, multi-point locking, and triple-pane windows.

Doors also have performance ratings from the National Fenestration Rating Council (NFRC). The label shows the Solar Heat Gain Coefficient (SHGC) and U-Factor. Some models of glass or patio doors are made with layers of glass, low-emissivity (low-e) coatings, and/or low-conductivity gases between the glass panes. Storm doors made of aluminum, steel, fiberglass, or wood may have foam insulation inside their frames. Other models may have low-emissivity glass or glazing.[47]

BLUEPRINT #3

Heating, Ventilation, and Air Conditioning

Heating, ventilation, and air conditioning systems are commonly referred to as "HVAC." Systems that operate through the entire home are called "central" heating or air conditioning. Proper sizing of equipment is essential, since incorrect HVAC sizing can reduce overall effectiveness, cause stress on system components, and lead to poor humidity control. HVAC requirements are measured in British Thermal Units (BTUs) and based on the following factors:

- Geographic location of the home
- Home orientation (north, south, east, or west)
- House size in square feet of living space
- Window types, and where located
- Insulation

Requirements may also be measured in Gigajoules (GJ) and kilowatt hours (kWh). High-performance HVAC systems are based on measurable results and encompass a whole house approach. Heating and cooling efficiency is optimized when homes are equipped with proper ventilation, energy-efficient windows, adequate insulation, and air sealing. Using a programmable thermostat and ceiling fans also help maximize HVAC efficiency.

HVAC systems are built in accordance with ASHRAE. Founded in 1894 as the American Society of Heating, Refrigerating, and Air-Conditioning Engineers, ASHRAE standards are utilized in 132 nations. The building codes and home labeling programs featured in this book incorporate ASHRAE energy-efficiency protocols.

Furnaces

Furnaces deliver heat through hot-air ducts. Furnaces are the most common home heating system, and can run on gas, oil, propane, or electricity. Heating fuel efficiency is rated under a program called Annual Fuel Utilization Efficiency (AFUE), which measures the efficiency in converting fuel to energy. Energy-efficient furnaces are generally rated in the 80 to 95% range, and in accordance with the type of fuel, product criteria, and geographic area.[48]

Boilers

Boilers do not use a duct system. Homes are heated through steam or hot water that circulates through radiators, baseboards, or radiant floor systems. Fuel types used in boilers include gas, propane, and oil. Features that can improve boiler efficiency include an electric ignition, which eliminates the need to have the pilot light burning all the time, as well as technologies that extract more heat using the same amount of fuel. Boiler efficiency is also measured using the Annual Fuel Utilization Efficiency (AFUE) system.

Hot-Water Radiators

Hot-water radiators are one of the most common heat distribution systems in newer homes, second only to forced-air systems. They are typically a base-board-type radiator or an upright design that resembles steam radiators. To optimize energy efficiency in hot-water radiators, the system can be retro-fitted to provide additional settings to control heat in different areas of the home.

"Automatic valves" can be installed that are regulated by thermostats in each zone. To prevent water pipes from freezing, temperatures must be set to the lowest point recommended for the local climate, including zones within the home that are infrequently used.[49]

Steam Radiators

Steam heating is one of the oldest centralized heating methods and it is often found in older homes. Because the process involves boiling and condensing water, steam is less efficient, and there are often lag times between turning the boiler on and heat availability.

The plumbing infrastructure of steam systems is somewhat challenging for energy-efficient retrofit projects. There are a few steps you can take to prevent heat loss, such as installing "heat reflectors" behind the radiators. Reflectors can be especially helpful if the outside walls are poorly insulated. The best strategy is to consult with a heating specialist regarding cleaning, maintenance, and replacement of vents, valves, and steam traps to maintain maximum comfort.[50]

Ductless Systems

Energy-efficient heating and/or cooling systems are available for homes that cannot accommodate ductwork. Ductless systems are known as "mini-splits" and typically include a number of indoor units for each room or climate area, an outdoor unit, and connecting refrigerant lines. Both heating and cooling functions are generated through a heat pump. Common applications for ductless systems include homes with electric heat, or older homes that have radiators or baseboard heat. Ductless systems are often used to conserve energy in rooms that are not regularly occupied.[51]

Heat Pumps

Heat pumps offer an energy-efficient alternative to furnaces and air conditioners. Products operate the same way as refrigerators, making the cool space cooler and the warm space warmer. "Air-source heat pumps" (ASHP) have been used for many years in nearly all parts of the United States.

Until recently they have not been used in areas with extended periods of subfreezing temperatures. However, in recent years, air-source heat pump technology has advanced so that it now offers a legitimate space heating alternative in colder regions. Natural Resources Canada completed a study that found that air-source heat pumps work well in Canadian winters based on testing completed in Ontario.[52]

> An air-source heat pump can deliver one-and-a-half to three times more heat energy to a home than the electrical energy it consumes. This is because a heat pump moves heat rather than converting it from a fuel.[53]
>
> —U.S. Department of Energy

"Ground-source heat pumps" (GSHP) extract heat from the ground with buried plastic pipe. The below-grade ground temperature is constant and improves the system's efficiency. Heat is removed from the ground in winter for space heating. In the summer, heat is removed back to the ground to cool the home. "Water source pumps" operate similarly to ground-source systems, but they extract heat from a body of water that is cycled through pipes from nearby lakes or reservoirs. Heat is collected from water and delivered to heat or cool the inside.

"Absorption" heat pumps can be driven by gas, propane, solar-heated water, or geothermal heated water. Because gas is the predominant energy source, these products are also referred to as gas-fired heat pumps.

The chart below lists a number of heating systems that can be used to heat an entire home or provide a supplemental source of heat. Information is adapted from the U.S. Department of Energy.[54]

Alternative Types of Heating	
Wood Stoves	Wood stoves are typically made of cast iron, steel, or stone and generate heat from split logs, known as cordwood. EPA-certified stoves are cleaner burning and more energy efficient.
Pellet Stoves	Pellet stoves are similar in appearance to woodstoves and need electricity to operate. Pellets made from ground, dried wood and biomass wastes are poured into a hopper. Corn kernels can be used in lieu of pellets.
Forced Air Furnaces	Also known as warm-air furnaces, units are designed to burn cordwood, wood pellets, or wood chips and can heat an entire residence. Heat is distributed through ducts powered by a blower fan.
Fireplaces	Traditional masonry fireplaces are built with brick or stone. Low-mass fireplaces are engineered and prefabricated in a manufacturing facility prior to installation. Most fireplaces are not used as a primary source of heat.
Fireplace Inserts	Units are installed within the firebox of an existing metal or masonry fireplace. Similar in function to free-standing wood burning stoves. EPA-certified models are less polluting and more efficient.
Fireplace Retrofits	A fireplace retrofit is a device that is installed into an existing wood-burning fireplace to help reduce smoke pollution. They can be installed in masonry or factory-built fireplaces.
Gas & Propane Stoves	Stoves can burn either natural gas or propane, and are typically very energy efficient. They emit very little pollution, require little maintenance, and can be installed almost anywhere in the home. They can be vented through an existing chimney or through a wall. The EPA supports models that vent outside.

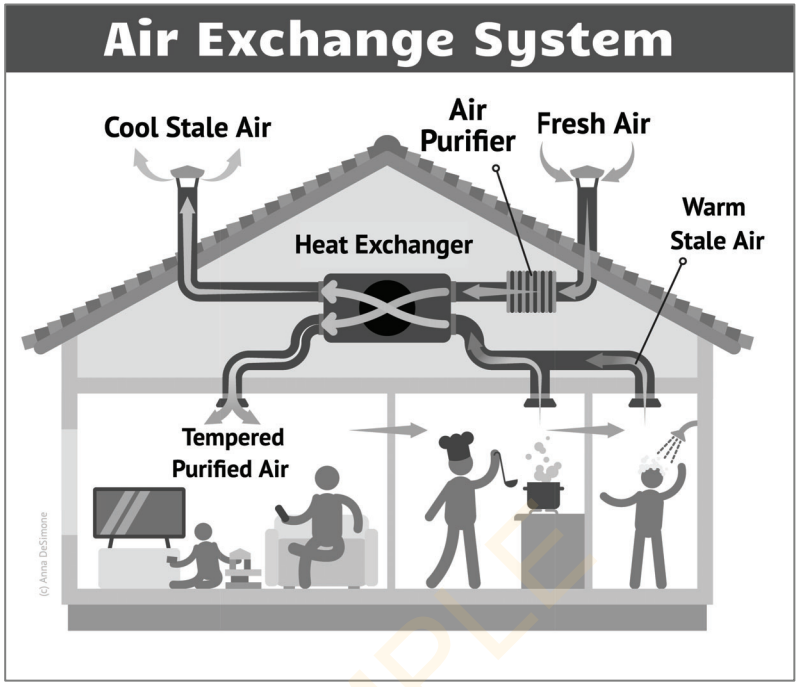
Ventilation

"Whole-house ventilation" systems deliver controlled, uniform ventilation throughout the entire home. Systems can use one or more fans within the home's ductwork system to exhaust stale air from the house, and/or supply fresh air into the house.

Air filtration and ventilation help to control moisture, reduce indoor air pollutants, and alleviate common household problems. Ventilation systems are constantly working and continuously exchange indoor air with outdoor air to control airborne pollutants.

An important function of the home ventilation system is that air leakage is controlled through strategically placed "intentional" vents. As explained earlier in the thermal enclosure section, the home must be well-sealed so that the air cooled by an air conditioning system—and/or the air warmed by a heating system—does not escape.

Types of Ventilation Systems
EXHAUST VENTILATION Systems work by depressurizing the building, typically with one fan connected to a centrally located exhaust point in the house.
SUPPLY VENTILATION Systems work by pressurizing the building, forcing outside air into the home, while the inside air exits through various vents.
BALANCED VENTILATION Systems neither pressurize nor depressurize a house. Instead, they introduce and exhaust equal quantities of fresh outside air and polluted inside air.
ENERGY RECOVERY VENTILATION Systems provide controlled ventilation while minimizing energy loss and maintaining constant temperatures and humidity.



Mechanical Air Exchange Systems

Because energy-efficient homes are built to a higher standard of air tightness, mechanical ventilation is recommended for a number of reasons. Drafty old homes lose a lot of heat—but they also let in healthy fresh air. According to Health Canada, mechanical ventilation systems provide three important benefits: [55]

- They provide oxygen for occupants since people deplete oxygen as they breathe.
- They remove contaminants that are emitted by people and certain building materials.
- They remove excess humidity, which ensures building durability and efficiency in heating, and helps prevent mold and mildew.

Considered an essential component of high-performance HVAC systems, mechanical air exchange systems are comprised of two types: heat recovery ventilation and energy recovery ventilation. Each type is described below.

Heat Recovery Ventilation (HRV)

Heat recovery systems use the heat in stale exhaust air to preheat incoming fresh air. The cold, dry incoming air absorbs this heat as it passes through the exchange unit. This reduces the energy required to bring outside air up to the ambient room temperature, saving money on heating bills.

Because the incoming and outgoing air are traveling in separate channels, air sources never mix. This approach is known as counterflow. Although HRVs require the operation of a fan on a continual basis, the energy recovered from the inside air is many times that of the energy required for the fan.[56] HRVs are considered a good option if the home does not have air conditioning, or if the home is located in a less-humid climate.

Energy Recovery Ventilation (ERV)

Energy recovery systems work in similar ways as HRVs, but transfer some of the moisture from the outgoing airstream into the incoming air so that the humidity in the home stays at a constant level.

In cold winter climates, ERV systems transfer humidity from the air being extracted to the incoming outdoor (and dry) air to help keep the ambient internal humidity at a reasonable level at all times. In the summer, the humidity transfer reverses and the humidity in outside air is removed before it is injected into the home.[57] ERVs are considered a good option if the home has air conditioning and the home is located in a humid climate.

Fans

"Whole-house fans" provide excellent ventilation to help lower indoor temperatures, and in most climates, they can serve as a substitute for an air conditioner. When combined with ceiling fans, whole house fans help deliver more comfort in hot weather. Fans can be installed with or without ductwork, and are generally installed in an attic, with a roof-mounted vent.[58]

Fans are the least expensive and most energy-efficient way to cool a home, and work well when combined with other heating or cooling methods. "Spot ventilation" fans are used in strategic places such as bathrooms and kitchens—and vented outside.

Ceiling fans re-circulate air and can be used on a year-round basis. High-volume, low-speed fans (HVLS) are more aerodynamic and can move large volumes of air while delivering more comfort.

In the summer, ceiling fans should be operated *counterclockwise* so that the airflow is pushed downward, creating a cooling effect. In the winter, fans should turn in a *clockwise* direction, which sends the heat in a downward direction.

> Ceiling fans cool people—not rooms. To save energy, turn off the ceiling fan when the room is not occupied.[59]
>
> —Energy Star

Duct Cleaning

Air ducts in the home can harbor particles of dust, pollen, or other debris. If moisture is present, the potential for mold growth increases, and spores are released into the living areas.

Air duct cleaning is performed by a team of professionals who will remove the grills in front of each vent. A special long hose is connected to a high-powered vacuum cleaner that extracts the contents and sends it to a truck parked outside your home. The service provider may suggest the application of "biocides" into the ductwork to kill microbiological contaminants. Some duct cleaners have small robots with rotating brushes that provide a more thorough cleaning.

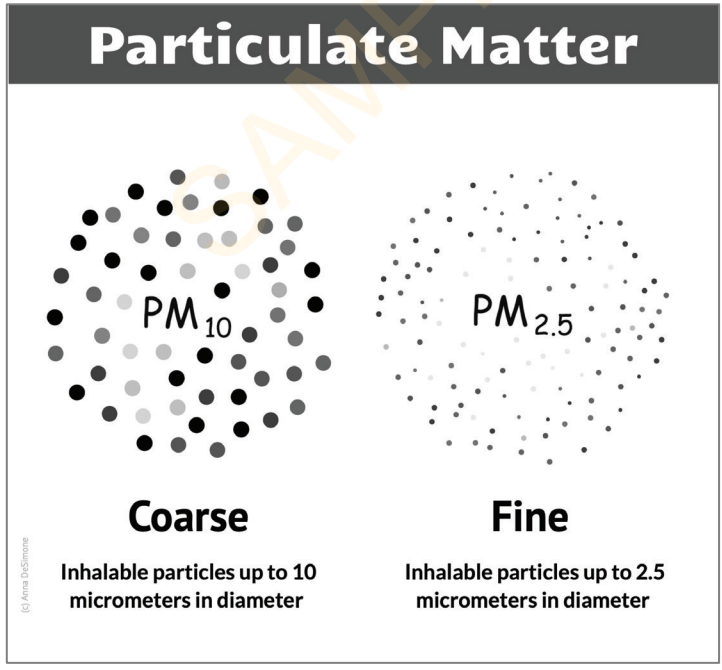
If you have furry pets, frequently use a fireplace or wood (or pellet) burning stove, or there are smokers in your household, it's a good idea to schedule duct cleaning every few years.

Indoor Air Quality

The primary cause of indoor air quality problems stems from pollution sources that release gases or particles into the air inside the home. Also, high temperatures and humidity levels can increase the concentration of some pollutants.

Pollutants consist of "particulate matter (PM)." PMs represent a mixture of solid particles and liquid droplets found in the air. Some particles, such as dust, dirt, soot, or smoke, are large or dark enough to be seen with the naked eye. Others are so small they can only be detected using an electron microscope.

There are two types of PMs: "fine particulate matter," which is up to 2.5 micrometers in diameter, and "coarse particulate matter," which is up to 10 micrometers in diameter. The average human hair is about 70 micrometers in diameter, making it 30 times larger than the fine particle. The two types may also be referred to as "fine" and "ultrafine."



PMs originate from indoor sources and outside sources that migrate into the home. Examples of indoor sources are cooking, burning of candles, cigarette smoking, and unvented fireplaces or space heaters. Examples of outdoor sources are construction sites, unpaved roads, fields, smokestacks, and fires.

Outdoor PMs are also generated from the atmosphere as a result of complex reactions of chemicals and pollutants emitted from power plants, industries, and automobiles.[60]

Management of indoor air quality requires circulation and ventilation. If ventilation is not adequate, pollutant levels can increase in two ways:

- by not bringing in enough fresh outdoor air to dilute emissions from indoor sources, and
- by not carrying indoor air pollutants out of the home.

The most effective solution to improve indoor air quality in your home involves removing or reducing the sources of pollutants and ventilating or exchanging indoor air with clean outdoor air.

This objective can be facilitated through a whole-house air filtering system that is integrated with the home's furnace or HVAC system. Portable air cleaners can reduce indoor air pollution; however, they cannot remove every type of pollutant.[61]

There are many shapes and sizes of air filters. "Flat" filters are matted, with densely packed fibers. "Pleated," accordion-like filters are constructed with similar matted fibers. "Media" filters are accordion-like units of filtration media, typically at least 8 inches thick.

Below is a chart listing the most common types of air cleaning filters and efficiency ratings used in HVAC systems and air purification appliances.

Types of Air Cleaning Filters

HEPA

High Efficiency Particulate Air (HEPA) are filters made of various synthetic fibers. HEPA filters block out 99.97% of all particles 0.3 micrometers or larger and capture about 80% of indoor particles.

ULPA

Ultra-Low Penetration Air (ULPA) is a new filter technology that blocks 99.99% of particles measuring 0.12 micrometers—much smaller than the HEPA threshold. ULPA may restrict air flow, therefore cleaning less air.

ELECTRONIC

Electronic filters are sometimes called electrostatic precipitators. A high-voltage current puts an electrical charge on particles as air passes through. A charged collector plate traps the particles at the opposite end of the unit. Filters may be inserted into ductwork.

ULTRAVIOLET

Components of ultraviolet (UV) radiation are built into the filtering system to extinguish airborne pollutants such as mold, fungus, and bacteria. UV filters can be installed alongside an electrostatic system.

Efficiency Rating Systems

CADR

Clean Air Delivery Rate (CADR) is a measure of the amount of contaminant-free air delivered by a room air cleaner. Energy Star products require CADR testing.

MERV

Minimum Efficiency Reporting Value (MERV) is a rating system that provides an overall value of effectiveness of an air filter on a 16-point scale. Residential home products are generally within the 6 to 12 range.

MPR

The micro-particle performance rating (MPR) is a system that was developed by 3M which rates the manufacturer's filters and ability to capture airborne particles smaller than 1 micron.

FPR

Filter performance ratings (FPR) are similar to MERV and based on a number scale of 4 through 10. Designed by Home Depot, FPR assesses brands sold in stores, including Honeywell.

EPA Indoor airPLUS

The Environmental Protection Agency has a voluntary partnership and labeling program called *EPA Indoor airPLUS*. The EPA created *Indoor airPLUS* to help builders meet the growing consumer preference for homes with improved indoor air quality. *Indoor airPLUS* builds on the foundation of the EPA's Energy Star requirements for new homes.

The builder must first design a home to earn the Energy Star certified home label, and then add additional home design and construction features to help protect qualified homes from moisture and mold, pests, and combustion gases and other airborne pollutants.

Before the home officially earns the *Indoor airPLUS* label, it is inspected by an independent third-party to ensure compliance with the EPA's guidelines and specifications.

Resources:

EPA Indoor Air Plus Program
www.epa.gov/indoorairplus

EPA Indoor Air Quality
www.epa.gov/indoor-air-quality-iaq

Canada Residential Indoor Air Quality Guidelines
www.canada.ca/en/health-canada/services/air-quality/residential-indoor-air-quality-guidelines.html

Air Conditioning

Most residential central air conditioners are called “split-systems” because they have both outdoor and indoor components. The evaporator coil is attached to the furnace inside the home. The condenser and compressor are installed outside.

Air conditioners are rated according to the “Seasonal Energy Efficiency Ratio (SEER)” and “Energy Efficiency Ratio (EER).” SEER measures how efficiently a cooling system will operate over an entire season. EER measures how efficiently a cooling system will operate when the outdoor temperature is at a specific level, such as 95 degrees Fahrenheit.[62]

SEER ratings were created so that consumers could compare the cooling costs of different air conditioners over one-, five-, ten-, and fifteen-year time periods. Factors are based on the air conditioner’s size, local cost of electricity per kilowatt-hour (kWh), and the annual cooling hours for your location as estimated by the Environmental Protection Agency.[63]

Ductless Mini-split Air Conditioners

Mini-splits are small-size systems that offer flexibility for heating and cooling individual rooms, each with its own thermostat. Since mini-splits have no ducts, they avoid the energy losses associated with the ductwork of central forced-air systems. The outdoor unit can be located as far away as 50 feet from the indoor evaporator. The indoor air handlers can be suspended from a ceiling, mounted flush into a drop ceiling, or hung on a wall. Floor-standing models are also available. Unlike window units, they are installed with only a small hole in the wall.

Room Air Conditioners

Room-size air conditioners have significantly advanced in recent years, and models now have energy-saving features. Air conditioners with “connected functionality” allow users to adjust settings using smart home technology. Products are available that are “smart-grid ready,” allowing users to take advantage of cost-saving programs offered by a utility company.

Evaporative Coolers

Evaporative coolers are suitable for geographic areas that have low humidity. Water is evaporated into the air, providing a natural and energy-efficient means of cooling. Products are also known as "swamp coolers." They can be connected to ductwork to cool a number of rooms. Floor-standing, portable devices will cool an entire room or section of the home.

When operating an evaporative cooler, windows are opened part way to allow warm indoor air to escape as it is replaced by cooled air. Unlike central air conditioning systems that recirculate the same air, evaporative coolers provide a steady stream of outdoor air into the house. According to the Department of Energy, systems cost about half as much as central air conditioning systems and use about one-quarter as much energy.[64]

Programmable Thermostats

Advanced scheduling of air temperatures can save a significant amount of money. Programmable devices are effective for reducing energy costs to heat the home in the winter—or cool the home in the summer.

Basic features allow homeowners to schedule settings for each HVAC zone in the home for different days and times. More advanced features include voice-activation, mobile apps, email alerts, and other reminders. Popular models include Google Nest, Ecobee, Comfort, Johnson Controls GLAS, Heagstat, Orbit, Lux, and several types from Honeywell.

Sophisticated devices include sensors that monitor outdoor temperatures, humidity levels, and automatically adjust settings. A "changeover" feature automatically switches the system from heating to cooling as the weather changes. When you're on your way home from work, based on your mobile phone's location, the *Honeywell Lyric* starts warming or cooling your house when you are 10 miles away.

Some utility companies offer free programmable thermostats to their customers during special promotions or with the purchase of certain appliances.

BLUEPRINT #4

Lighting and Appliances

The U.S. Environmental Protection Agency established the Energy Star program in 1992. To date, the program and its partners helped American families save more than 4 trillion kilowatt-hours of electricity and achieve over 3.5 billion metric tons of greenhouse gas reductions.[65]

Energy Star Canada is a voluntary partnership between the government of Canada and industry to make high-efficiency products readily available and visible to Canadians. The program was initiated in 2001 and is administered by Natural Resources Canada.[66]

> Lighting and appliances in your home come with two price tags—the purchase price and cost to operate and maintain them.[67]
>
> —Energy Star

Lighting

Light bulbs and fixtures are now available that use 70 to 90% less energy than traditional models. New types of bulbs and fixtures can last up to 15 times longer than traditional incandescent light bulbs.

LED stands for light emitting diode. LED lighting products produce light up to 90% more efficiently than incandescent light bulbs. Incandescent bulbs produce light using electricity to heat a metal filament until it becomes "white" hot or is said to incandesce. As a result, incandescent bulbs release 90% of their energy as heat.

Energy Star LED bulbs are subject to very specific requirements designed to replicate the experience of a standard bulb and can be used for a wide variety of applications. LEDs are "directional" light sources, which means they emit light in a specific direction, and are able to use light and energy more efficiently in a multitude of applications.[68]

Manufacturers and utility companies sometimes give homeowners free LED bulbs in conjunction with product promotions.

Appliances

Energy Star has certified approximately 70,000 products based on its energy-efficiency criteria. Builders throughout the U.S. and Canada offer Energy Star products in their energy-efficient home models. Products include furnaces, boilers, heat pumps, heating, ventilation systems, fans, air conditioners, and the full range of household appliances and lighting. The chart below highlights recent advancements in the performance of premium products with the Energy Star label.[69]

Appliance	Performance
Refrigerators	New models operate more quietly, and redesigned doors provide better insulation to keep food fresher, and with about 9% more efficiency.
Dishwashers	Smart features provide more effective and quieter operation and minimize water use. Energy efficiency is about 12% greater than conventional units.
Clothes Washers	New models utilize 45% less water and 25% less energy than standard washers.
Ceiling Fans	New models move air 50% more efficiently than conventional fans while providing the same amount of cooling.
Ventilation Fans	Products now include high-performance motors and improved blade designs, using 50% less energy.

Find an Energy Star Product in the U.S.
https://www.energystar.gov/productfinder/?s=mega

Find an Energy Star Product in Canada
https://www.nrcan.gc.ca/energy-efficiency/energy-star-canada/energy-star-products/12519

BLUEPRINT #5

Water Management

Our final blueprint encompasses one of the most important aspects of our lives—water. There are three imperatives covered: efficient hot water heating; water conservation; and water safety.

Efficient Water Heating

There are a number of innovative hot-water heating options that use less energy, save money, and provide a household with sufficient hot water. Conventional storage water heaters remain the most popular type of water heating system. Single-family storage water heaters generally include a "ready reservoir," which holds anywhere from 20 to 80 gallons of water. Hot water is released from the top of the tank, and as water is used, cold water enters the bottom of the tank, ensuring the tank is always full. Tanks are usually heavily insulated, and the recommended thermal resistance (R-value) ranges from R-12 to R-25.

"Tankless" water heaters, also known as "demand" or "tankless coil" heaters, do not require a storage tank. When a hot water tap is turned on, water is heated as it flows through a heating coil or heat exchanger installed on the main furnace or boiler. Tankless coil water heaters are most efficient during cold months when the home heating system is used regularly. Conversely, these systems are less efficient in warmer climates.

"Heat pump" water heaters use electricity to move heat from one place to another instead of generating heat directly. Heaters can be installed as a stand-alone system or in combination with the home's space heating system. They work best in moderate climates and can also be retrofitted to work with an existing conventional storage water heater.[70]

> Heat pump water heaters have shown to be two–to three–times more efficient than conventional electric water heaters.
>
> —U.S. Department of Energy

Solar Hot Water Heating

Solar hot water heating is a great way to heat your hot water for free. Systems include insulated storage tanks and solar collectors. The two types of solar water heating systems are “active” and “passive.”

With an active system, “direct pumps” circulate household water through collectors. These systems work well in moderate climates. In colder climates, systems utilize “indirect pumps,” which circulate non-freezing “heat transfer fluid” through the collectors and a heat exchanger. This process heats the water that flows into the home.

Passive systems include “integral collector-storage,” which work well in moderate climates. The second passive type is “thermosyphon,” which requires storage tanks be located above the collectors so that warm water rises to them. Roofs must be able to handle their weight.

Water Conservation

According to the Environmental Protection Agency, each American uses an average of 88 gallons of water a day at home. At least 20% less water can be used by installing water-efficient fixtures and appliances.[71]

“Water re-use,” also known as “water recycling,” reclaims water from a variety of sources. Water undergoes a treatment process and is then re-used for other purposes such as landscape irrigation. Water re-use can provide alternatives to existing water supplies and can be used to enhance water security, sustainability, and resilience.[72]

“Grey water” consists of water that is directed from sinks, showers, bathtubs, washing machines, and dishwashers. Water sourced from these household fixtures is considered safe to handle and is generally treated for re-use for landscape irrigation, toilet flushing, and other household uses.

“Rainwater recovery” systems capture rainwater from the roof of the home and redirect it to a storage tank. This water can be used for irrigating the landscape, watering vegetable gardens, and other outdoor purposes.

“Rainwater collectors” are available with varying degrees of functionality, including models that connect to bathroom fixtures.

EPA WaterSense

WaterSense is a program administered by the EPA that makes it easier for consumers to choose products that will help the environment. Products with the WaterSense label include sinks, faucets, toilets, showerheads, and lawn irrigation products.

WaterSense-labeled homes offer homebuyers a whole-house solution to help save water, energy, and money while maintaining a high level of performance.[73] Some of the benefits of WaterSense-labeled homes include:

- Faster hot water delivery
- No visible leaks
- Independently certified fixtures that use less water and perform as well or better than standard models
- Outdoor irrigation that is low-maintenance, water-efficient, and that offers high-performance

Resources:

WaterSense-labeled Homes
https://www.epa.gov/watersense/watersense-labeled-homes

WaterSense – Product Search
https://lookforwatersense.epa.gov

WaterSense – Find a Rebate
https://lookforwatersense.epa.gov/Rebate-Finder.html

Water Safety

Congress passed the Safe Drinking Water Act (SDWA) in 1974 to protect public health by regulating the nation's public drinking water supply. The SDWA regulates many laws to protect drinking water and its sources, including rivers, lakes, reservoirs, springs, and groundwater wells.

Private wells that serve fewer than 25 individuals are excluded from SDWA regulation. SDWA authorizes the Environmental Protection Agency to set national health-based standards for drinking water to protect against both naturally occurring and human-made contaminants.

The National Primary Drinking Water Regulations (NPDWRs) oversee the legally enforceable standards that apply to public water systems. Primary standards and treatment techniques protect consumers by limiting the levels of contaminants in drinking water.[74]

Most people in the United States receive water from a community water system that provides its customers with an annual water quality report, also known as a *Consumer Confidence Report*. The report contains information on contaminants found, possible health effects, and the water's source.

Private Drinking Water Wells

According to the Environmental Protection Agency, an estimated 13 million households rely on private wells for drinking water in the United States. The EPA does not regulate private wells, nor does it provide recommended criteria or standards for individual wells. Private well owners are responsible for the safety of their water.[75]

If you have a private drinking water supply, the EPA recommends that water be tested annually for total coliform bacteria, nitrates, total dissolved solids, and pH levels. Testing is especially important if you have a new well, or have replaced or repaired pipes, pumps, or the well casing. If anyone in your household is having recurring gastro-intestinal illness, order a coliform bacteria test immediately. Every three years, testing should be completed for sulfate, chloride, iron, and manganese.

If you are expecting a new baby in the household, have your well tested for nitrates before the baby is brought home—and then again within six months. The best time to test for nitrate is during the spring or summer following rain.

Water can be tested for chloride and sodium if your water tastes salty, and tested for hydrogen sulfide or metals if your water has an objectionable taste or smell. Volatile organic compounds (VOCs) testing is recommended if there have been any spills or leaks from chemicals or fuels near your water supply.[76]

Most county health departments provide assistance for testing bacteria or nitrates. If you can't find a state-certified laboratory in your area, you can call the *Safe Drinking Water Hotline* at 800-426-4791 or visit: https://www.epa.gov/ground-water-and-drinking-water/safe-drinking-water-information

Find a certified water testing laboratory in the U.S.
www.epa.gov/dwlabcert/contact-information-certification-programs-and-certified-laboratories-drinking-water

Tap Score
Easy home water testing and reporting from *Simple Lab*, an award-winning science and health services company founded at the University of California in Berkeley, offers testing for city water, well water, and specialized testing.
www.mytapscore.com

Canada

Health Canada's Water and Air Quality Bureau develops the *Guidelines for Canadian Drinking Water Quality* in partnership with the provinces, territories, and other federal departments. Guidelines are used by every jurisdiction in Canada and serve as the basis for establishing drinking water quality requirements for all Canadians.

Health Canada participates in the development of the World Health Organization (WHO) guidelines for drinking water. The Canada Bureau also works closely and shares information with other government agencies such as the U.S. Environmental Protection Agency.[77]

Health Canada Program, "Be Well Aware – Test Your Well Water"

Health Canada's Water Quality Division recommends water-quality testing every two years, or more often if changes in taste, smell, or color are noticed. More frequent testing is advised if there are any concerns about coliforms or *E. coli.* Water should be tested if there are recent activities or land-use changes near the well. Shallow wells, or wells that have only a thin layer of soil over rock can become contaminated and should be tested more often.

The local public health unit in your province may recommend testing of other chemicals that can affect health. Generalized water quality tests help determine what types of water treatment devices may be needed, or if there are conditions that could potentially cause problems.

The best times to sample your well water are in early spring just after the thaw, after a long dry spell, following heavy rains, or after not using it for a long time. Following are recommendations:

- Check the well cap regularly to ensure that it is securely in place and watertight.
- Run the cold water tap for a few minutes each morning or when the system has not been used for a number of hours. Use only cold tap water for drinking, cooking, and making baby formula.
- During boil-water advisories or boil-water orders, bring water to a rolling boil for a full minute for all water used for drinking, cooking, washing fruits and vegetables, and brushing your teeth.

The above information was adapted from Health Canada's *Be Well Aware*[78] publication, which is available at: www.canada.ca/en/health-canada

Canada Water Quality
www.canada.ca/en/health-canada/topics/health-environment/water-quality-health.html

SGS Water Testing in Canada
Home water testing services with offices located in all provinces.
www.sgs.ca/en/solutions/quality-water-testing-in-canada