Fundamentals of Building Green
Workbook

GPRO

Green Professional Building Skills Training

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Urban Green Council
55 Broad Street, 9th Fl.
New York, NY 10004
www.gpro.org
gpro@urbangreencouncil.org

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TABLE OF CONTENTS

ABOUT US

WHO IS URBAN GREEN COUNCIL?

Urban Green Council's mission is to transform buildings for a sustainable future in New York City and around the world.

We develop cutting-edge policy, we educate a broad range of professionals, and we research solutions that are amplified through coverage in major publications like *The New York Times*. By working with both government and industry, we leverage our effectiveness. Urban Green pursues activities that have scalable impact: And we focus exclusively on buildings, which account for 40 to 70 percent of carbon emissions in cities.

WHAT IS GPRO?

GPRO®—Green Professional Building Skills Training—is a certificate program designed for the people who build, renovate, and maintain buildings. It provides these professionals the tools to integrate high-performance construction and maintenance practices into their everyday work.

Our holistic approach to sustainability training, combined with expert advice and the latest adult learning techniques, have made GPRO an education trailblazer for building trades and operators across the country.

GPRO students stay ahead of the curve with training on high-performance building and earn the GPRO Certificate upon passing the certificate exam.

WHO SHOULD TAKE THIS COURSE?

GPRO Fundamentals is designed for anyone who would like a better understanding of high-performance building. This course is ideal for a range of audiences including:

- Sales or administrative staff who work in real estate, construction, architecture or engineering
- Workforce development providers
- Facilities and operations support staff
- College students interested in building sustainability

Fundamentals of Building Green explains how different systems work together to make buildings efficient, healthy and resilient, as well as where the green building industry is headed.

INTRODUCTION

Buildings are major consumers of natural resources in the U.S., accounting for 40 percent of energy and 13 percent of water use. So it's not surprising that green building techniques are increasingly important for construction and facilities staff across the country, as well as for the people who design these structures.

In *Fundamentals of Building Green*, you will learn how to see buildings differently and discover strategies to improve their performance.

At the end of this course, you will be able to:

- Explain how reducing building energy will reduce the effects of climate change.
- Describe the basic elements of green, high-performance construction and building operations.
- Explain the role of trades on high-performance job sites.
- Recognize energy-consuming building systems and describe some strategies to reduce building energy use.

As you will see throughout this course, building green significantly reduces the waste of energy, water, and materials. It improves the health and productivity of workers and occupants and increases the lifespan and performance of building systems.

Fundamentals of Building Green will help you understand important green building definitions and abbreviations. Note: words listed in ***bold italics*** throughout the text can be found in the glossary beginning on page 25. Please visit **GPRO.org** for practice tests and additional resources.

Working towards a GPRO certificate and committing to green work practices is an important contribution to the health of our environment. Each one of us can make a difference in preserving the Earth's resources for future generations, and together we can make a significant impact.

Thank you for taking *Fundamentals of Building Green*!

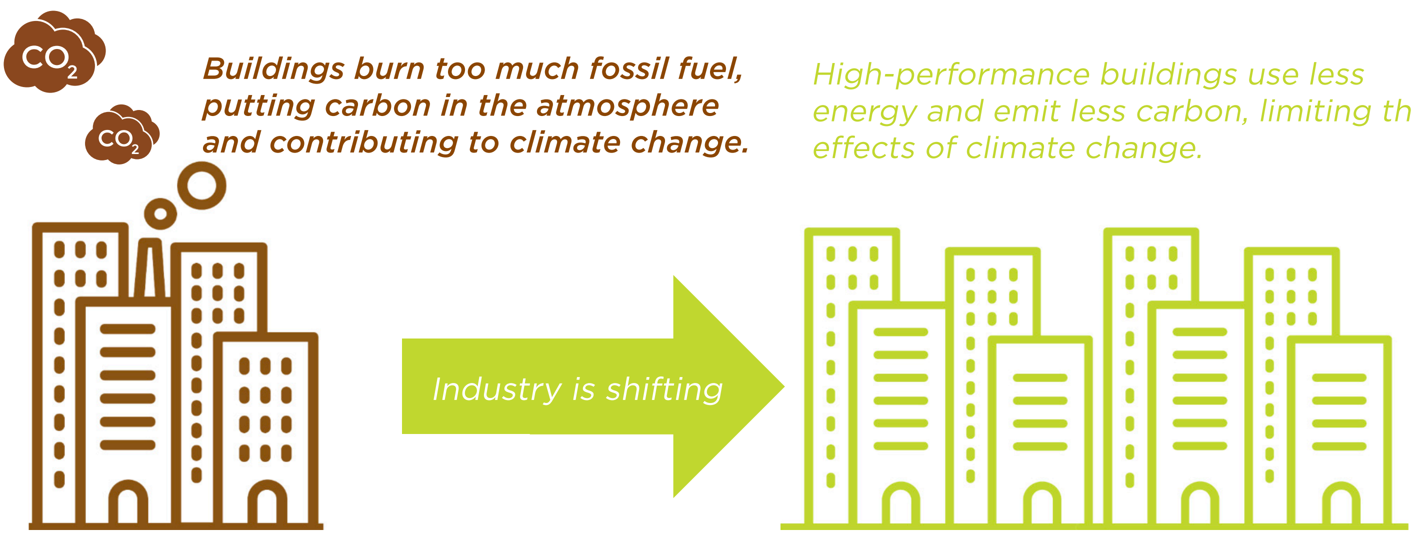
PART A: SUSTAINABILITY

CHAPTER 1

CONNECTION BETWEEN BUILDINGS AND CLIMATE CHANGE

BUILDINGS AND CARBON

Because the amount of energy we use to construct and operate buildings directly affects how much the climate will continue to change, success in the construction industry over the next half century will require an understanding of the relationship between building energy and carbon.



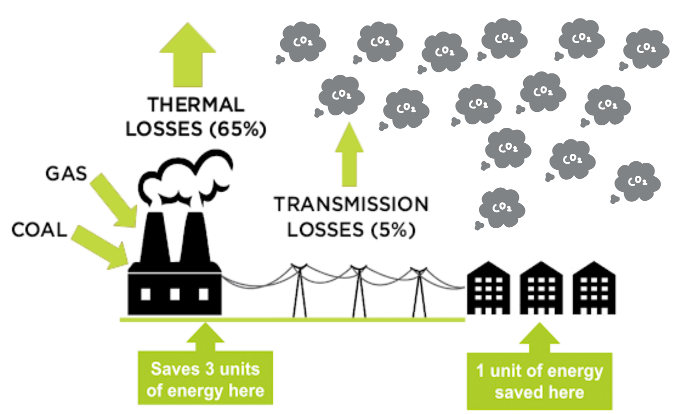
ENERGY THAT FUELS BUILDINGS

Site energy is the amount of fuel and electricity a building consumes on-site. But it doesn't tell the whole story.

- Natural gas and fuel oil are mined or drilled.
- Electricity is generated, typically from centralized power plants.

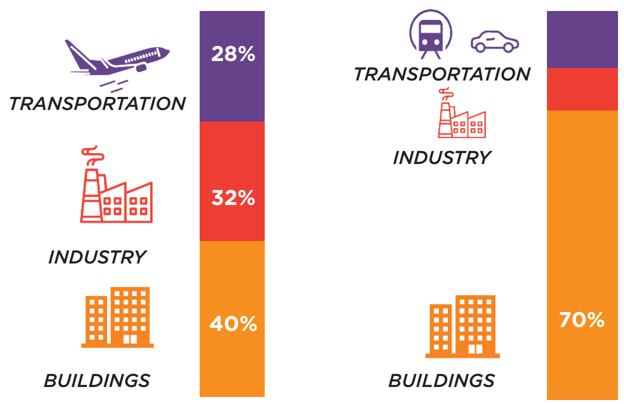
Source energy is the total amount of raw fuel required to operate a building. For a true measure of environmental impact, we also need to include the energy it takes to generate the electricity.

Power-generation plants employ a mix of fuels, some cleaner than others. On average in the U.S., up to 70 percent of the energy supplied to a power plant can be lost due to wasted heat and other losses in transmission and distribution.



For every 1 unit of electrical energy saved in a building, 3 units of source energy are saved at the power-generation plant.

Buildings Use More Energy than Other Sectors



Energy Use by Sector (U.S.)

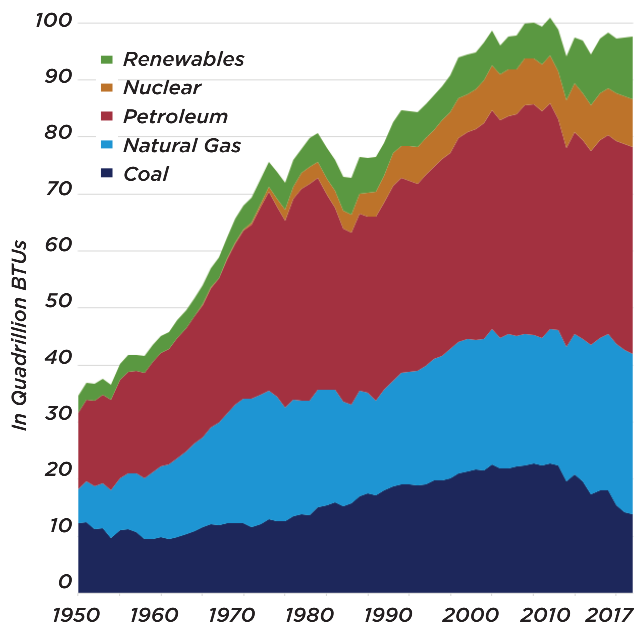
Energy Use by Sector (New York City)

Nationally, the building sector consumes the most energy, two thirds of which is fossil fuel. In cities, building energy can be responsible for up to 75 percent of carbon emissions!

Where Does This Energy Come From?

Buildings use energy for heating, cooling, cooking, and to power all the appliances of modern life. Where does this energy come from?

- Gas and oil are drilled, then piped or trucked to the building. These energy sources are ***fossil fuels —*** the remains of ancient plants that were compacted and transformed deep under the earth over millions of years.
- Electricity is generated in centralized power plants that are fueled by fossil fuels, nuclear power, and increasingly renewable energy sources.



This graph shows the major sources of primary energy consumption, in the U.S. from 1950 to 2017. The shares of natural gas and petroleum are shrinking, while renewables are growing.

Renewable Energy

Renewable energy comes from sustainable sources that will not be depleted over time.

These sources produce energy without creating pollutants because they don't burn fossil fuels. The best known of these sources are wind and solar.

There are many other sources of renewable energy such as geothermal electrical plants that take advantage of the constant ground temperatures. Biomass burns wood and wood-processing wastes to heat buildings and generate electricity. Agricultural crop waste is another source of biomass that can be burned as a fuel or converted to liquid biofuels.

Wind power, an energy source that mitigates climate changes, already generates about 6.5% of U.S. electric energy and 6% of global electric energy.

SUS·TAIN·A·BIL·I·TY

noun

Meeting the needs of the present without compromising the needs of future generations.

WHAT IS SUSTAINABILITY

Sustainability is the capacity to thrive long-term without using up resources. It means meeting the needs of the present without compromising the ability of future generations to meet their own needs.

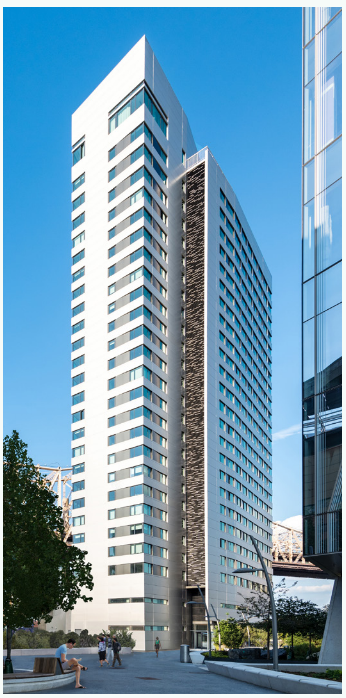
A sustainable world is one that is healthy and productive, and provides opportunities and economic security for people and their families. This course will focus on how sustainable construction and building operations practices will create jobs, save money, make people healthier, and preserve the environment.

CHAPTER 2
WHAT ARE HIGH-PERFORMANCE BUILDINGS?

DEFINING A HIGH-PERFORMANCE BUILDING

High-performance buildings are sometimes referred to as ***green buildings***. They come in all styles, types, and sizes, but they have three things in common:

1. **Efficient***:* They use less energy and water.
2. **Healthy:** They improve the health of workers and future occupants.
3. **Environmentally responsible:** They are durable, use materials that don't damage the environment, and have a low impact on the community and surrounding areas.



Photographer: Field Condition

CASE STUDY:

The House at Cornell Tech

Roosevelt Island, New York City

The House at Cornell Tech, the world's first residential high-rise built to ***Passive House*** standards, is a 26-story building that houses students and faculty members in 352 apartments. This low carbon, energy-efficient, and healthy building has achieved Passive House Certification and earned LEED Platinum certification.

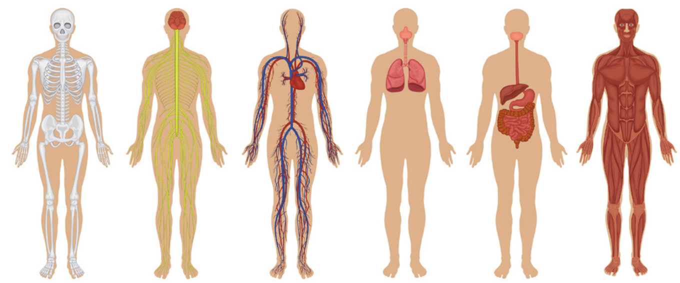
Passive House buildings use 60 to 70 percent less energy than typical buildings. To achieve that level of performance, the building envelope must be airtight. Prefabricated panels (each one story tall) fitted with triple-paned windows, were assembled in York, Pennsylvania, then hauled by barge to Roosevelt Island for installation. A louver system spans the building to serve as "gills" where the heating and cooling systems live, allowing them to breathe.

Passive House buildings must provide energy recovery ventilators (ERVs) to circulate fresh air effectively without giving up efficiency. Three ERV units serve the entire building, achieving a neutral airflow. "If we're putting air in, we have to take it out," says Julie Janiski, a project design manager for BuroHappold Engineering, noting that air is constantly being exhausted from kitchens and bathrooms, while fresh air flows into living rooms and bedrooms. Residents decide for themselves how warm or cool they'd like to keep their apartments, adjusting individual refrigerant-based fan units in each room.

SYSTEMS THINKING

Systems thinking means understanding how individual systems work together. People who use systems thinking can anticipate how changes to one system will affect another.

You already understand systems thinking. When you exercise, your lungs (respiratory system) need more air to send more oxygen to your muscles (muscular system). These systems interact all the time. When blood oxygen gets low, your heart beats more rapidly and you breathe more deeply.



Just like the systems of a human body, building systems interact with each other all the time.

QUESTIONS TO ANSWER:

What is a high-performance building?

How are high-performance buildings different from regular buildings?

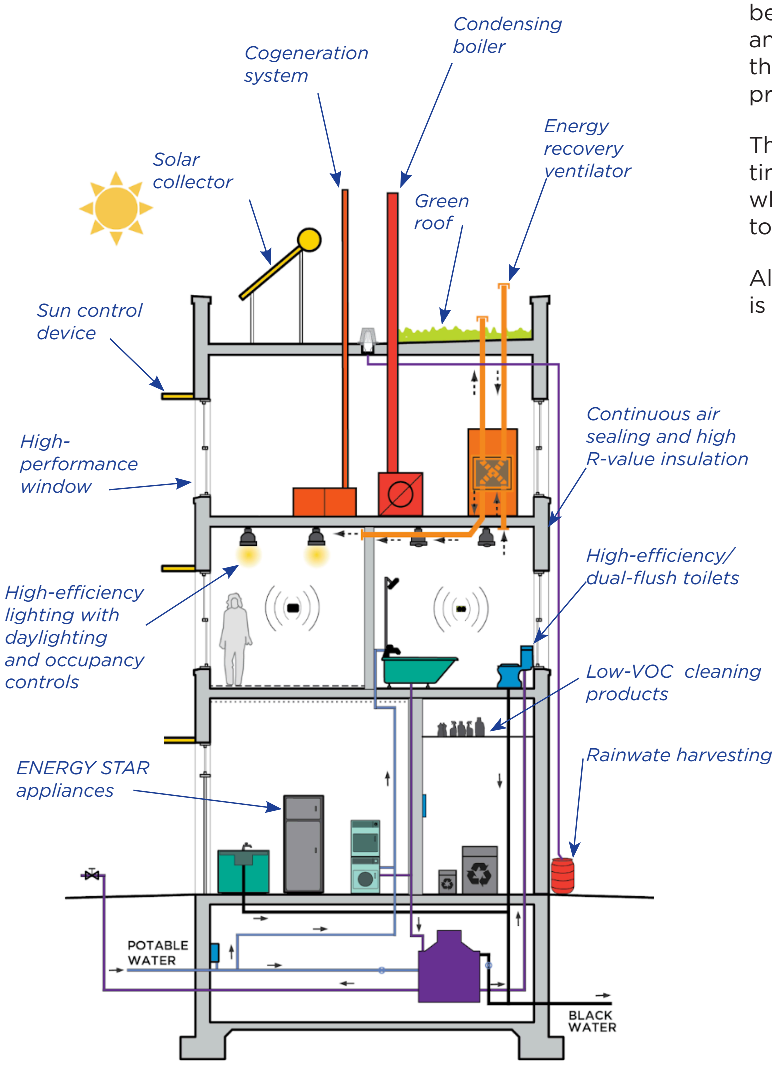
WHOLE BUILDING APPROACH

Systems thinking is a key principle of high-performance building. It is often called the ***Whole-Building Approach***, which means that the building is designed, built, and operated by teams who understand that the building is a complete entity — changes in one system affect outcomes in another.

The goal of the entire team is to create a building in which all the systems work together in sync.

As examples, the carpenters who build and air seal the exterior walls and the sheetmetal workers who insulate the ductwork will each have a direct impact on how well the ***HVAC*** system heats and cools the spaces.

In high-performing buildings, systems work well together to provide a comfortable, healthy environment as efficiently as possible.



This diagram shows technologies commonly found in high-performance buildings. The Whole-Building Approach means that all systems work together to provide an efficient and healthy environment.

INTEGRATED PROJECT DELIVERY

To achieve a high level of performance, teams practice ***Integrated Project Delivery***, which requires active and effective coordination among the design, construction, and operations teams throughout the entire project, sometimes before construction even begins.

Everyone involved with the building has input on the project, from the design phase through construction and operations, because shared goals and intent means fewer misunderstandings and change orders.

Using the Whole-Building Approach, construction managers implement collaborative processes such as ***charrettes*** and make sure that construction trades are knowledgeable about each other's work and schedules throughout the entire project.

For example, the construction and operations teams may be asked for input during the design process to identify and solve issues before they become actual problems, and the operations team may participate in the commissioning process to ensure that the building performs as designed.

This approach requires more work at the front end — a lot of time and energy is often invested early in the design phase when there is maximum flexibility and the best opportunities to make adjustments based on team members' input.

Although this approach is not yet common in the industry, it is very common on high-performance teams.

Integrated Project Delivery means coordination among the design, construction, and operations teams throughout the entire project.

CHAPTER 3
CAUSES AND EFFECTS OF CLIMATE CHANGE

WEATHER VS. CLIMATE

Weather and climate are not the same. ***Weather*** is the current state of the atmosphere: a combination of temperature, rainfall, humidity, clouds, and wind. It is measured over short periods of time, in hours, days, and weeks. ***Climate*** is the average weather pattern at one place over an extended period of time, 30 years or more. Climate includes both normal and extreme weather (such as storms or heat waves). For example, the climate of the Southwest is dry and hot, even though the weather occasionally includes rain.

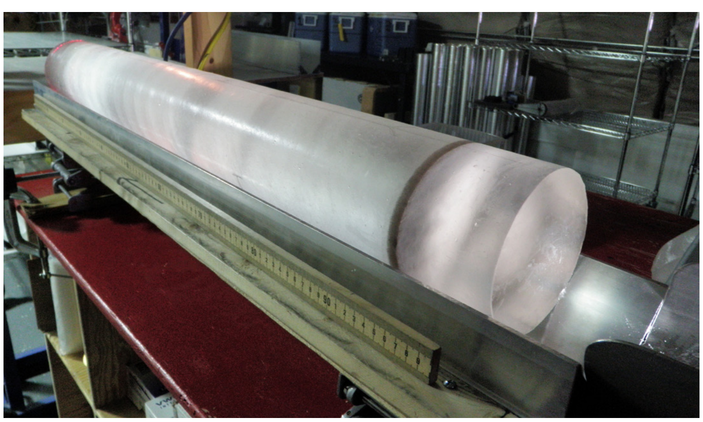
WHAT IS EARTH'S "NORMAL" TEMPERATURE?

To determine if the climate is changing, scientists must first confirm the Earth's "normal" temperature.

Scientists Track CO2 and Temperature Over Time

Scientists working in the U.S. Geological Survey National Ice Core Lab use the air bubbles trapped in ice cores to get a glimpse of ***carbon dioxide (CO_2)*** levels on Earth over time. Carbon dioxide is the principal gas that affects global temperatures.

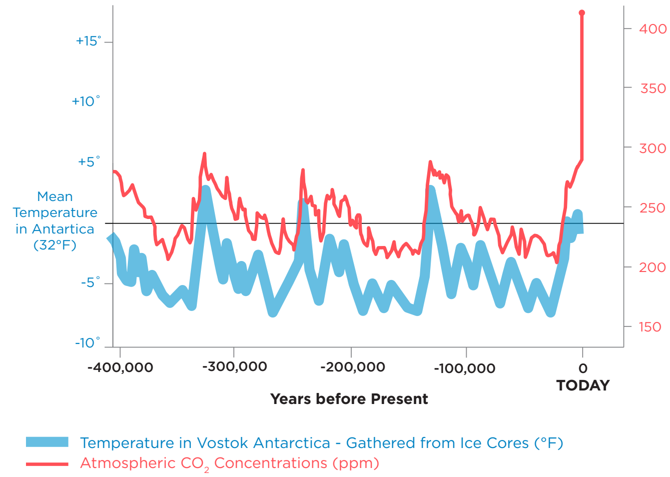
A scientist working in the U.S. Geological Survey National Ice Core Lab.



Ice cores can provide insight into Earth's atmosphere over tens or even hundreds of thousands of years. Pictured above is a 1-meter long section of the West Antarctic Ice Sheet Divide core, with a dark layer of volcanic ash visible. *Photo credit: Heidi Roop*

TEMPERATURES ARE RISING

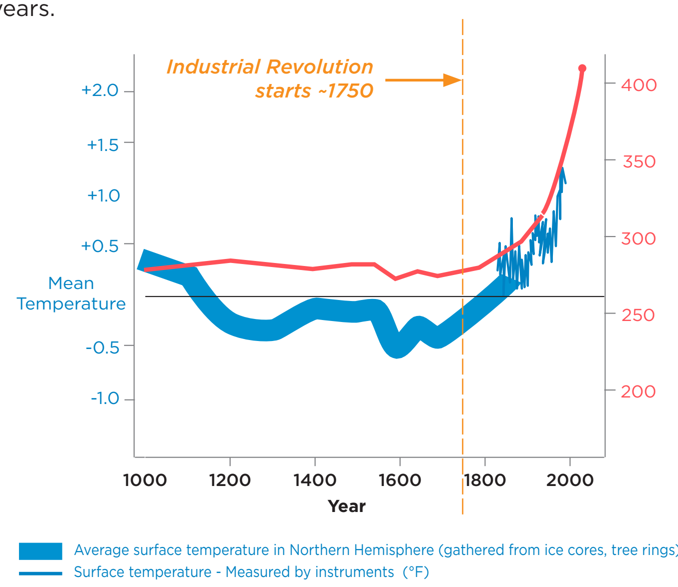
The Earth's climate changes naturally due to small variations in the planet's orbit. Over time, the average global temperature cycled between cool periods (ice ages) and warm periods. The level of CO_2 in the atmosphere has always closely mirrored the Earth's warming and cooling cycles. The recent dramatic rise in carbon dioxide levels is cause for concern.



Concentrations of CO_2 have correlated closely with global surface temperatures over the past 400,000 years.

In the graph below, notice what happens to the CO_2 levels and temperatures after about 1750.

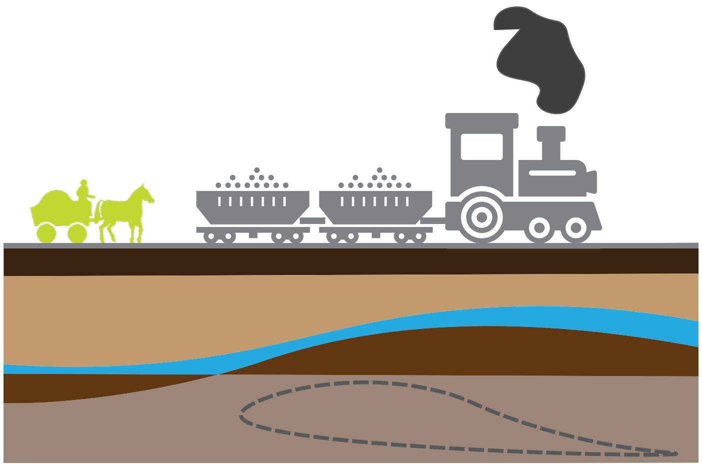
During the ***Industrial Revolution***, animal and human labor were replaced with fossil fuel–burning combustion machines, and carbon began to be pumped into the atmosphere. Because carbon in the atmosphere holds heat, the Earth's temperature has been steadily rising. It is likely that the planet will soon be the warmest it has been in the last million years.



CO_2 levels increased dramatically after the start of the Industrial Revolution, beginning a global warming period.

GREENHOUSE EFFECT

Since the beginning of industrialization, humans burned coal, gas, and oil on a large scale to produce energy. The amount of carbon (as CO_2) and methane (CH_4) in the atmosphere began to rise, at first slowly and now more quickly.



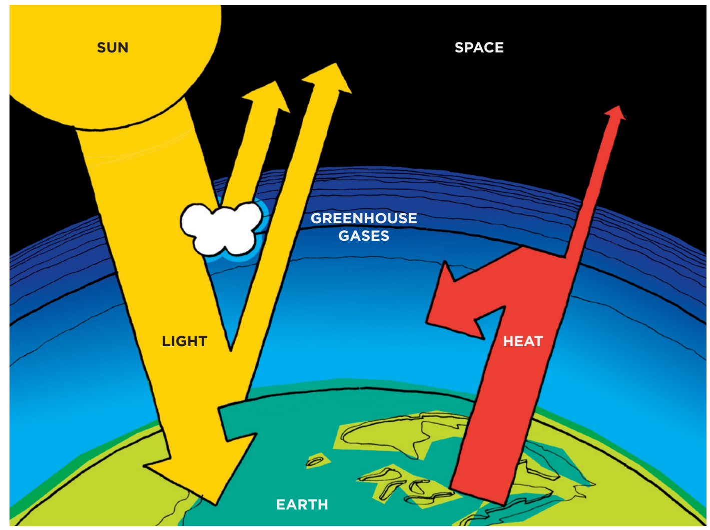
Fossil fuels: Carbon from coal and oil that was buried for millions of years (as fossils) is dug up, burned, and emitted into the atmosphere as greenhouse gases.

The Greenhouse Effect Supports Life on Earth

Carbon dioxide, along with other common gases such as ***methane***, are potent ***greenhouse gases (GHGs)*** that trap heat in the atmosphere. These gases act like the glass windshield of a car, letting in sunlight, which warms the Earth's surface. Like any warm object, the Earth then radiates the heat back into space.

The ***greenhouse effect*** describes how the Earth's atmosphere allows GHGs to trap heat, keeping our planet warm enough to support life. As greenhouse gases accumulate, they absorb much more of this radiated heat instead of letting it pass through. As a result, some of the energy that came in as sunlight is now trapped at the Earth's surface as heat.

The strength of the greenhouse effect and how much it will affect ***global warming*** will depend on the amount of greenhouse gases that continue to accumulate in the atmosphere.



Adding GHGs from fossil fuels is like adding blankets — they trap more heat and make Earth hotter.

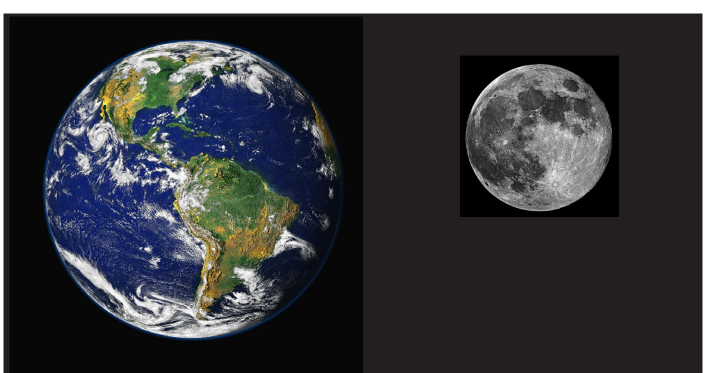
CLIMATE CHANGE IS HAPPENING NOW

Climate change refers to long-term changes in the average temperature, rainfall, snow, wind patterns, ocean currents, and other aspects of weather at a particular location.

The climate is already changing. Global climate temperatures are already getting warmer: 2017 beat 2016 for the hottest year on record; 2016 beat 2015, and so on.

Seventeen of the 18 hottest years on record have occurred since the year 2000. NASA publishes monthly reports based on publicly available data from about 6,300 meteorological stations around the world.

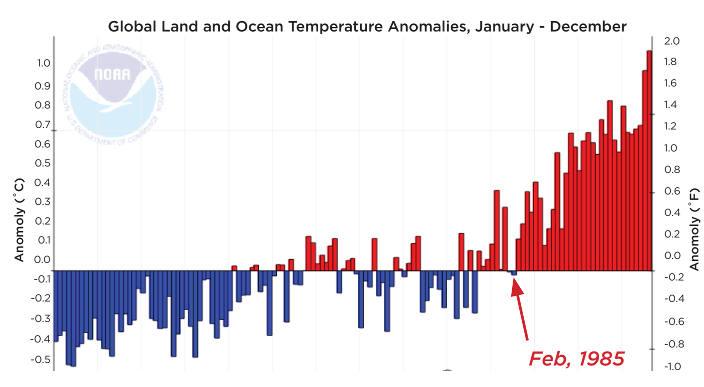
Visit *www.climate.nasa.gov/vital-signs* for current information.



Earth's atmosphere keeps the average temperature at 56˚F

With no atmosphere, the moon's average temperature is -9˚F

The Earth would be a ball of ice without the greenhouse effect.



Anyone who was born after February, 1985, has never experienced a month in which the average surface temperature of the Earth was cooler than 1900's average.

THE CLIMATE IS ALREADY WARMING

People all over the world are already seeing impacts of climate change.

Dry Places are Getting Drier

Lake Mead Reservoir serves water to Arizona, California and Nevada, providing sustenance to nearly 20 million people and large areas of farmland. It has not reached full capacity since 1983.

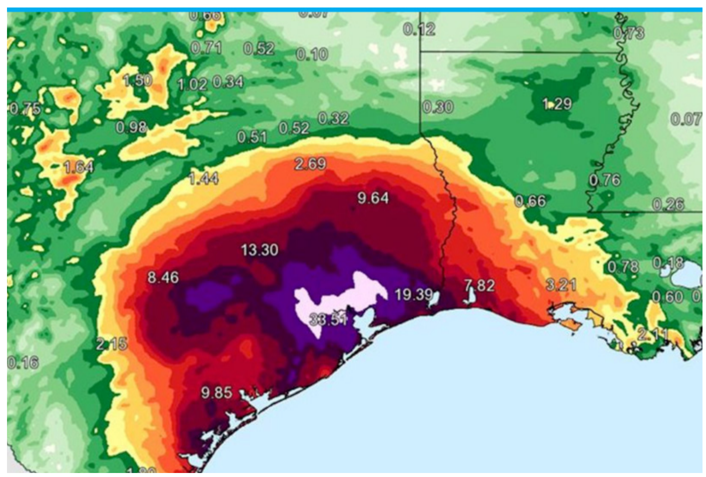
Small Changes in Temperature are Causing BIg Shifts in Food & Wildlife Cycles

A rise of 1˚F caused infestation of mountain pine beetles which destroyed local timber and recreation industries in Colorado.

Hot Places are Getting Hotter

A heat wave in 2015 melted asphalt in New Delhi, India, and caused the deaths of at least 2,500 people.

Storms are Bigger and Cause More Damage



The National Weather Service had to add a new color to its maps to show Harvey's rainfall.

Wildfires are Much Bigger and More Frequent

In the summer of 2013, the Rim Fire burned over 255,000 acres. Approximately 77,254 acres were in Yosemite National Park.

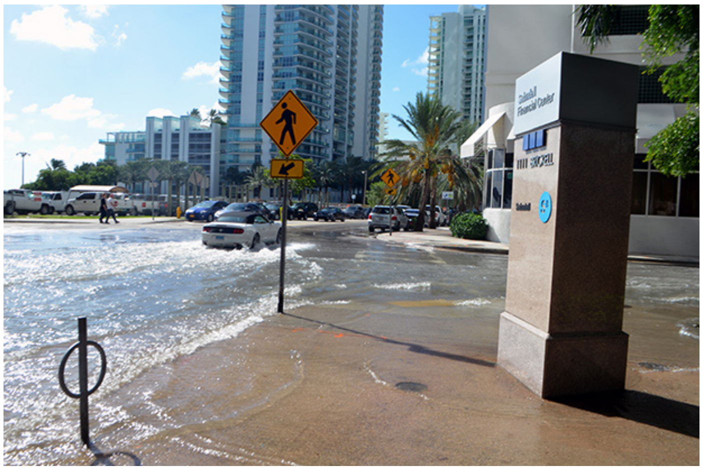
More People are Dying and Losing their Homes

Homes and businesses are surrounded by floodwater on March 20, 2019, in Hamburg, Iowa.

SEA LEVELS ARE RISING

In the U.S., the most at-risk locations are coastal. If sea levels continue to rise, Florida and cities such as New York, Boston, New Orleans and San Francisco will be under several feet of water.

Many places are already experiencing sea level rise due to warming oceans and melting ice. For example, Miami floods at high tides, known as king tides, due to sea levels that continue to rise.



King tides in Miami, FL. These tidal floods are often called sunny-day or blue-sky floods, as they occur on an otherwise beautiful, calm day.

How Hot is Too Hot?

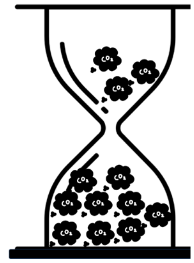
The Earth can withstand a maximum temperature rise of 1.5˚C (2.7˚F) without triggering catastrophic feedback loops in which warmer temperatures lead to further warming.

For example, warmer air leads to an increase in the amount of water vapor in the atmosphere, which in turn prevents heat from escaping and leads to further warming.

In addition, as temperatures continue to rise, permafrost begins to melt. Permafrost is land that remains frozen year-round. As it melts, it releases carbon from decaying matter that had been frozen underground since the last ice age, 10,000 years ago.

Methane bubbling up from melting permafrost underneath Vermillion Lake, Banff National Park, Alberta, Canada.

The World's Carbon Budget is Almost Depleted

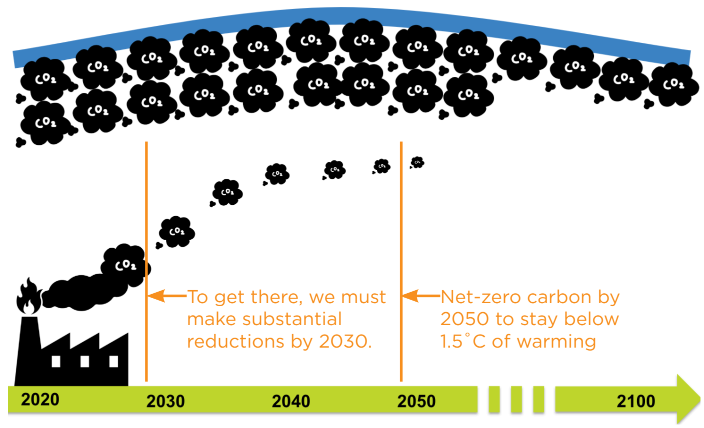


A carbon budget is a simplified way to track the additional carbon that can be emitted, in order to limit global warming to below and increase of 1.5˚C (2.7˚F).

According to the ***Intergovernmental Panel on Climate Change (IPCC),*** about three-fourths of the world's carbon budget has already been used. At current rates, the remaining carbon budget is estimated to be depleted between 2021 and 2030, and devastating effects will become unavoidable.

CO_2 Accumulates in the Atmosphere.

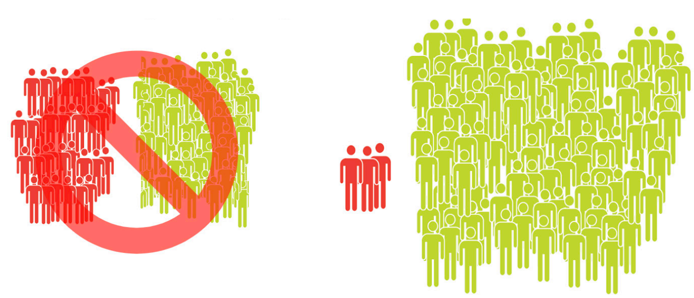
To stay below 1.5˚C (2.7˚F) of warming, global carbon emissions need to fall to net-zero by 2050. To get there, we must make substantial reductions in emissions by 2030.



Public Opinion About Climate Change is Often Incorrect

No one disputes that the levels of carbon dioxide in the atmosphere and global temperatures have increased. And over 97 percent of climate scientists agree that combustion of fossil fuels is the main contributor to increased CO_2 levels.

However, there are skeptics who deny that climate change is due to man-made activities. These claims occur in selected press and social media, where the fossil fuel industry has spent millions of dollars to support the spread of skeptical beliefs. In the face of melting glaciers and rising seas, it is very hard to take these skeptics seriously. Read for yourself at: IPCC Special Report: Global Warming of 1.5°C (2018) www.ipcc.ch/sr15/.



Public Opinion: *2016 polls say that the scientific community is divided on whether or not climate change is happening.*

Reality: *Over 97% of scientists agree climate change is occurring and is caused by humans.*

CHAPTER 4
WORKING TOWARDS SOLUTIONS

ENVIRONMENTAL DISASTERS

Global Solutions: The Montreal Protocol (1987)

The ***ozone*** layer protects the Earth from much of the sun's UV radiation, which causes skin cancer.

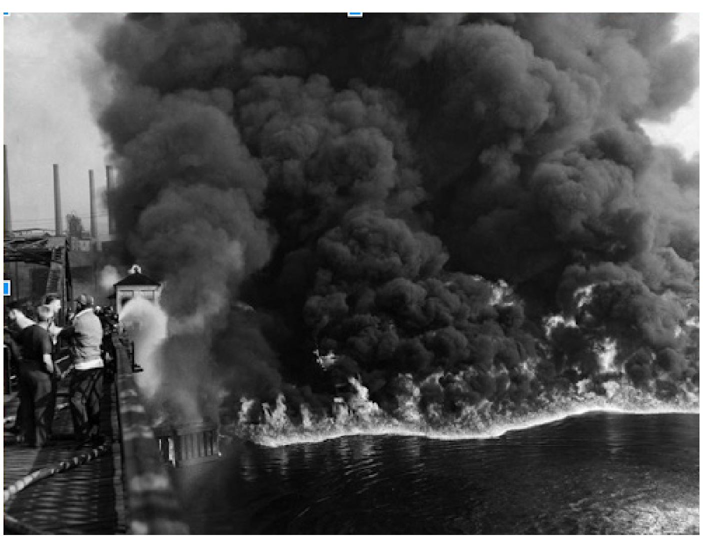
In the 1970s, scientists began noticing large holes forming in the ozone. They attributed them to ***chlorofluorocarbons*** (CFCs), which are organic compounds made of carbon, chlorine and fluorine used as propellants, solvents and refrigerants.

Through the 1987 ***Montreal Protocol***, every country in the United Nations agreed to reduce the amount of CFCs. By 2010, the ozone hole stopped growing. The Montreal Protocol was one of the most successful and effective environmental treaties ever negotiated and implemented.

Through the Montreal Protocol, countries phased out the production and use of ozone-depleting chemicals to heal the ozone layer.

Americans and the Global Community have Solved Environmental Problems in the Past

Many environmental disasters have mobilized Americans to call for greater environmental protections. These disasters brought environmental issues to the public eye.



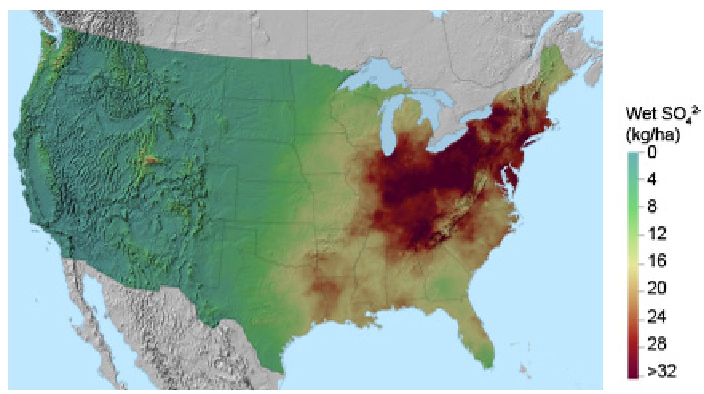
The Cuyahoga River in Cleveland, Ohio, was so polluted from industrial discharges that it caught fire.

National Solutions

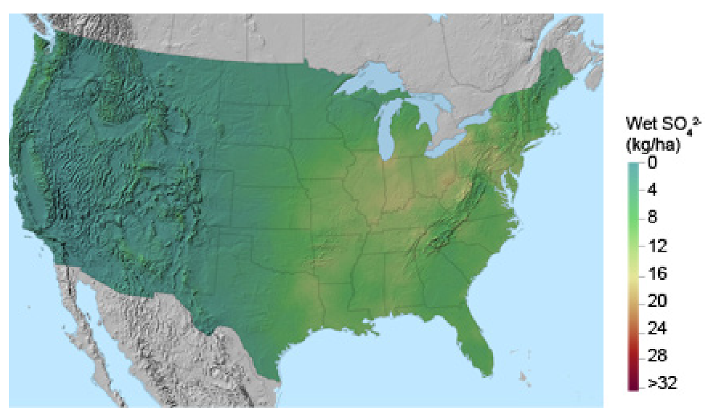
Acid rain is a product of ***sulfur dioxide (SO_2)*** and ***nitrogen oxides (NOx),*** which are released from fossil fuel–burning power plants. These gases are absorbed by moisture in the atmosphere, which becomes extremely acidic. It then rains down and kills trees, poisons waterways and accelerates the weathering of buildings.

In 1990, the U.S. Congress and ***Environmental Protection Agency (EPA)*** created the ***Acid Rain Program***, a ***cap and trade*** program that required power plants to reduce their emissions of SO2 and NOx. Companies were allowed to trade "emissions credits" with other power plants as long as regional levels of emissions were kept below a certain level.

This stimulated new and more advanced technologies to reduce acid rain and allowed struggling older plants to purchase credits instead of having to be decommissioned. This new market for buying, selling and trading emissions limited government involvement and reduced the cost of compliance. The result was a drastic reduction in acid rain and was much less expensive than anticipated.



Prevalence of acid rain in the U.S. 1989–1991



By 2011, acid rain in the U.S. was dramatically reduced. The successful U.S. acid rain "cap and trade" pollution program was a blueprint for modern day carbon emissions trading plans and was much less expensive to implement than originally anticipated.

TWO RESPONSES TO CLIMATE CHANGE

Mitigation

Mitigation is any action that reduces the risk of climate change by lowering greenhouse gas emissions. Examples are:

- More renewable energy sources
- Stricter energy codes leading to more high-performing buildings
- A price or cap on carbon

Geothermal heat is an energy source that mitigates climate change. A geothermal power plant generates electricity by extracting heat from the Earth's crust and using it to produce steam to spins turbines.

Adaptation

Resilience means the capacity to recover quickly from extreme weather events. Designers, builders and operators will need new solutions for buildings to adapt to the changing climate.

Adaptation recognizes that effects of climate change are already happening and includes site-specific strategies to make buildings more resilient.

If your building is located in a flood zone or an area where storms are getting stronger, you might see requirements in new building codes such as to:

- Install stronger windows to withstand severe winds and storms and provide better ***insulation*** for livability in extreme temperatures.
- Ensure that backup power and drinking water are available to residents of multi-family buildings after extreme weather.

An adaptation strategy in a flood prone area is to raise buildings and critical systems to avoid flood damage.

Retrofitting Buildings is Key Strategy

Because such a huge portion of existing buildings in North America need to be upgraded to use less energy and withstand changes in climate, ***retrofitting*** existing buildings will be the largest single creator of local jobs.

This is especially true in U.S. cities, where the majority of buildings in 2050 already exist now. These older buildings were constructed using standards created in an era of low-cost energy and will need major improvements to dramatically reduce energy use.

Although new buildings can use less energy and water than those they replace (on a per square foot basis), substantial energy is required to demolish old structures and then produce, transport and assemble new materials.

Therefore, retrofitting conserves embodied energy, so it has a smaller environmental impact than constructing a similar, but even more efficient, new building.

House of Lebanon, Margaret Murray Washington School, Washington, D.C., exemplifies restoration and adaptive reuse of an historic school campus to meet the needs of an affordable housing program for independent seniors.

CASE STUDY: UNITED NATIONS

Retrofit or Rebuild?

During a recent renovation of the United Nations in New York City, the team studied the lifetime carbon cost of demolishing and rebuilding the campus versus retrofitting the existing buildings.

They calculated that although the new, high-performance buildings would emit less CO_2 per year, due to the slow purging of CO_2 from the atmosphere, it would take 35 to 70 years before the operational efficiencies gained by the new, more efficient construction would offset the carbon cost of demolishing the building.

The U.N. opted to retrofit rather than rebuild.

CHAPTER 5
VALUE OF HIGH-PERFORMANCE BUILDINGS

DOES A HIGH-PERFORMANCE BUILDING COST MORE?

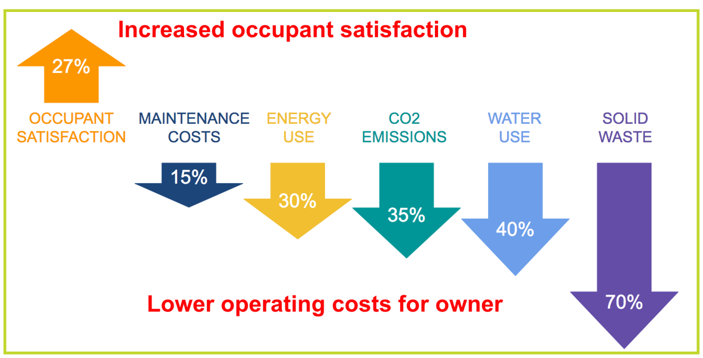
The overall cost of a high-performance building has two components:

- ***First costs:*** The amount of money it costs to design and construct the building
- ***O&M costs:*** Long-term expenses for operating and maintaining the building

Just like conventional buildings, the components and systems used in high-performance buildings vary in complexity and require different levels of coordination among trades.

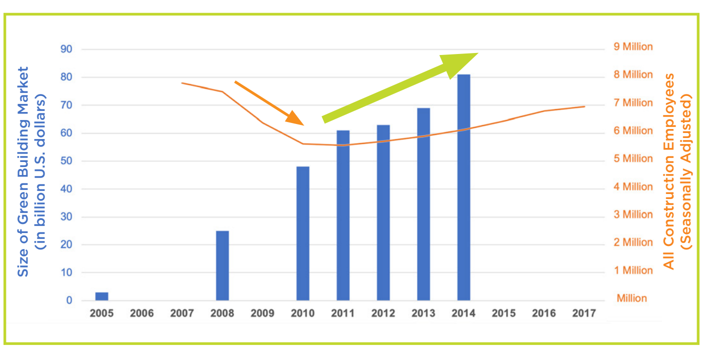
Because of this, people often assume that high-performance buildings are more expensive to build. However, once design and construction teams become familiar with new techniques, many costs and complications are eliminated. Some experienced green builders report that due to a more collaborative process, they can actually build green at a lower first cost.

High-performance buildings generally have lower operational costs than conventional buildings due to lower fuel, electricity and water use over time. This provides significant financial returns to the building owner. Over the life of the building, it's actually more expensive to NOT build green!



In addition to energy and utility savings, green buildings also frequently outperform conventional buildings across a wide variety of measurements, including building value, occupancy rates and tenant satisfaction.

Growth of High-Performance Building Market



The U.S. green building market grew from $3 billion to $48 billion in 5 years and continued growing....even during the recession, when the rest of the industry suffered a dramatic downturn.

GREEN JOBS

High-performance building spurs job growth and creates new job opportunities for incumbent workers. These buildings require workers with the skills, knowledge and ability to implement sustainable strategies in the competitive construction market.

Green For All defines a ***green job*** as a "well-paid, career-track job that contributes directly to preserving or enhancing environmental quality." Green jobs are just a different way of doing the job you're already doing.

Green jobs:

- Require new thinking about old skills, including re-training workers on green practices.
- Are often local jobs that are difficult to outsource, such as energy auditors and weatherization workers.
- Include simple fixes that help homeowners save on energy bills.
- Include manufacturing of renewable technologies, such as wind and solar, which are rapidly growing fields.
- Include on-site retrofitting of existing facilities and residences. Trained building operators can make the building perform more efficiently and save huge amounts of money.

A green job is a well-paid, career-track job that contributes directly to preserving or enhancing environmental quality.

2.5 Million Jobs in Energy Efficiency in U.S.

According to the U.S. Energy Employment Report (USEER), 2.5 million people worked in the U.S. energy efficiency sector in 2018. Examples include:

- Installing smart lighting systems.
- Sealing duct leaks in HVAC systems.
- Insulating walls and ceilings.
- Installing and servicing mechanical systems.
- Manufacturing and installing state-of-the-art appliances.

PART B: GREEN BUILDING PRACTICES

CHAPTER 6

SMALL CHANGES, HUGE IMPACT

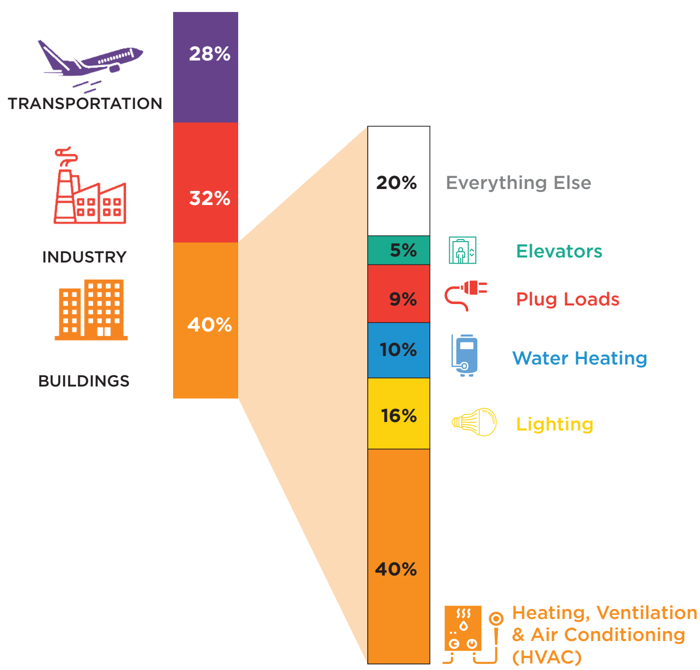
WHICH BUILDING SYSTEMS USE THE MOST ENERGY?

In this course, we are going to focus on the three building systems that consume the most energy: HVAC, lighting and water heating.

However, there is another important system that significantly affects how much heating, cooling and lighting the building needs: the ***building envelope,*** sometimes referred to as the ***thermal envelope***. The envelope is the largest building system, made up of the foundation, exterior walls, roof, windows and doors.

An envelope that is well insulated and air sealed will have lower heating and cooling loads. And a building that has well-placed windows can save a lot of lighting energy through ***daylighting*** practices.

The proportions below are based on the average commercial building in the U.S. Energy usage in individual buildings will vary.



Distribution of energy across building systems (based on the average commercial building in the U.S.).

8 STRATEGIES

THAT HAVE AN OUTSIZED IMPACT ON BUILDING PERFORMANCE

1. ***Envelope:*** Seal and insulate building exterior
2. **HVAC:** Properly sized heating, cooling and ventilation systems
3. **Water:** Strategies to conserve water
4. **Lighting:** Efficient electrical and lighting systems
5. **IAQ:** Healthy indoor air quality
6. **Materials:** Use environmentally-friendly materials
7. **Testing:** Test and commission systems to ensure performance
8. ***Sustainable Building Operations:*** Ensure continuous performance

QUESTIONS TO ANSWER:

How does the interaction between the systems affect the building's energy use?

1. What are some examples of building systems working against each other?

2. What are some examples of building systems working well together?

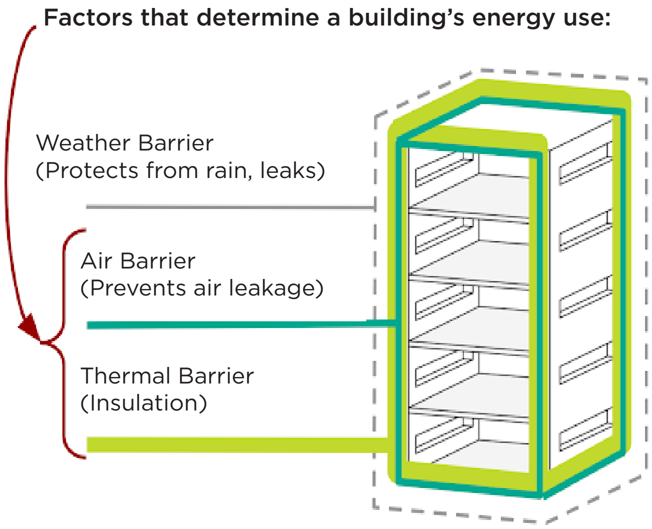
CHAPTER 7
TIGHT BUILDING ENVELOPE

BASICS OF HEAT AND AIR FLOW IN BUILDINGS

Temperature is how hot or cold an object is.

Thermal Energy is continuously transferred between objects.

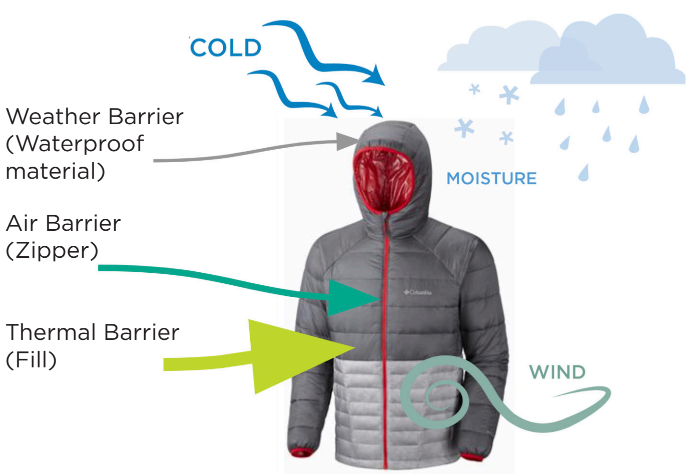
- Heat (thermal energy) moves from HIGH to LOW temperature.
- Air moves from HIGH to LOW pressure.
- Moisture moves from WET to DRY.



The quality of the air barrier and the thermal barrier are primarily responsible for the performance of the building envelope.

The Building Envelope is the First Line of Defense Between Indoor and Outdoor Environments

The performance of the envelope has a substantial effect on the amount of energy used by the building's heating and cooling systems to keep the interior comfortable.



Just as a winter jacket keeps our bodies warm and dry, a building envelope prevents heat, moisture and air from moving between the interior of the building and the outside.

HEAT MOVES IN THREE WAYS

Conduction is heat transfer between solid objects.

Radiation requires direct line of sight to transfer thermal energy.

Convection requires a fluid (gas or liquid) to transfer thermal energy.

MANAGING AIR MOVEMENT IN BUILDINGS

What Makes an Effective Air Barrier?

Air-sealing materials such as caulk are used to plug any holes around penetrations and windows and any other area where air may escape. Leaks are commonly located:

- Between window/door frames and jambs.
- Around all electrical outlets at exterior walls.
- At all wall/floor and wall/ceiling joints.
- At all through-wall penetrations.

The most important aspect of an air barrier is that it be continuous. The quality of the air and thermal barrier will determine how much energy the building will use over its lifetime.

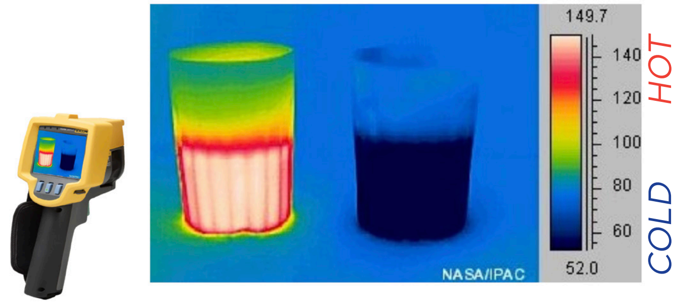
Air sealing with caulk at the interior.

Air sealing using a liquid applied membrane on the exterior wall to ensure the air barrier is continuous.

On a green construction site, you may see signs like the one above. Trades working on a building after the air barrier has been completed must be very careful to avoid penetrations at exterior walls.

Infrared Cameras Used by Many Trades

An ***infrared (IR) camera*** is a useful tool to indicate where buildings are losing heat. In addition, electricians can use IR cameras to identify hot connections, overloaded circuits and transformers. Mechanical insulators use IR cameras for quality control to “see” that the installation is complete at all joints and bends.

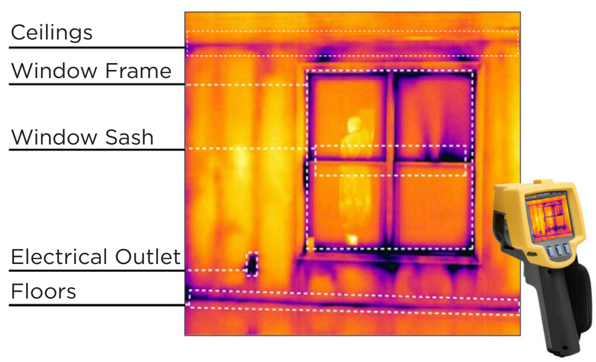


Many trades use infrared (IR) cameras for a variety of applications because hot and cold temperatures show up as different colors.

Test Air Barrier Before Inspection

Many jurisdictions have new energy codes that require testing of the building envelope. New best practice is to do a “pre-test” before closing up the walls using diagnostic tools such as ***blower doors*** and IR cameras. It’s a lot less expensive to fix air leaks before the walls are closed up.

The blower door tries to “inflate” the building, and measures how much air flows in at a specified pressure. The resulting air leaks can occur anywhere there is a joint, and the IR camera can show hot spots where the air is getting out, isolating the leak for repair.



IR cameras can pinpoint areas of air leakage prior to the final air leakage test.

A building must pass an air leakage (blower door) test to ensure that it complies with a maximum allowable amount of air leakage at the walls, windows, roof and slab.

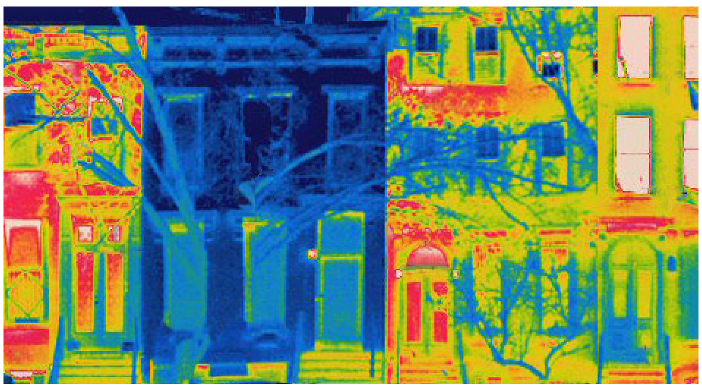
MANAGING HEAT FLOW IN BUILDINGS

What Makes a Thermal Barrier Effective?

Like the air barrier, a thermal barrier needs to be continuous. This means that insulation must cover the entirety of the building envelope without breaks. Special attention must be paid to wall studs and windows, as these are typical areas that transfer heat easily. A layer of continuous rigid insulation on the outside of the building envelope can help prevent heat loss through studs (see IR photo on previous page showing heat flowing through metal studs in poorly insulated wall).

New high-performance windows can greatly reduce the amount of heat loss by using triple-paned glass with gas fill between panes.

The thermal barrier prevents unwanted heat gain and loss through the envelope. Typically, the air barrier and thermal barrier align, which means that you can't have an air barrier at the interior and insulation at the exterior of the wall or materials in between may get damaged over time.

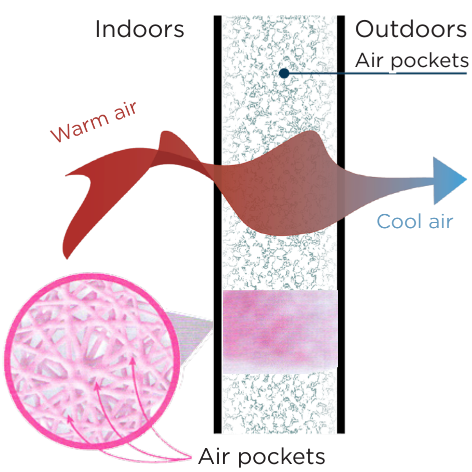


An IR camera shows which surfaces are cold (blue) and which are warm (red and yellow). The warm surfaces are not well insulated and heat is escaping to the outside.

How Insulation Works

Insulation works by trapping small pockets of air. Trapped air is a poor conductor of heat. That's why insulating materials are generally lightweight and bulky, to create the air pockets that resist heat transfer.

It's important to note that insulation doesn't prevent heat transfer — it just slows it down. The ***R-value*** of a material is an indication of how well it insulates — the higher the R-value, the more the insulation slows heat flow.



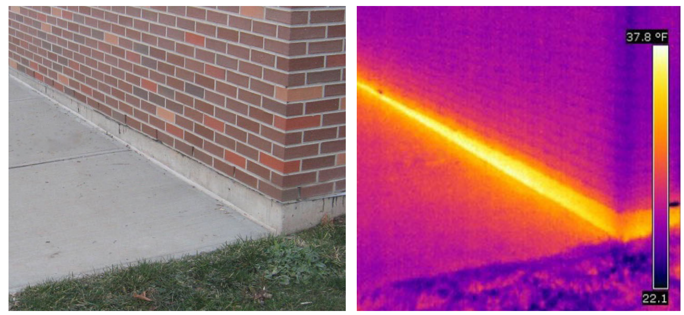
Insulation works by trapping small pockets of air.

Effective Insulation Must be Continuous

The vast majority of older buildings (and most newer buildings) were not constructed with continuous insulation. You will find gaps at virtually every joint where dissimilar materials meet, such as where the wall meets the floor or ceiling, around windows, door jambs, electrical boxes and plumbing penetrations.

THERMAL BRIDGING

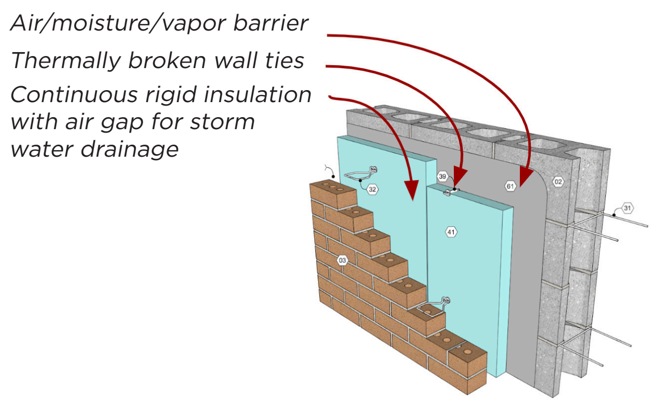
Thermal bridging occurs when a poor insulating material allows heat flow across a thermal barrier. To prevent thermal bridging, a ***thermal break*** must be provided in order to create continuous insulation.



Thermal bridging at slab edge.

New Details for Thermal Breaks

Builders will need to use new details and practices to provide thermal breaks at the building's entire ***thermal envelope***. An example is shown below.



The code requirement for continuous insulation means that standard building practices are changing. For example, bricklayers must provide thermal breaks at wall ties and avoid penetrating the air barrier.

Stop Moisture and Water Vapor

Water vapor, generated inside the building, must be kept out of the insulation at the same time as heat is kept in (otherwise it will condense there and ruin it).

A "vapor retarder" is a layer that will prevent water vapor from entering the wall. In a cold climate, it must always be inside the insulation. The "air barrier" can be combined with the vapor retarder or it can be a separate layer. If separate, it is applied on the outside of the insulation to prevent liquid water from leaking through the facade and damaging the insulation. It will also allow water vapor from inside to escape.

CHAPTER 8
RIGHT-SIZED HVAC

RIGHT-SIZED AND EFFICIENT MECHANICAL SYSTEMS

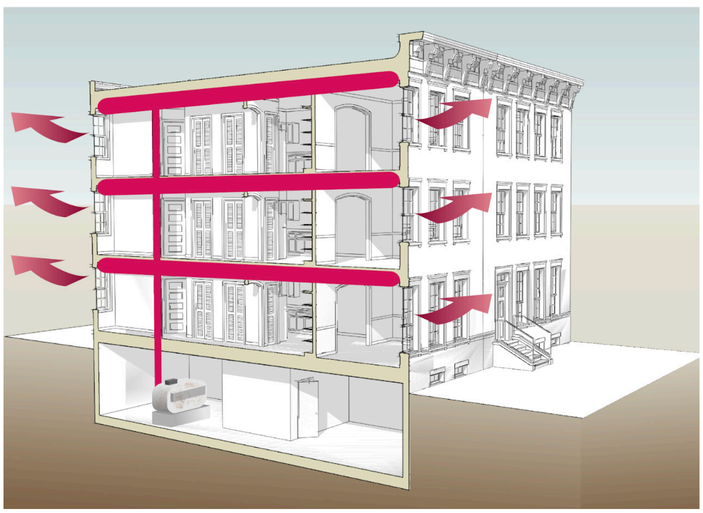
Now that the envelope is airtight and well insulated, the heating and cooling loads can be smaller.

Efficiency means minimizing energy losses to get more "service" out of a system without adding more fuel.

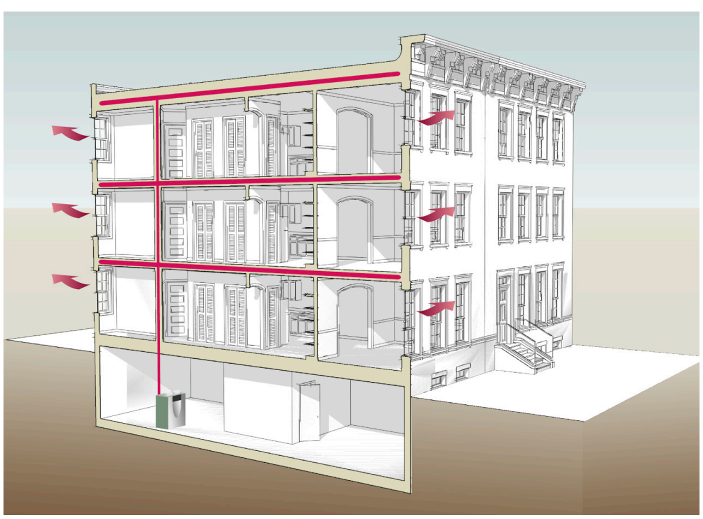
A mechanical system that is properly sized and employs efficient equipment will use less energy over its lifetime. These systems may also last longer (because oversized equipment short-cycles, wearing out mechanical parts).

Although these systems can provide better comfort for occupants, they can also be more complex because they have more sensors and controls.

Well-trained HVAC professionals will be in great demand to install and service these systems.



Leaky, poorly insulated envelope = larger heating and cooling loads.



Tighter envelope = smaller heating and cooling loads.

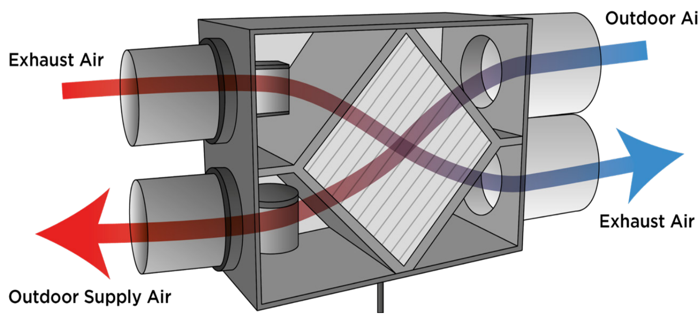
Seal it Tight, Ventilate Right

Ventilation (providing fresh air) is necessary for a healthy indoor environment.

High-performance buildings tend to provide healthier environments because they bring in clean filtered air through mechanical ventilation, rather than dirty air through cracks in the envelope. To ensure that air is delivered where it is intended to go and there is no unnecessary heat transfer, contractors must make sure the ducts and distribution system are well sealed and insulated.

Because these buildings do not depend on cracks in the walls to provide "fresh" air, they can use more energy to ventilate than conventionally-built buildings. Controlled ventilation uses a lot of energy to heat and cool outside air.

High-performance buildings use ***Energy Recovery Ventilators (ERV)*** to increase ventilation efficiency. ERVs capture and reuse the energy (heat) in the air before it is exhausted.



ERVs capture heat from the building's exhaust air to heat incoming, fresh air.

Smart Buildings

Rapidly improving building automation technology is allowing more "smart" buildings to come online. Systems respond to controls and sensors to improve energy efficiency, water efficiency and indoor air quality and provide data that operators use to further optimize systems.

BMS (Building Management Systems) and EMS (Energy Management Systems), along with automatic temperature controls, help operators meet occupant needs while saving energy.

CHAPTER 9
WATER CONSERVATION

CONSERVING WATER ALSO CONSERVES ENERGY

The water and wastewater sectors annually consume 3 percent of the total electricity produced in the U.S.

Showers and toilets typically represent the largest water demand in a building. Installing efficient fixtures and appliances helps people use less water without making major lifestyle changes.

Using less water also means using less energy to heat and distribute it. ***ENERGY STAR®*** ratings identify energy-efficient and water-efficient products (water heaters, dishwashers, washing machines, geothermal heat pumps and boilers). ***WaterSense*** products are 20 percent more efficient than conventional fixtures and appliances.

Toilets and Fixtures

Low-flow (1.6 gallons/flush) and high-efficiency toilets (1.28 gallons/flush) are mandated by code in many jurisdictions and are commonplace throughout the U.S.

Low-flow showerheads and on-demand water heaters reduce waste that comes from letting water run while waiting for it to get hot. Automatic sensors or metering controls reduce water use at sink faucets in public spaces.

Water Reuse & Alternative Wastewater Systems

As water resources are depleted and water supply and sewer costs increase, new water reuse and alternative wastewater technologies are becoming available.

Harvested Water is often used for non-potable uses such as landscape irrigation, sidewalk washing, HVAC cooling towers and urinal and toilet flushing. Sources include:

- ***Rainwater*** (collected through rooftop catchment systems)
- ***Stormwater runoff*** (collected from controlled areas, such as sidewalks)
- ***Condensate*** (collected from mechanical systems)

Treatable Wastewater:

Using drinkable water for the majority of our water needs is unnecessary, wasteful and expensive. Thinking of wastewater not as waste but rather as a supply source is an increasingly common green buidling strategy that conserves potable water.

- ***Greywater*** is untreated household wastewater that has not come into contact with toilet or kitchen waste, such as water from bathtubs, showers, bathroom sinks and laundry sinks. Greywater can often be used to supply underground irrigation systems, depending on the jurisdiction.
- ***Blackwater*** is untreated household wastewater from toilets, urinals and kitchen sinks. On-site treatment of blackwater for reuse is much more complex than greywater treatment.

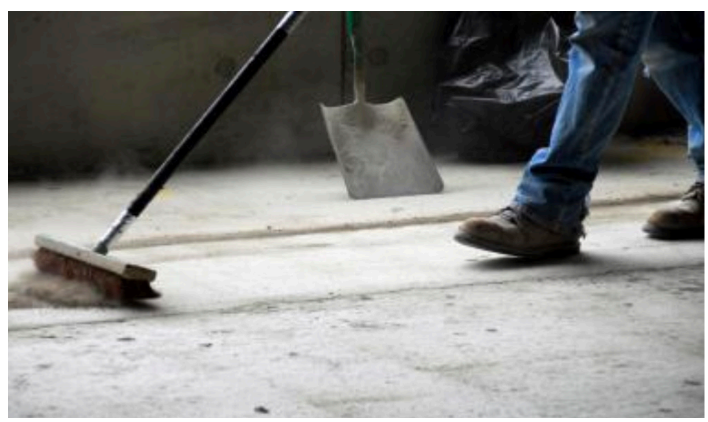
Using Renewable Energy to Heat Water

Solar thermal energy systems harvest solar energy to heat water. In the simplest and most common application, solar collectors use the sun's energy to heat domestic hot water in buildings.

Rooftop solar thermal flat-plate collectors.

Reducing Water Use on Construction Sites

- Clean tools in buckets of water rather than running faucets.
- When cleaning floors, use brooms, squeegees and vacuums first. If water is necessary, use water brooms or trigger guns attached to hoses.



Use water-free cleaning strategies on construction sites.

O&M Strategies to Conserve Water

- Monitor water usage to detect changes.
- Fix leaks immediately and survey previous fixture leakage periodically. An unaddressed leak can be a significant and expensive waste of water.
- Don't wash sidewalks with ***potable water***.
- Insulate all hot and cold plumbing pipes to avoid energy loss and condensation.

CHAPTER 10

EFFICIENT LIGHTING AND ELECTRICAL SYSTEMS

LIGHTING ENERGY

Energy Consumption from Lighting (kWh) =

POWER (kW) X **TIME (hours)**

To reduce the amount of energy that is consumed by lighting, we can do two things:

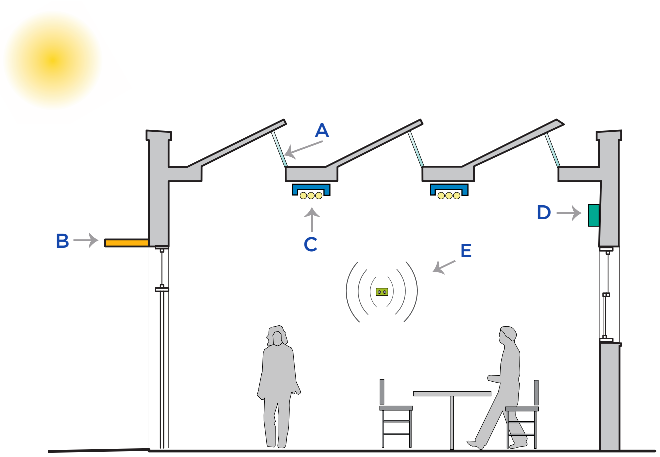
1. Reduce the power that goes to lighting. ***Lighting Power Density (LPD)*** is a term that identifies how much power is allocated to a building's lighting systems. As energy codes get stricter, this allocation gets smaller and smaller.

2. Reduce the amount of time that lights are on. Use sensors and controls to turn off lights in empty rooms and turn off or dim lights when there is enough ambient daylight.

Efficient Lighting Design

Efficient lighting design includes strategies that take advantage of natural light and don't rely on occupants to turn off the lights.

Daylighting strategies avoid glare and heat gain using lightshelves that deflect sunlight and North–facing skylights.

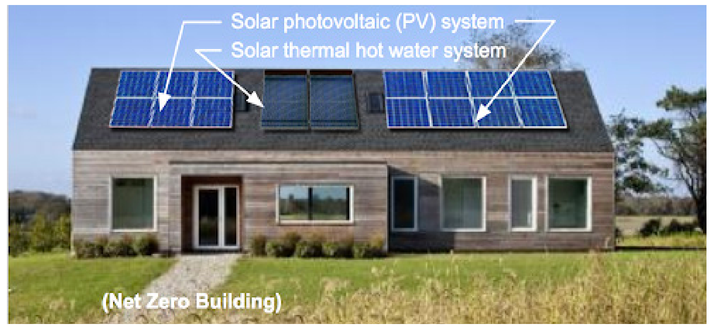


A. Skylights provide northern, indirect daylighting
B. Exterior shading devices reduce solar heat gain in summer
C. High-efficiency LED lighting
D. Daylight-responsive light sensors and controls dim and brighten the interior lights depending on the amount of available sunlight
E. Vacancy sensors dim or turn off lights when room is unoccupied

Net Zero Energy Buildings

Net Zero Energy (NZE) buildings produce enough on-site renewable energy to offset all of the energy the building uses on an annual basis.

An NZE building must be very energy efficient because renewable energy is expensive and shouldn't be used for energy that will be wasted.



For a building to be NZE, the total amount of energy used annually must be roughly equal to the amount of renewable energy created on the site.

GENERATE ENERGY FROM LOW-CARBON AND CARBON-FREE RENEWABLE SOURCES

Renewable energy sources, such as solar, tidal, wind, hydropower and geothermal, are abundant, sustainable and will not be depleted over time. Renewables release far fewer pollutants into the atmosphere than fossil fuels.

On the utility scale, ***nuclear power*** can be considered a renewable resource. It is cleaner than fossil fuels in many ways, but it has its own unique problems, specifically the safe disposal of nuclear waste and the risk of catastrophic disasters such as Fukushima in 2011.

Building-mounted systems such as ***solar photovoltaic (PV) panels*** use sunlight to make electricity, and solar thermal collectors use the sun's energy to heat water or air.

These technologies are rapidly becoming less expensive and more common. Wind power now costs the same as fossil fuel power in many locations.

Solar photovoltaic (PV) panels use sunlight to make electricity.

CHAPTER 11
HEALTHY INDOOR ENVIRONMENTS

GREEN BUILDINGS HAVE GOOD IAQ

We spend 90 percent of our lives inside buildings, but indoor air is often more polluted than the air outdoors.

A high-performing building is one that not only operates efficiently but also has good indoor air quality (IAQ) and provides a healthy, pleasant place in which to live or work.

The CogFx study shows that people perform better cognitively in high-performing buildings with good air quality.

Building Products Can Contain Harmful Toxins

During construction, workers are exposed to many chemicals and air pollutants released from building materials, equipment and cleaning products.

After the building is complete, occupants can be exposed to dangerous substances if the building's ventilation system is not properly managed.

- ***Volatile Organic Compounds (VOCs):*** Found in solvents, glues and cleaning products. Volatile means that the chemical will evaporate into the air quickly.
- ***Formaldehyde:*** Released from adhesives in plywood and other pressed-wood products; it is a known ***carcinogen***.
- ***Polyvinylchloride (PVC):*** A common type of plastic. The manufacturing process uses crude oil and chlorine gas that release hazardous chemical byproducts.

Safety First

Safety data sheets (SDS) for all chemicals should be available on a jobsite so that workers have proper protection and can respond to emergency situations.

SDSs can be downloaded from the website of the material's manufacturer.

Purchase Green-Certified Products

UL Environment eco-INSTITUT	Greenguard	Carpet and Rug Institute (CRI) Green Label Plus	Green Seal

Poor Indoor Environmental Quality is Easier to Prevent than Fix

Safer alternatives are now widely available for most building products. These are products that reduce or eliminate contaminants that are irritating or harmful to people. Choose low-VOC products such as water-based latex paints. Avoid products that have an intense odor or contain urea-formaldehyde.

Construction Indoor Air Quality Plan

A ***Construction Indoor Air Quality (CIAQ) plan*** reduces indoor air quality problems resulting from construction activities. Its goal is to protect the health and well-being of both construction workers during construction and building occupants after the space is completed. As part of a CIAQ plan, contractors must:

1. Vent: Make sure there is enough fresh air by properly ventilating the area, removing contaminants before they can be inhaled or absorbed into materials.
2. Protect: Seal all HVAC equipment and ductwork openings with plastic to keep out moisture and dust prior to installation. Protect moisture-sensitive materials — cover up equipment and materials, especially porous items such as drywall, ceiling tiles and insulation.
3. Control: Out-gas carpet and woodwork in unoccupied spaces prior to installation. Use Low or No-VOC adhesives, sealants, paints and coatings.
4. Interrupt the path of pollutants with partitions or plastic sheeting.
5. Clean continually.
6. Flush out indoor air or test air to meet standards.
7. Housekeeping: Schedule construction activities to reduce exposure to contaminants; provide ongoing cleaning.

Partition off dusty areas.

Protect moisture-sensitive items.

CHAPTER 12
ENVIRONMENTALLY-FRIENDLY MATERIALS

MEASURING ENVIRONMENTAL IMPACT

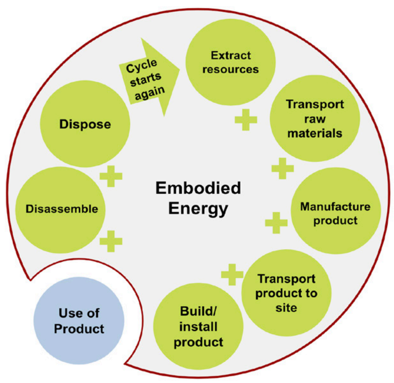
Everything used to construct a building originally comes from nature. Harvesting raw materials such as minerals and wood can damage local ecosystems. The supply of raw materials is not infinite — we can run out if we don't harvest them in a sustainable way.

Responsible construction and operations practices will protect these resources for future generations.

Embodied Energy

Embodied energy is the total amount of energy required to extract a product's raw materials and produce, transport, distribute and install the product.

Energy consumed by the product during its use, like gas or oil used for heating a building, is not normally included in the accounting of embodied energy.

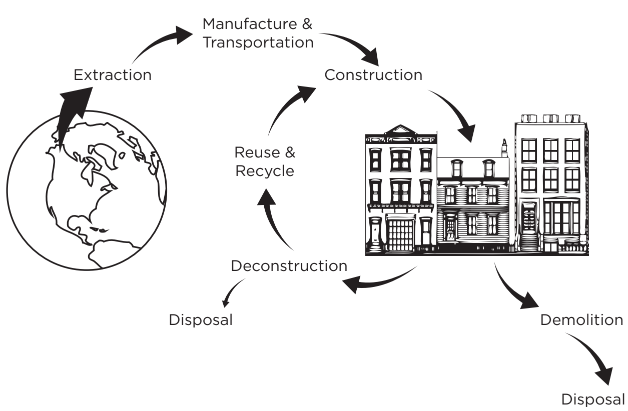


Reusing materials conserves the embodied energy of those materials, as opposed to producing new materials, which requires more energy. Sending materials from a deconstructed building to a landfill is the equivalent of "throwing away" its embodied energy.

Some teams are opting to return to mass timber construction over steel framing to reduce their building's carbon footprint.

Life Cycle Assessment

Life cycle assessment (LCA) measures the total environmental impact of a building. Experts can calculate LCAs for individual products used in construction, from flooring to HVAC systems, or for an entire building. Knowledgeable designers and builders can choose more environmentally-friendly products based on the LCA results.

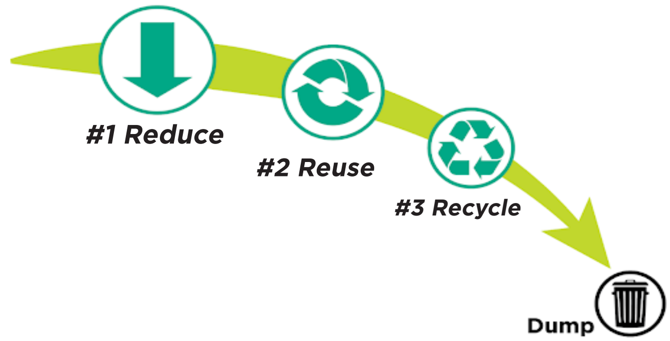


Reuse and recycling can extend the life cycle of building materials and substantially reduce the amount of construction waste sent to landfills.

REDUCING ENVIRONMENTAL IMPACT

The Order of the 3 R's is Important:

Reusing material is preferable to recycling because it avoids the pollution associated with remanufacturing the product.



Each consecutive process uses more energy and creates additional pollution.

Construction Waste Management

Construction Waste Management (CWM) practices reduce the amount of construction and demolition waste going into landfills and incinerators.

Proper CWM requires waste to be sorted into reusable, recyclable and hazardous materials. Sorting can occur on-site in separate dumpsters or off-site at a recycler's sorting facility.

The more that construction waste is sorted, the better the rates of reclamation.

Purchase Regionally Sourced Products

Regional materials are extracted and manufactured near your construction site. Using regional materials supports the local economy and stimulates local job growth. It also greatly reduces the amount of energy used to transport products.

Although this approach is easier in some parts of the country, there are opportunities to purchase locally-made building products all over the U.S.

LEED defines regional materials as extracted or manufactured within 100 miles (161 km) of the project site.

CHAPTER 13
CODES AND COMMISSIONING

TESTING PERFORMANCE OF NEW BUILDINGS

Teams need a way to test and measure if their buildings are meeting their performance goals. ***Commissioning (Cx)*** ensures that a building's systems perform as designed.

Commissioning focuses on the building's energy-consuming mechanical and electrical systems. Increasingly, building envelopes are also tested as part of the Cx process. Life safety systems are commissioned in all buildings.

Commissioning is a process that occurs throughout the entire project. Early in the design phase, energy-efficiency strategies are selected and equipment is specified by the design team. At the same time, the Commissioning Agent develops a Cx Plan.

During the construction phase, the Cx Agent monitors the installation of the systems to ensure that they are installed properly.

As the project nears completion, the Cx Agent verifies and documents that all of the systems have been tested and can be operated to meet the design intent specified in the ***Owner's Project Requirements (OPR)***. As part of the Cx process, operations personnel should be trained so they can diagnose operational problems and reduce energy consumption. The final result is a report to the owner that documents the processes and final performance of building systems.

As buildings and their systems have become more complex, Cx has become not only a valuable tool but required by code to ensure that the systems are operating as designed.

Who Does Commissioning?

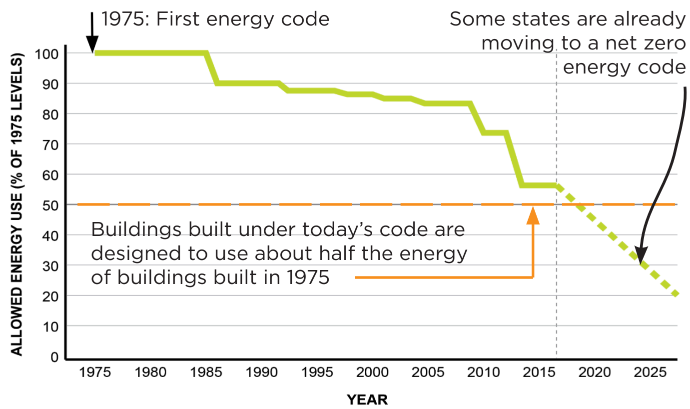
- Cx Agents are typically third-party contractors hired by the Owner.
- Construction Managers manage the Cx process.
- All trades who work on any energy-using systems participate in the building commissioning process.

The Commissioning Agent verifies and documents the performance of equipment and confirms that all systems work together properly.

ENERGY CODES ARE GETTING STRICTER

Codes are required by law, and ***rating systems*** are voluntary standards that define building quality above and beyond code levels.

Building energy codes are the basic legal structures that regulate how much energy a building uses over its lifetime. Energy codes are quickly getting more stringent across North America.



Building energy use allowed under International Energy Conservation Code (IECC) over the life of the building.

Green Buildings Require Proof of Performance

Green buildings require rigorous testing to ensure that they perform as intended. Below are some examples of green building rating systems.

Passive House buildings reduce energy use by 90% or more.

The U.S. Green Building Council developed the LEED certification (Leadership in Energy and Environmental Design), the most comprehensive of the rating systems.

DOE Zero Energy Ready Homes are third-party verified and are at least 40%-50% more energy efficient than a typical new home.

Green Globes is the most widely used rating system in Canada.

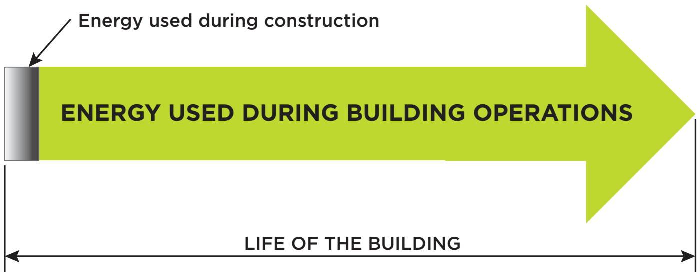
Enterprise Green Communities certified buildings are sustainable, affordable homes.

Living Buildings generate all their own energy from renewable sources.

CHAPTER 14
OPTIMIZING EXISTING BUILDINGS

BUILDING OPERATIONS AND MAINTENANCE

Skilled workers ensure that building systems run smoothly and efficiently every day. The building operations team is responsible for the largest portion of a building's energy consumption over its lifetime.



Unfortunately, most existing buildings are not operating as efficiently as possible, which leads to unnecessary energy and water waste. But with the right skills and information, trained operators can identify these inefficiencies and generate improvements that will ultimately decrease the environmental footprint of their buildings.

Building operators are critical to a building's long-term sustainability because they:

- Ensure systems run smoothly and efficiently every day.
- Measure and monitor system performance.
- Collect occupant feedback and diagnose common problems.
- Implement preventive maintenance.

This is especially important when buildings contain new technologies or cutting-edge equipment. Many advanced building systems, like lighting controls and building energy-monitoring systems, require frequent assessment, analysis and fine-tuning.

New tools and software applications such as equipment fault detection, energy analysis, load profiling, facility benchmarking, asset performance tracking, and carbon and greenhouse gas reporting are now available to help the next generation of operators improve building performance even more.

Understanding Energy Use

Benchmarking is the practice of calculating a building's baseline energy or water use over at least a full year to determine:

- How the building's performance compares to other buildings of similar size and type.
- How energy and water use changes from year to year.

EXISTING BUILDING COMMISSIONING

As buildings age, their systems lose performance over time. Building operations teams at even the greenest buildings can regularly uncover energy-saving opportunities with an ongoing ***Existing Building Commissioning*** process.

Existing Building Commissioning:

- Cx Agents collect and analyze energy data and test equipment.
- Cx Agents work with operators to optimize existing systems based on test results to meet current needs for the facility.
- This process should be done every 3 to 5 years or whenever a new system is installed.

Energy Audit:

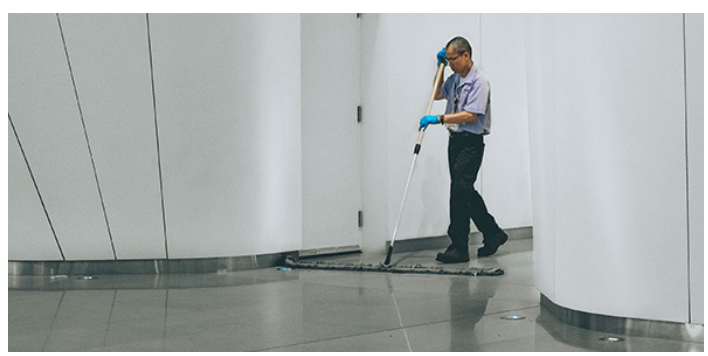
- Inspectors propose longer-term capital improvement measures based on age and condition of the equipment and newly available technology improvements.
- Audits are useful for planning energy retrofits, specifically when replacing or upgrading equipment is necessary.
- Energy audits should be performed about every 10 years.

Green Operations Strategies Reduce Workers' Exposure to Unhealthy Chemicals

Many high-performance building teams adopt an ***Integrated Cleaning Plan*** to create a healthier and safer working environment for the cleaners as well as the occupants.

An Integrated Cleaning Plan may include:

- A schedule that reduces exposure to cleaning products.
- Use of certified low-VOC cleaning products.
- Use of ***high-efficiency particulate absorption (HEPA)*** / micron filter vacuum to decrease asthma attacks.
- Training for cleaners.
- Using spray bottles to spot clean instead of aerosols.
- Dry-mopping floors to prevent mold growth and cleaning hard floors with dry microfiber cloths.



Green cleaning strategies reduce cleaners' exposure to unhealthy chemicals.

TEST YOURSELF QUESTIONS

AVAILABLE REVIEW TOOLS:

1. Test Yourself Questions

Answer the following *Test Yourself Questions* to review the key concepts covered in this course. These questions are also available as online flashcards for study at home.

2. Multiple Choice Practice Tests (ONLINE)

Self-paced multiple choice Practice Exams that you can take on your mobile device.

Review tools can be found at: ***www.gpro.org/tyq-fund***

How will the transition to high-performance building impact the job market and economy?

How are weather and climate different?

What is the greenhouse effect? How does it affect us both positively and negatively?

How does an excess of CO_2 affect the atmosphere?

Name one method that scientists use to track levels of CO_2 in the atmosphere over time.

How do we know that global climate change is happening?

How does burning fossil fuels impact global warming?

What did the EPA Acid Rain program accomplish?

What needs to happen by the year 2050 to keep global temperature rise below 1.5˚C?

What needs to happen by the year 2030 to ensure that climate goals are met by 2050?

Give an example of an adaptation strategy.

Give an example of a mitigation strategy.

How can construction materials affect your health?

How does high-performance building save money for an owner?

TEST YOURSELF QUESTIONS

How is an Integrated Project Delivery different from a conventional process?

What are energy codes and rating systems? How are they similar and different?

Name two green building rating systems.

What are some examples of water-efficient fixtures?

What are some methods to reduce water use on a construction site?

Describe strategies to improve the following building systems:

- Building envelope: .

- Lighting:

- HVAC system:

What are some of the benefits of retrofitting a building?

What is the definition of commissioning?

How are specific trades involved in the commissioning process?

What is the goal of a construction waste management (CWM) plan

How can poor indoor air quality harm human health?

What are some common indoor air contaminants and where do they come from?

What measures are included in a CIAQ Plan?

GLOSSARY

Note: This glossary contains many words that are important in the high-performing building industry. Those terms that appear in this workbook have been listed along with their accompanying page numbers.

abatement – a reduction; specifically, asbestos abatement is the process of removing asbestos from a building.

absorbent landscape – a material that allows water to trickle directly into the ground, naturally filtering out contaminants

acid rain p. 9 – is a product of sulfur dioxide (SO_2) and nitrogen oxides (NOx), which are released from fossil fuel-burning power plants. These gases are absorbed by moisture in the atmosphere, which then becomes extremely acidic.

Acid Rain Program p. 9 – a cap and trade program that required power plants to reduce their emissions of SO_2 and NOx by installing available technologies. Companies were allowed to trade "emissions credits" with other power plants as long as regional levels of emissions were kept below a certain level.

adaptation p. 10 – an approach to climate change that recognizes the effects that are already happening and includes strategies to make buildings more resilient

agrifiber – a material made from agricultural products and used for interiors of buildings, such as wheatboard and strawboard

albedo – how much a surface reflects light, instead of absorbing it

American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) – a professional organization that prepares and maintains a widely used set of building performance standards

benchmarking p. 22 – the process of calculating a building's baseline energy or water use over at least a full year, to track and compare future energy and water use

biodiversity – the variety in animal and plant life that exists in a given area, frequently regarded as an indicator of ecosystem health

bioswale – a carefully engineered planted strip of landscaping that traps stormwater

blackwater p. 17 – untreated household wastewater from toilets, urinals, kitchen drains, clothes washers; any wastewater containing such a component as well as greywater discharge

blower door p. 14 - a testing tool to ensure that a building envelope complies with a maximum allowable amount of air leakage. Best practice is to use a blower door diagnostically prior to final inspection.

brownfield – a site left contaminated by chemicals from industrial uses

building envelope p. 12 – the largest building system, made up of a building's foundation, exterior walls, roof, windows and doors. Also see thermal envelope.

cap and trade p. 9 – a market-based regulation tool that limits emissions by allowing companies to buy and sell emission credits

carbon dioxide (CO_2) p. 5 – a naturally occuring gas that is also produced by the burning of fossil fuels. Carbon dioxide is the most important gas for controlling the Earth's temperature.

carbon dioxide equivalency (CO_2e) – a measurement used to compare greenhouse gases by determining the amount of carbon dioxide that would have the same global warming potential as one unit of another gas over a given time period

carbon footprint – a measurement of the total amount of all greenhouse gas emissions released during the production, use and disposal of any product

carbon monoxide (CO) – a colorless, odorless, tasteless gas that is highly toxic to humans in high concentrations. It is often a product of incomplete combustion of fuels like coal, gas and oil.

carcinogen p. 19 – cancer-causing substance

Carpet and Rug Institute (CRI) Green Label Plus p. 19 – certifies low-emitting carpets, rugs and adhesives

charrette p. 4 – a process of collaborative design that includes the input of many individuals from various areas of a project's development process

chlorofluorocarbons (CFCs) p. 9 – organic compounds made of carbon, chlorine and fluorine used as propellants, solvents and refrigerants. They were phased out of production by the Montreal Protocol due to their role in the depletion of the ozone layer.

Clean Air Act – the law that defines the EPA's responsibilities for protecting and improving the nation's air quality, passed in 1970

Clean Water Act – the law that gives the EPA the authority to create and enforce water pollution regulations in the U.S., passed in 1972

clear cutting – cutting down all trees in an area, which can destroy entire ecosystems

GLOSSARY

climate p. 5 – the average weather pattern at one place over an extended period of time, 30 years or more

climate change p. 6 – long-term changes in the average temperature, rainfall, snow, wind patterns, ocean currents and other aspects of weather at some location

codes p. 21 – the basic legal structures establishing minimum levels of construction quality in order to protect occupants' health and safety, and regulate energy use

combined sewer overflow (CSO) – a mixture of excess water and sewage that is dumped out of a water treatment system, often directly into a nearby body of water

commissioning (Cx) p. 21 – a process that ensures all building systems perform as designed to meet the Owner's Project Requirements (OPR). Commissioning saves energy, reduces costs, improves indoor air quality and reduces call-backs.

commissioning agent (CxA) p. 21 – a professional who optimizes existing systems based on testing to meet current needs for the facility

composting toilet – a toilet that processes solid waste into compost and evaporates liquid waste

condensate p. 17 - water recovered from condensation formed from heating or cooling systems

condensation - water that collects as droplets on a cold surface when humid air comes in contact with it

conservation movement – a movement aimed at protecting and managing natural resources for future use

constructed wetland – a manmade wetland that captures, slows and filters stormwater runoff, while maintaining and restoring native species to the area. It can also be used to process and clean wastewater from a building.

Construction Activity Pollution Prevention (CAPP) – a set of procedures for reducing contamination from work sites. CAPP is a prerequisite for LEED certification.

Construction Indoor Air Quality (CIAQ) p. 19 – a set of measures for reducing indoor air quality problems that result from construction or renovation activities

Construction Waste Management (CWM) p. 20 – a work practice that reduces the amount of construction and demolition waste going into landfills and incinerators, and reduces the demand for virgin materials by recycling or reusing existing materials

cool roof – a roof with a white or lightly colored surface to reflect sunlight away from a building

daylighting p. 12 – the practice of using natural light to illuminate building spaces by strategic placement of windows and reflective surfaces

DDT – a colorless, odorless insecticide that is toxic to humans and animals. It was banned in the U.S. in 1972.

Department of Energy (DOE) – a federal agency that ensures America's security and prosperity by addressing its energy, environmental and nuclear challenges through transformative science and technology solutions

drought-resistant plants – plant species that are adapted to the local climate

dual-flush toilets – toilet fixtures that have low-volume and high-volume flushing options to minimize excessive use of water

embodied energy p. 20 – the total amount of energy required to extract a product's raw materials and produce, transport, distribute and install the product

energy audit p. 22 - an inspection survey and analysis of energy flows for the purpose of energy conservation in a building

Energy Policy Act (EPAct) – government act established in 1992 to address energy and water use in buildings. These requirements lowered the allowable flush and flow rates of common fixtures.

energy recovery ventilator p. 16 - a device that captures and reuses the energy (heat) in the air before it is exhausted

ENERGY STAR p. 17 – a joint program of the U.S. Environmental Protection Agency and the U.S. Department of Energy that sets standards for energy-efficient products

Energy Use Intensity (EUI) – a building's annual energy and water consumption divided by the building's area. This represents the total fuel and electricity consumed on a per-square-foot basis.

environmental justice – the fair treatment and meaningful involvement of all people regardless of race, color, national origin or income with respect to the development, implementation and enforcement of environmental laws, regulations and policies

Environmental Protection Agency (EPA) p. 9 – a Federal agency whose mission is to protect human health and the environment by monitoring and regulating pollutants

Existing Building Commissioning (Cx) p. 22 - Commissioning Agents optimize existing systems based on testing to meet current needs for the facility. This process should be undertaken every 3 to 5 years or whenever a new system is installed.

first costs p. 11 – the amount of money it costs to design and construct a building

flow restrictor – an attachment that restricts flow rates and, with an aerator, produces a mist rather than a steady stream to minimize water use

fly ash – a type of waste from coal-burning power plants that can be combined with blast-furnace slag to replace sand, gravel and gypsum in bricks and new concrete

GLOSSARY

Forest Stewardship Council (FSC) – a program that certifies sustainably managed forests and wood products, recognized by LEED

formaldehyde p. 19 – a chemical released from adhesives in plywood and other pressed wood products; it is a known carcinogen.

fossil fuels p. 2 – the remains of ancient plants that were compacted and transformed into coal, oil, and natural gas deep under the earth over millions of years

global warming p. 6 – the rising of the earth's temperatures due to the accumulation of greenhouse gases.

green building p. 3 – a high-performing, environmentally-friendly structure that eliminates the wasteful use of materials, water, and energy; improves the health and productivity of workers and occupants; and increases the lifetime and performance of building systems

green job p. 11 – a well-paid, career-track job that contributes directly to preserving or enhancing environmental quality

green roof – a roof that is covered with living vegetation, which could mean potted plants and trees, grass planted into the roof or full vegetable gardens. They are made up of a layer of insulation, a layer of drainage, barriers that prevent roots from penetrating the roof membrane, lightweight soil and plants that are specifically appropriate for roofs.

Green Seal p. 19 – an industry standard that certifies low-emitting paints, adhesives, solvents, cleaning products and services, and lighting

GREENGUARD p. 19 – a label that certifies building materials, furniture, furnishings, finishes, and cleaning products with low emissions of air pollutants

greenhouse effect p. 6 – describes how the Earth's atmosphere allows greenhouse gases (GHGs) to trap heat, keeping our planet warm enough to support life

greenhouse gases (GHGs) p. 6 – gases, including carbon dioxide, water vapor and methane, that trap heat in the atmosphere

GreenScreen – a method of assessing chemicals in order to determine how hazardous or safe they are

greywater (or graywater) p. 17 – untreated household wastewater that has not come into contact with toilet or kitchen waste, such as wastewater from bathtubs, showers, bathroom sinks and laundry sinks.

gypsum – a sulfate mineral used in wallboards and fertilizers

harvested water p. 17 - rainwater, stormwater or condensate that is captured and reused, typically for non-potable uses

heat island effect – when a developed area experiences warmer temperatures due to the presence of dark surfaces that store and release heat, such as asphalt and concrete

high-efficiency particulate absorption (HEPA) p. 22 – a type of air filter that meets high efficiency standards set by the U.S. Department of Energy

HVAC p. 4 – heating, ventilation and air-conditioning systems

hydraulic fracturing (fracking) – the process of extracting natural gas by forcing a water and chemical mixture down a well at high pressure to create and expand fractures which release gas from the rock

hydroelectric power – electricity created by the mechanical force of moving water

impervious surfaces – surfaces that do not absorb water

Indoor air quality (IAQ) p. 12 - IAQ refers to the air quality within and around buildings and structures, especially as it relates to the health and comfort of building occupants.

Industrial Revolution p. 5 – the transition from using human and animal labor to mechanical labor. It began around 1750 and was firmly established in northern Europe and the U.S. by 1850.

Infrared (IR) camera p. 14 - a camera that produces a thermal image that shows differences in temperatures

insulation p. 10 - a building material that reduces heat transfer between objects of differing temperature

Integrated Cleaning Plan p. 22 – a collection of strategies that contribute to a healthier and safer working environment for the people doing the cleaning as well as the occupants

integrated Project Delivery p. 4 – active and effective coordination among the design, construction and operations teams throughout the entire project, sometimes before construction even begins.

Intergovernmental Panel on Climate Change (IPCC) p. 8 - an organization of 195 governments (including the U.S. and Canada). Created in 1988, the objective of the IPCC is to provide governments at all levels with scientific information that they can use to develop climate policies.

International Code Council (ICC) – a nonprofit professional organization that prepares the model building codes and model energy code that are the basis for most building and energy codes used in the U.S.

International Energy Conservation Code (IECC) – a model energy code, with sections for residential and commercial buildings, that is modified and adopted by many states

International Green Construction Code (IgCC) – a model building energy code that is considered more rigorous than the IECC and is sometimes used as an alternative code for developers who would like their buildings to meet a higher energy-efficiency standard

lead – a heavy metal that is toxic to humans, commonly used in paints and gasoline before the 1970s

Leadership in Energy and Environmental Design (LEED) p. 21 – a set of standards developed by the U.S. Green Building Council for environmentally sustainable construction and building operations

life cycle assessment (LCA) p. 20 – an assessment of the total environmental impact associated with all the processes that go into a product or service from extraction to disposal

Lighting Power Density (LPD) p. 18 - a term that identifies how much power is allocated to a building's lighting systems.

mercury – a heavy metal with toxic effects on humans, commonly used in fluorescent lighting and released in the burning of fossil fuels

methane p. 6 – a greenhouse gas that is the main component of natural gas

Minimum Efficiency Reporting Value (MERV) – a rating system for air filters where higher numbers indicate greater filtration

mitigation p. 10 – to reduce the severity; specifically, climate change mitigation is any action that reduces the risk of climate change.

Montreal Protocol p. 9 – an international treaty adopted in 1987 to stop the use and production of ozone-depleting chemicals

mountaintop removal – a surface mining method that involves removing the summit of a mountain to extract material and depositing the debris in nearby valleys

national forest – a forest or woodland area managed by the U.S. Forest Service

national park – a reserve of natural, semi-natural or developed land that a state declares or owns for conservation purposes

natural resources – materials that are derived from the environment, including minerals, forests, water and fertile land

Net Zero Energy (NZE) building p. 18 - a building that produces enough on-site renewable energy to offset all of the energy the building uses on an annual basis

nitrogen oxides (NOx) p. 9 – nitric oxide (NO) and nitrogen dioxide (NO_2), which contribute to the creation of acid rain

non-point pollution – pollution without one specific source, such as stormwater runoff

non-potable – water that is not safe for drinking

nuclear power p. 18 – energy produced by an atomic reaction generated by a nuclear reactor

O&M costs p. 11 – operations and maintenance costs, or long-term building expenses

Occupational Safety and Health Administration (OSHA) – part of the U.S. Department of Labor that sets standards for workers' health and safety

open pit mining - A surface mining method where a large pit is made and kept open to the surface for the length of the mine's existence. To collect the material, successive layers of mineral and "waste rock" are removed, forming ledges on each level of excavation.

Owner's Project Requirements (OPR) p. 21 – a description of the purpose of a project

ozone p. 9 – a gas in the upper atmosphere that protects life on Earth from ultraviolet radiation

particulates – tiny pieces of solid or liquid matter suspended in the atmosphere

passive design – a building design approach that takes advantage of local climate conditions to reduce heating and cooling loads, minimizing the need for mechanical equipment

Passive House p. 3 – a building standard that is considered to be the most rigorous energy standard in wide use; it has a goal of reducing energy consumption in buildings by at least 90 percent.

polybrominated diphenyl ethers (PBDEs) – toxic chemicals that replaced PCBs in flame retardants and were phased out

polychlorinated biphenyls (PCBs) – toxic chemicals used in flame retardants until the 1970s

polyvinylchloride (PVC) p. 19 – a type of plastic that is used almost everywhere. The manufacturing process uses crude oil and chlorine gas that release hazardous chemical byproducts.

Portfolio Manager – an online energy-tracking tool that helps building owners and operators understand water and energy consumption of a single building or group of buildings

potable water p. 17 – water that is safe for drinking

precautionary principle – states that chemicals must be tested for their toxicity before they come into widespread use

preservation movement – a movement aimed at protecting the environment from human activity

R-value p. 15 - an indication of how well the material insulates. Tthe higher the R-value, the more the insulation slows heat flow.

rainwater p. 17 – natural precipitation that has contacted a rooftop or other man-made aboveground surface

rating system / standard p. 21 – voluntary measures that define building quality above and beyond code levels

recommissioning – ongoing, regular commissioning to make sure building systems continue to operate as they were designed

GLOSSARY

recycle p. 20 – to turn waste products into materials that can be used to create new products

reduce p. 20 – the process of using less and discarding less

remediation – the act of fixing damage; specifically, environmental remediation deals with removing contaminants.

renewable energy p. 2 – energy that comes from sustainable sources that will not be depleted over time.

resilience p. 10 – the capacity to recover quickly from extreme weather events

retro-commissioning – recommissioning of a building that has never been commissioned before

retrofitting p. 10 – the addition of new technologies or features to older systems, especially in the process of upgrading a building to improve energy performance

reuse p. 20 – to use a product that has already been used for the same or different purpose, such as installing salvaged doors or bathtubs in a new house

safety data sheet (SDS) p. 19 - along with material safety data sheets (MSDS) and product safety data sheets (PSDS), these are documents that list information relating to occupational safety and health for the use of various substances and products.

sick building syndrome – a range of health problems that are directly linked to exposure to poor indoor air quality in buildings

site energy p. 1 – the amount of fuel and electricity a building consumes on-site

solar photovoltaic (PV) panels p. 18 – semiconductor surfaces that convert sunlight to electricity

solar thermal p. 17 - Systems that harvests solar energy to heat water.

source energy p.1 - the total amount of raw fuel required to operate the building, including the energy it takes to generate the electricity.

sprawl – unsustainable, low-density development

stormwater runoff p. 17 – rain or melted snow that flows off impervious surfaces into sewer systems and nearby waterways

strip mining – a surface mining method used to collect materials that occur close to ground level which involves removing a long strip of overlying soil and rock

sulfur oxides (SOx) p. 9 – toxic gases that contribute to the creation of acid rain

sustainability p. 2 – the capacity to thrive long-term without using up resources

sustainable development – development that meets the needs of the present without compromising the ability of future generations to meet their own needs, introducted by the Brundtland Commission in 1987

Sustainable Forestry Initiative (SFI) – a program that certifies sustainably managed forests and wood products, not as stringent as the Forest Stewardship Council

synergy – the idea that the impact of several coordinated activities can be greater than the sum of the impacts of the individual activities

systems thinking p. 3 - understanding how individual systems work together

tar sands (or oil sands) – a mix of clay, sand, water and bitumen. Bitumen, a viscous oil, is mined from tar sands mining, rather than pumping, and then refined into oil.

thermal break p. 15 – thermal break provides continuous insulation across a thermal bridge.

thermal bridge p. 15 – thermal bridging occurs when a poor insulating material allows heat flow across a thermal barrier.

thermal energy p. 13 – also called heat energy, thermal energy is the energy an object has because of the movement of its molecules, and heat can be transferred from one object to another object.

thermal envelope p. 12 – a building's outer walls, roof, foundation, windows and doors. The purpose of the thermal envelope is to prevent heat transfer from the interior to the exterior.

UL Environment eco-INSTITUT p. 19 – a unit of Underwriters Laboratories that certifies construction products, floor coverings, mattresses, bedding, furniture, textiles and consumer goods with low emissions

ultraviolet (UV) radiation – a form of energy from the sun and some lamps which causes skin cancer

ventilation p. 16 - part of the heating and cooling system, the ventilation system provides fresh air, which is necessary for a healthy indoor environment.

volatile organic compounds (VOC) p. 19 – carbon-based materials that evaporate into the air at room temperature

WaterSense p. 17 – an EPA program that encourages efficient water usage through labeling and consumer products

weather p. 5 – the current state of the atmosphere; a combination of temperature, rainfall, humidity, clouds and wind

wheatboard – an agrifiber board product with lower VOC emissions than standard plywood boards

Whole-Building Approach p. 4 – a method of thinking about buildings as integrated systems that depend on one another, rather than addressing each system individually

THANK YOU

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Technical Editor

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Urban Green Council Staff

Christina Anjesky, Managing Director

Bessie Weisman, Account Executive

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