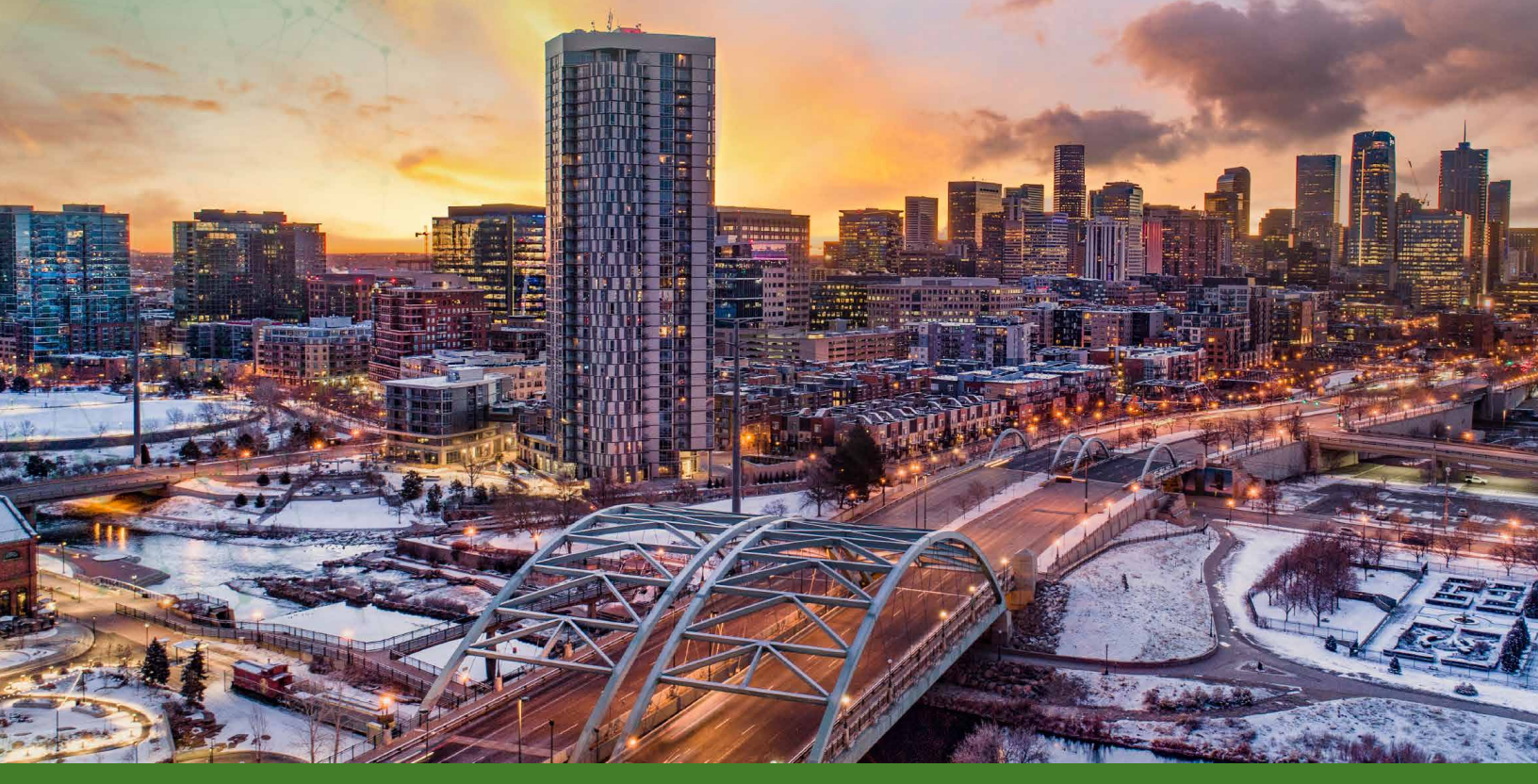
BUILDING CHANGE

COLORADO FORUM

The Nature Conservancy Colorado



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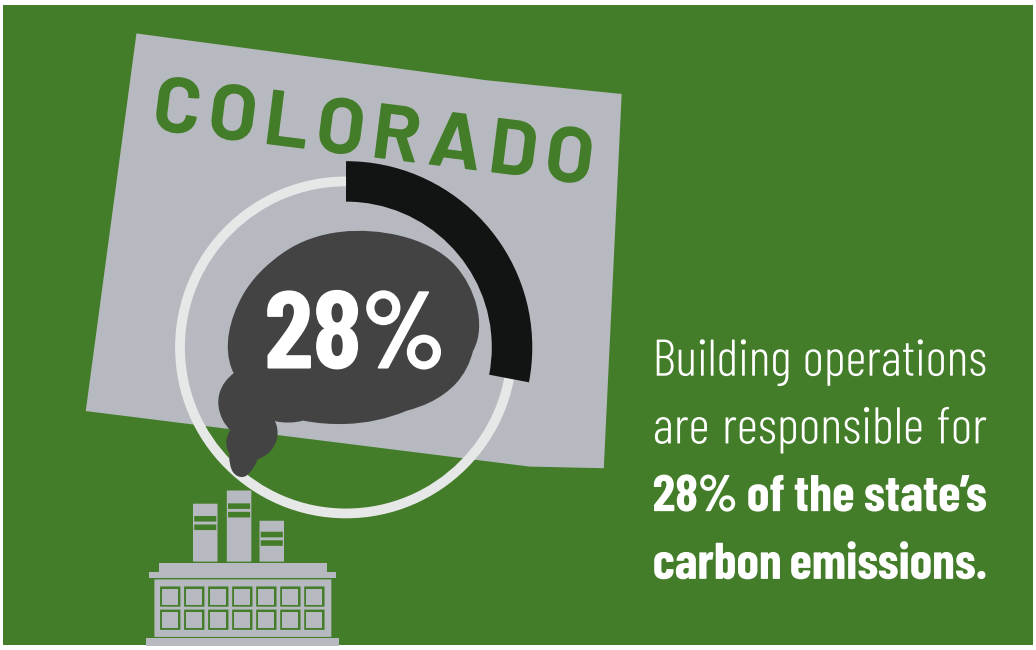
Why Building Change Matters

Climate change may be the single greatest public threat of our time. Effectively and rapidly addressing the risks of climate change may be humanity's biggest challenge but the potential solutions also present tremendous opportunities. We encourage Colorado to lead and act immediately to protect our people, environment, and financial wellbeing.

The built environment is not only a large contributor to climate change but also a huge opportunity to mitigate and plan for impacts. Reducing greenhouse gas emissions in the built environment is frequently accompanied by benefits such as more valuable building assets, more durable and flexible infrastructure, healthier indoor air quality, and more comfortable and resilient spaces. Investing in buildings also touches people directly by demonstrating action and potentially spurring additional investment and behavior change. This handbook provides solutions as to how Colorado's buildings can achieve a cleaner commercial, residential, and industrial building stock through less carbon utilization.

Colorado's recently enacted clean energy legislation builds on the state's progress to transition to renewable energy to power buildings. Constructing more efficient buildings with increased reliance on renewable electricity (rather than natural gas) will reduce pollution from Colorado's building sector and support the health and comfort of Colorado residents. Specifically, Colorado has set goals to reduce 50% of greenhouse gas (GHG) emissions by 2030 and 90% by 2050, relative to 2005 emissions levels. Many owners are installing solar panels, shifting their fuel mix right at their building. By transitioning our building sector to embrace cost-effective efficiency technologies that are available today, we can restore clean air to the Front Range. These technologies also make for healthier, safer, and lower operating cost buildings for Coloradans.

The Colorado Forum and The Nature Conservancy created a collaborative venture called the Healthy Colorado Initiative to accelerate the necessary transition towards a low carbon future. To reach goals set by the State, **Coloradans must immediately focus on decarbonizing buildings**. Whether you are planning a new building, a major renovation, a home remodel, or simply looking for simple, everyday practices that improve building efficiency, this handbook provides a wide range of suggestions for property owners to substantially reduce building sector pollution, save money, and lower Colorado's greenhouse gas emissions.



Each Decision Makes a Big Impact

The majority of the buildings built today will last through the year 2100, making it crucial for us to make proactive decisions with future generations in mind.[1] Given the opportunity to upgrade, remodel, or construct a new home or building, we must consider which choices reduce emissions, increase efficiency, and move the building toward net-zero energy use. The best path toward a cleaner and more efficient building sector is to create a set of clean energy goals to implement into each phase of a new build or retrofit process. This handbook will provide a framework to allow building owners to achieve their clean energy goals.

While clean energy legislation is an important way to institute widespread change, laws and regulations have moved slowly to promote energy efficiency and net-zero emissions. Instead of waiting for significant legal and regulatory changes, private actors can take steps to get ahead of the curve and implement change. **The private sector holds immense influence and can set an example by demonstrating how moving towards efficient *and* electrified buildings makes both environmental and economic sense**. For example, Amazon, among thousands of other companies such as Microsoft, Verizon, and JetBlue, has committed to net-zero emissions by 2040. Amazon's plan involves creating what it calls a "carbon system of record," which measures the sources of carbon across all areas of the business to identify the most significant emitting sectors and create tailored mitigation solutions to lower emissions. Creating an effective, workable plan involves looking at the whole system and targeting seemingly small decision points that can amount to massive emissions reductions. A method like Amazon's creates an easy on-ramp to introduce climate-oriented thinking into all decision points without sacrificing the bottom line.[2]

Companies with net-zero emissions plans demonstrate how businesses can lead by example in progressive climate action. This handbook provides various case studies to portray methods that have been implemented with the hope to achieve net-zero emissions. Hopefully, they offer guidance as you think about next steps for your building project(s).

1 The Future of Energy: Buildings, *The Institute for Science & Policy*
2 Cooperation is Crucial to Private-sector Decarbonization, says Amazon Sustainability Head, *Stanford University*

Key Concepts and Best Practices

Building decarbonization includes five main components: electrification, best-in-class energy efficiency, smart buildings, on-site renewables and/or grid integration, and design process.

ELECTRIFICATION

Our electricity is steadily becoming cleaner as utilities shift to more renewable energy and retire fossil fuel sources, and as homeowners and companies install renewable power on their buildings. Switching appliances and heating sources from natural gas and propane to electric energy reduces fossil fuel use. These changes substantially reduce GHG emissions without sacrificing the quality of heating or cooling for your building. The two most substantial electrification technologies, heat pumps and induction ranges, are notably more efficient than their gas counterpart.

To meet Colorado's clean energy goals, all new buildings need to utilize efficient electric equipment, and roughly a quarter of all existing buildings need to be converted to primary heating with electric heat pumps by 2030. To achieve this, we need to retrofit 3-5% of our buildings every year, a substantial increase from the current rate of approximately 1% per year.[3]

While the task seems monumental, shifts in Colorado's gas consumption can have a sizable impact. If 15% of direct natural gas use in residential and commercial sectors switched to electricity, and the increased electricity demand is met with zero emission energy sources (e.g. wind, solar), Colorado would cut GHG emissions by 1.6 million metric tons by 2030.[4]

3 Cooperation is crucial to private-sector decarbonization, says Amazon sustainability head, *RMI*
4 Colorado's Climate Action Plan Emission Targets: Illustrative Strategies and GHG Abatement Potentials, *M.J. Bradley & Associates*

IMPROVED BUILDING ENERGY EFFICIENCY

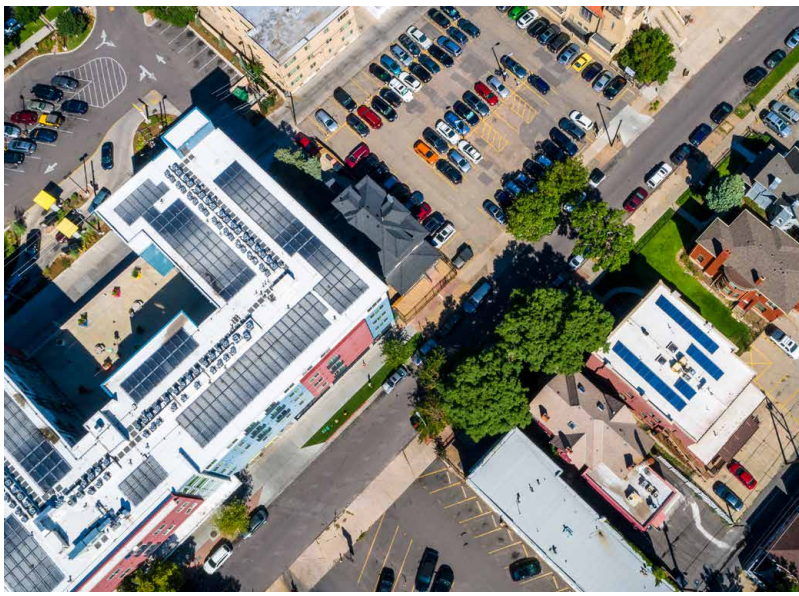
Improving building energy efficiency offers numerous benefits, including reducing energy and maintenance costs as well as ensuring occupant health and well-being through a subset of strategies that also improve indoor air quality. Building energy efficiency includes:

- Improving opaque building insulation
- Changing from incandescent or CFL light bulbs to LED bulbs and providing occupancy-based lighting controls
- Focusing on the largest direct use of fossil fuel in buildings: heating and cooling. Air source heat pump technology is a particularly efficient way to heat and cool, delivering two to four times more energy than the electricity consumed
- Sealed air leaks
- Reducing the heat loss through glazing and/or window replacements or retrofits while also mitigating solar gain
- Upgraded electric appliances (where possible, heat pump based) rather than gas powered
- Vacancy sensors tied to lighting and outlets
- Dedicated focus on reducing energy use of miscellaneous plug-in items
- Daylight maximization
- Using plug load occupancy controls to turn off equipment when not in use

The ENERGY STAR program, run by the Environmental Protection Agency, promotes energy efficiency for commercial buildings; in 2016, it helped businesses and organizations save nearly $10 billion in energy costs.[5]

In addition to benefiting the environment and people's health, energy-efficient buildings typically have lower operating costs, better financing terms, command higher rents and occupancy rates for commercial buildings and yield higher purchase prices for residential buildings.[6] All of this increases a property's value, generating an internal rate of return of up to 25% on energy improvements.[7] Improving energy efficiency often involves higher up-front costs than typical maintenance work, but these investments may have a shorter payback period. The U.S. Department of Energy estimates that the typical household can save 25% on utility bills with energy efficiency measures and up to 30% savings through improvements in regulating interior temperature.

Improved building energy efficiency also opens up the door to numerous building certifications which outwardly demonstrate progress to key stakeholders whether that be investors, occupants, employees, students or faculty.



5 ENERGY STAR Facts and Stats
6 Energy Efficiency & Financial Performance: A Review of Studies in the Market, *U.S. Department of Energy*
7 How much does energy efficiency cost?, *Energy Sage*

SMART BUILDINGS

Smart buildings optimize energy consumption by allowing an owner or tenant to remotely manage energy use in the building and communicate with the energy provider to assist in managing energy use during peak times. You may already have the beginning of a smart, grid-interactive building. Smart thermostats, like Nest or Ecobee, have the ability to manage an HVAC system remotely and to interact with the grid. Such thermostats use motion detection to determine when and where to provide heating or cooling. By communicating with the grid, smart thermostats anticipate periods of increased demand on the grid and will cool or heat the building in advance of peak energy use. This saves money and energy for both the occupant and the utility. Some utility providers even offer financial incentives to use a grid-interconnected product.

Smart thermostats are just one example of how smart buildings benefit the energy grid and consumers. Some other ways a grid-interactive building can reduce energy and costs include:

- Battery storage, which can offset higher utility rates when demand is high
- Thermal storage, which can shift the use of heating and cooling to times of day when utility rates or grid emission rates are lower
- Smart electric vehicle charging, optimizing when the vehicle is charged so that the owner receives the lowest rate
- Grid-interactive electric water heaters

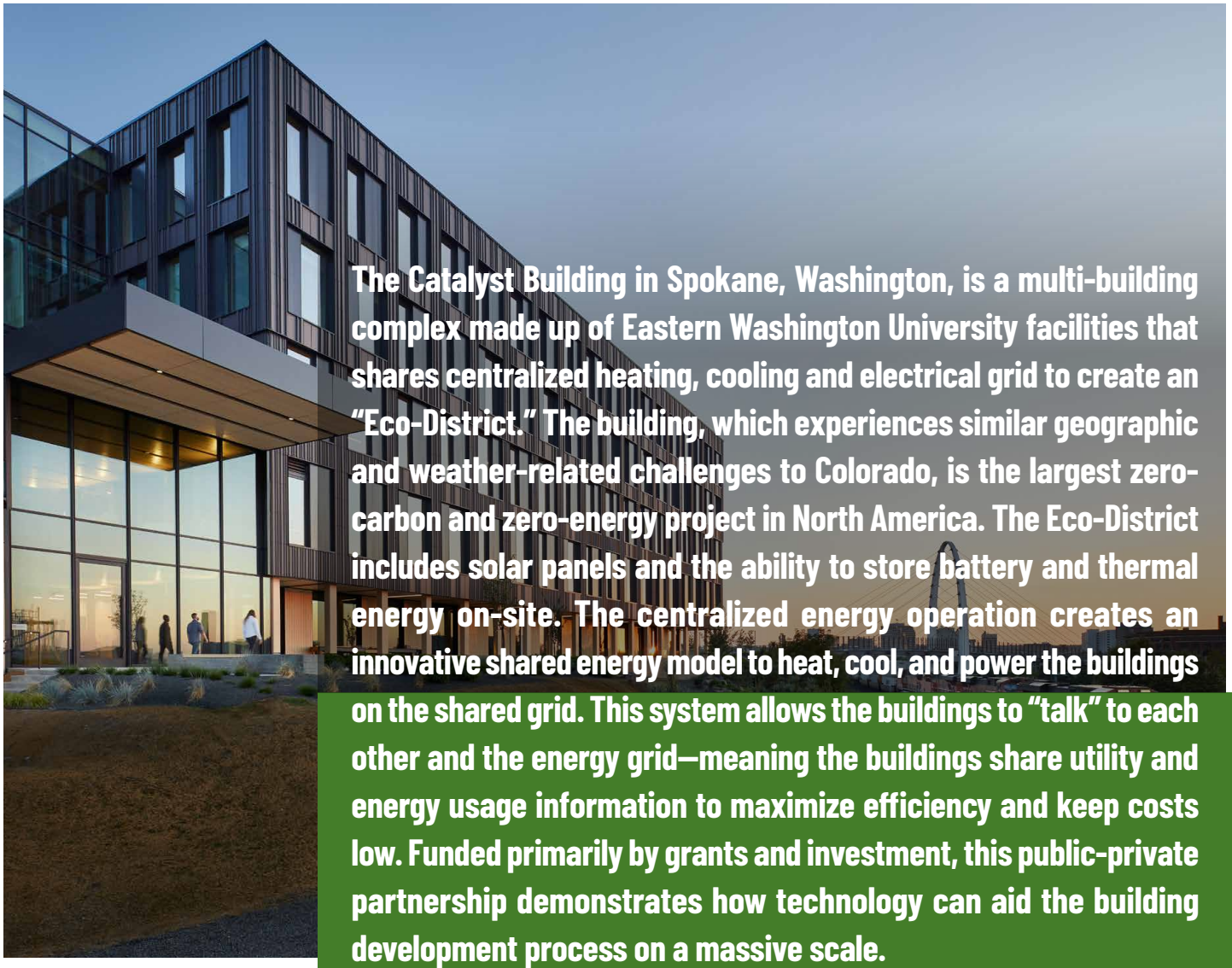
Smart buildings create a two-way communication line between the user or occupant of a building and the grid. To learn more, click here.

DESIGN PROCESS

Reaching net-zero emissions for a building requires research and early planning. Incorporating low-emissions goals in the nascent design stages, for either retrofits or new construction, allows the property owner and contractor to achieve efficient clean energy strategies during construction and throughout the life of the building. This is known as a whole systems approach and is critical to achieving net-zero emissions in buildings. Thoughtful and early planning also maximizes the rate of return and minimizes costs along the way.

This integrated delivery model is equally applicable to existing buildings. A whole-building or systems approach provides the structure needed to optimize when upgrades are made, to decide which upgrades or planning choices to pursue, and to achieve a net-zero or low-emissions project in a cost-efficient manner.

To learn More about the Eco-District, click here.



The Catalyst Building in Spokane, Washington, is a multi-building complex made up of Eastern Washington University facilities that shares centralized heating, cooling and electrical grid to create an "Eco-District." The building, which experiences similar geographic and weather-related challenges to Colorado, is the largest zero-carbon and zero-energy project in North America. The Eco-District includes solar panels and the ability to store battery and thermal energy on-site. The centralized energy operation creates an innovative shared energy model to heat, cool, and power the buildings on the shared grid. This system allows the buildings to "talk" to each other and the energy grid—meaning the buildings share utility and energy usage information to maximize efficiency and keep costs low. Funded primarily by grants and investment, this public-private partnership demonstrates how technology can aid the building development process on a massive scale.

If you are constructing a new building or doing a substantial retrofit, you may want to consider off-site construction to potentially lower costs and further your impact. There is a broad range of prefabrications and modular solutions that exist and should be considered. For example, off-site construction uses precast concrete which lowers building GHG emissions that come from embedded carbon in most building materials. Reducing the on-site construction schedule is not only a potential for cost savings, but it can also help speed to market, which benefits the owner.

Learn more about hybrid construction here:

> Examples of useful hybrid building technology

> What is hybrid construction?

> Hybrid timber construction

> Hybrid concrete construction

If you are planning to retrofit a building to achieve zero carbon, RMI (formerly known as Rocky Mountain Institute) and Urban Land Institute recommend the approach below to accomplish that goal:[8]

SET TANGIBLE SUSTAINABILITY GOALS. Projects are successful when energy and sustainability goals are clear, actionable, within the desired budget, and well-known across the organization. At a minimum, set an energy target and a goal around financing and investment such as payback requirements for individual projects, desired impact on asset value, or internal rate-of-return requirements. Goals should be informed by a cursory analysis of the building portfolio to determine the amount of savings available from viable energy projects. It is very important for an entire organization, including its leaders, accounting, facilities, sustainability, and other functions, to participate in the goal-setting process from the start, as early buy-in from all stakeholders will make it easier to stay the course.

ESTABLISH AN ENERGY BASELINE. Once goals are set, the next step in improving a building's performance is to understand how the building is actually performing so the team can track progress toward goals and identify opportunities. Most of the information to develop a plan can be gathered during a site visit, including:

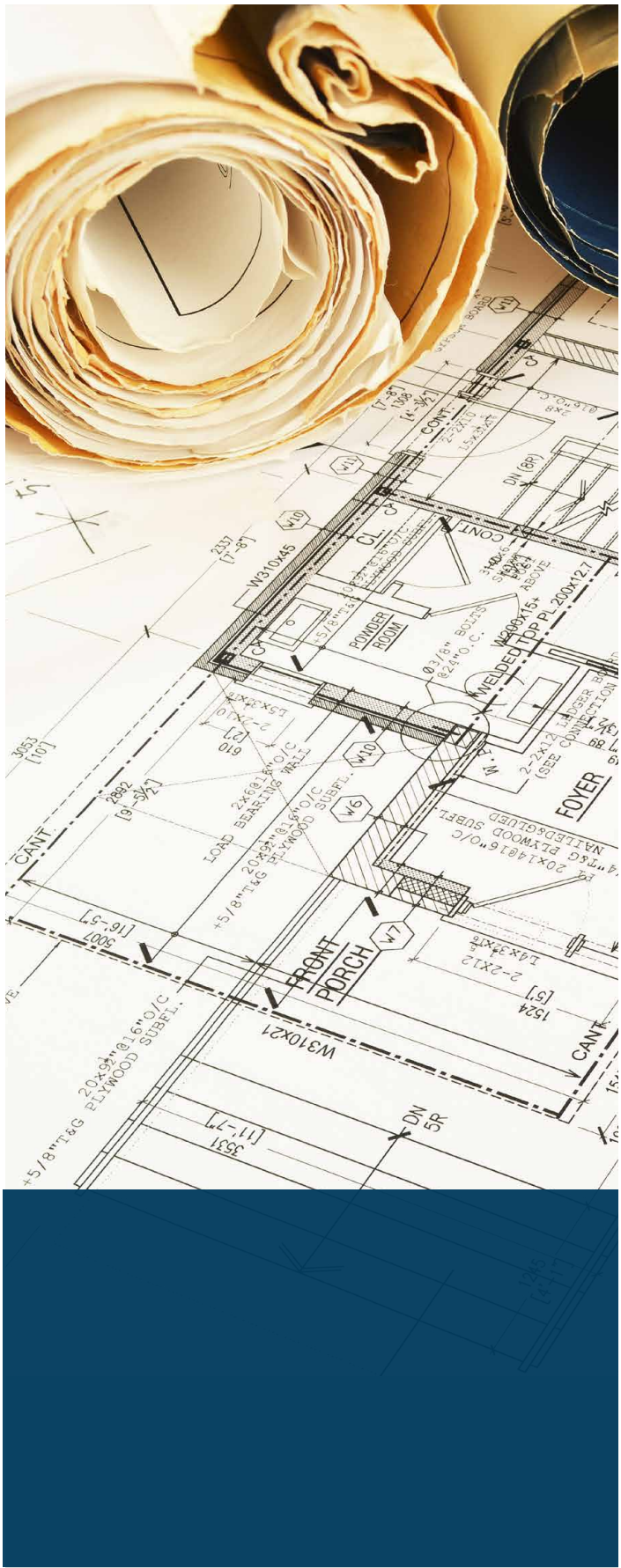
- type, age, and condition of equipment in the building, including HVAC equipment, lighting, controls, roof, windows, etc.
- approximate window-to-wall ratio
- insulation levels in the roof and walls and insulation weak points (from thermal imaging)
- infiltration levels (from blower door testing); current utility rate structure (from utility bills)

8 The approach has been modified for purposes of this handbook. To read the approach in its entirety, click here.

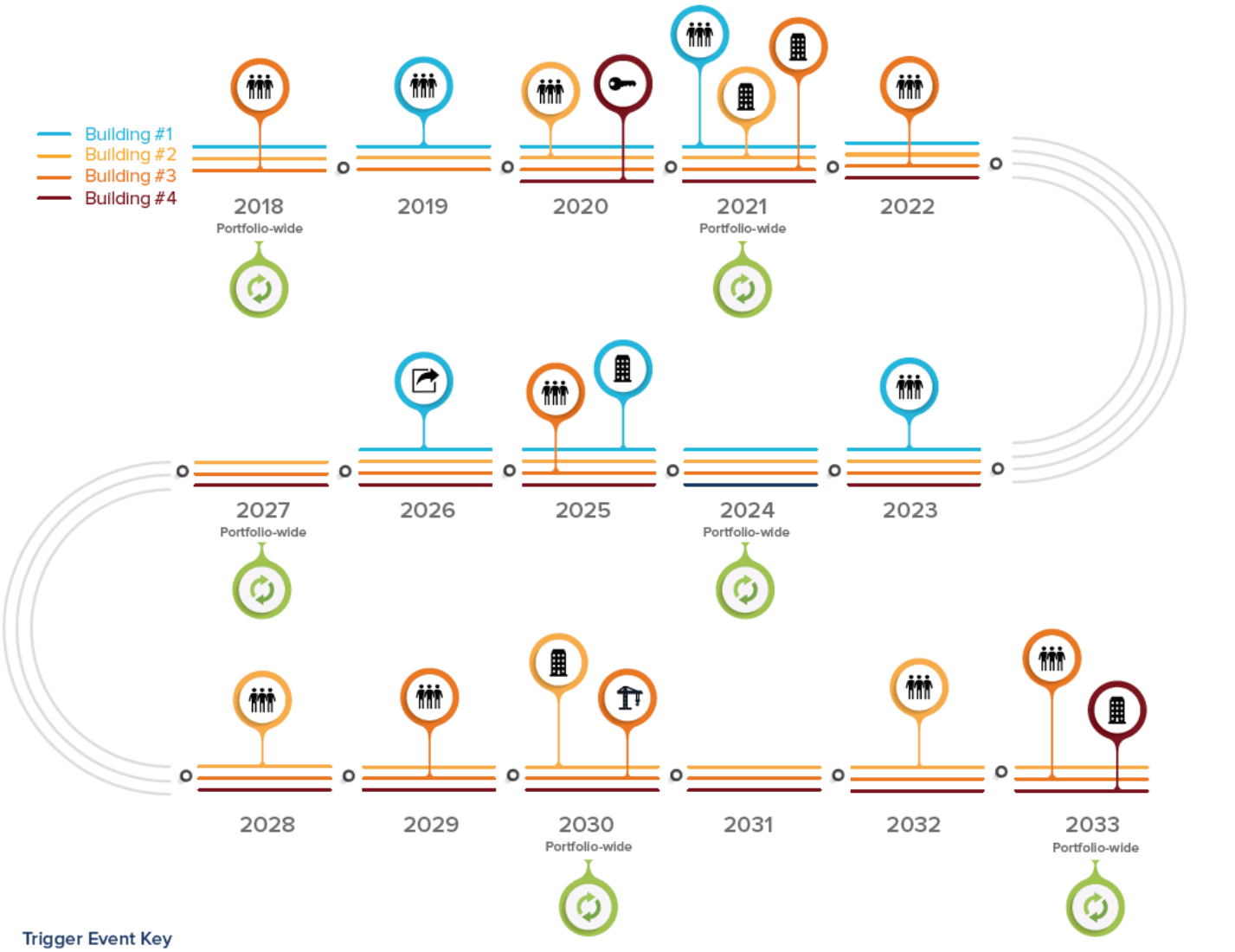
PLAN EFFICIENCY PROJECTS. Independent energy conservation measures can be no-cost, which means they generate savings immediately. Analyze the budget by assessing upfront costs versus savings over time. Some examples of energy conservation measures are 1) adjusting mechanical and lighting schedules to match current building occupancy; 2) adjusting heating, cooling, and lighting zones so consistently unoccupied zones aren't conditioned, ventilated, or lit; 3) engaging and educating tenants by providing actual use data to inform occupant behavior; 4) controlling entry and exit (keep doors closed, encourage revolving door use); and 5) using window blinds to reduce heat gain in summer and allow heat gain in winter.

More in-depth measures include load reduction energy conservation measures that reduce the building's heating and/or cooling loads. These include strategies like building envelope improvements (adding wall or roof insulation, sealing for air tightness, adding window films and exterior shading devices, etc.), lighting upgrades (replacement with LED fixtures or bulbs, dimming capabilities, vacancy and daylight controls, etc.), and plug load reduction (implementing equipment sleep mode, metering workstations, upgrading equipment, swapping desktops for laptops, etc.).

The cumulative effect of these projects is the ability to downsize to smaller, less expensive HVAC equipment when it is time for replacement at the end of its useful life. Implementing these efficiency projects should be planned out through a trigger event calendar. A trigger event calendar is a calendar of energy upgrades, linked with key asset improvement cycles. Triggers are the building life-cycle events that may enable a deep retrofit as a result of major building investments, changes in usage, or other events.



Example Trigger Event Calendar*



Trigger Event Key

Lease Turnover or Renewal

Actions to Consider
- Green lease language
- Adjust energy charge based on lease structure
- Plug load budget
- Tenant energy feedback
- Low-/no-cost cost ECMs
- HVAC reconfiguration or envelope upgrades

Major Equipment Replacement

Actions to Consider
- Replace major HVAC or water heating equipment
- Add roof and insulation
- High-performance windows
- Replace fossil fuel gensets with electric and thermal storage
- Fuel switching from gas to electric

New Building Entering Portfolio

Actions to Consider
- Standardize property condition report to include energy audit and functional performance tests
- Evaluate all "actions to consider" for lease turnover and major equipment replacement trigger events

Building Leaving Portfolio

Actions to Consider
- Include energy information in statement of value
- Standardize property conditions report to include energy audit and functional performance tests
- Provide energy one-page summary to agents and prospective buyers

New Construction or Major Renovation Project

Actions to Consider
- Design all new construction to NZE (or NZE-ready)
- Consider systems like ground source heat pumps
- Design roofs to handle on-site solar PV

Regular Energy Checkups

Actions to Consider
- Continuously:
  - Tenant engagement
  - Commissioning
- Every three years:
  - Assess new utility rates
  - Reconsider solar PV and energy storage

* FROM: Guide: Best Practices For Acheiving Zero Over Time For Building Portfolios

ANALYZE RENEWABLE ENERGY AND ENERGY STORAGE TO DETERMINE HOW MUCH ENERGY YOU NEED AND WHETHER IT IS CURRENTLY COST-EFFECTIVE. Renewable energy generation and storage prices are dropping quickly. Also, government incentives, such as rebates, discounts, or tax credits and deductions, change regularly, so an analysis from two years ago may no longer be helpful. Once a site has maximized building efficiency, building owners should offset energy consumption with renewable energy in this general order of priority: 1) pursue on-site renewable energy to the fullest extent; 2) pursue local community solar; 3) pursue other local off-site renewable energy options.

START IMPLEMENTING YOUR PROJECTS AND TRACK YOUR PROGRESS. Tracking the building's actual energy consumption against its goal of net-zero emissions will help the owner to understand the progress that is being made. Installing submeters (energy meters that sit below a master meter) will enable performance tracking. This will allow the building owner to analyze where the energy upgrades may be falling short or exceeding the expected improvements.

INSTALLING SUBMETERS (ENERGY METERS THAT SIT BELOW A MASTER METER) WILL ENABLE PERFORMANCE TRACKING SPECIFIC TO BUILDING END USES. There are benefits to installing meters that can individually track the energy being used from different systems, including the HVAC system, lighting, and plug loads, to enable owners and operators to easily identify savings opportunities. Sub-metered information and a robust building controls system can continually improve the property's performance and fine-tune building energy systems to ensure they're always performing at their potential. You may also want to consider interval meters, which can show the load profile of the building every 15 minutes, to immediately spot spikes and take corrective action.

Commercial Buildings

Creating a net-zero energy commercial building can be accomplished with new buildings or through retrofitting existing buildings. In either case, a key to success is in the whole systems planning and design process.

As employees head back to the office after Covid-19 risks subside, the workplace will look different. RMI predicts that by 2035, 75% of U.S. floor space will be new or renovated. This offers significant potential for business owners to implement a variety of practices that can vastly diminish GHG emissions. Whether your business is remodeling, purchasing a new building, or just identifying simple practices to save energy, we have listed some recommendations below.

Commercial Building Economics: Smart buildings help to manage demand charges, which are fees applied to electric bills based upon the highest amount of power drawn during a billing cycle. **Those charges can total up to 60% of annual energy costs.** Demand charges apply almost exclusively to commercial buildings and are rarely used for residential customers.

- Install electric heat pumps or Variable Refrigerant Flow (VRF) systems instead of gas heating equipment. Air source heat pump and VRF systems use electricity to harness energy from the surrounding air and pump that energy indoors in the form of heat—much like an air conditioner in reverse. Both heat pump and VRF systems are incredibly energy efficient heating and cooling options for large spaces. These systems can achieve efficiencies three to four times higher than conventional heating technologies.

Want to learn more about electric heat pumps and how they reduce GHG emissions in your building? click here.

- Ensure buildings have proper insulation and that each room is sealed against air leaks. Aging buildings tend to have older insulation and windows. When rooms are properly sealed and ventilated and windows are updated, the risk of air/heat in the cooling/heating process escaping and being wasted is reduced.

- Install sensors and/or timers for appliances and lights. Technologies like light timers or sensors lower unnecessary electricity use. This allows buildings to be more efficient, lowers pollution levels, and saves money for property owners.

- Upgrade to smart technology when available. Smart technology refers to any system that enables a building owner to monitor building characteristics, analyze the data, and generate insights around usage patterns and trends that can be used to optimize the building's environment and operations. These technologies include Nest thermostats, submeters that monitor energy consumption, and grid interactive water heaters. This technology allows building owners to better monitor and control emitting sources in order to make the building more efficient.

COMMERCIAL BUILDING CASE STUDIES

The case studies below offer examples of how newly built commercial space can be net zero buildings. As you are thinking about your next new building, here are some ideas to consider:

>> Small Office:

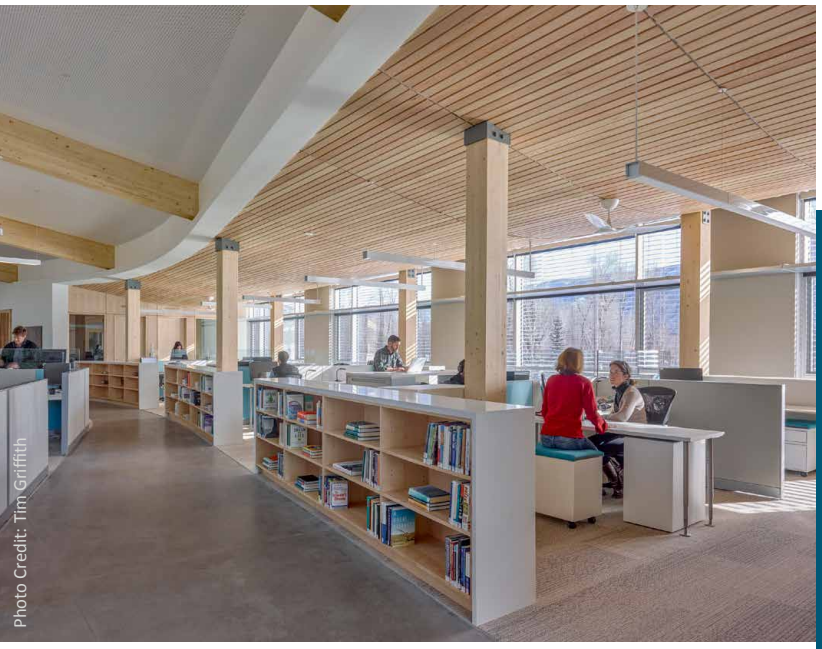


Photo Credit: Tim Griffith

The RMI Innovation Center, located in Basalt, Colorado, is a 15,610 square-foot office building and state-of-the-art convening center that demonstrates how carbon-free buildings should be designed, contracted, constructed, and operated. The building, located in a cold climate zone at ~6600 Ft. elevation, is exceeding performance expectations. It produces more energy than it uses by leveraging the following key strategies: all electric systems, low embodied carbon construction, battery storage to provide demand flexibility, highly passive design to minimize active heating systems, no mechanical cooling system, and an Integrated Project Delivery contracting methodology. The excess energy is used to power six on-site electric vehicles.

The RMI building is 74% more efficient than the average office in the same climate while costing less to operate, emitting less carbon, and increasing reliability. The building is fully insulated, and the windows are all airtight. RMI encourages individual heating and cooling by supplying employees with fans/heaters and chairs that can be heated or cooled to individual preference which requires less energy than the associated energy consumption of heating and cooling entire rooms. Finally, the building utilizes natural light and relies on efficient LED light bulbs as the primary lighting tools. These design choices equip the building to last 100 years and demonstrate how offices can vastly diminish carbon emissions.

> ***Our goal was an RMI building that supports our mission, including a fiscally responsible solution. The Innovation Center was built at a cost similar to other local examples, and it costs much less to operate each year than a typical building. Plus, RMI's staff are proud, comfortable, and productive working in the daylit, well-ventilated space, which provides much bigger returns than utility bill savings for any company. Much of the success of the project was due to a clear alignment around goals from the beginning, a strong design/construction team and an integrative design process. It's easy for owners to set these expectations up front, and costs much less than 'greening' a building as an afterthought.***
>
> **– Marty Pickett, *Managing Director RMI***

Learn more about this project HERE.

>> Medium Office:

Photo Credit: Morgan Creek Ventures

The Boulder Commons, located in the heart of downtown Boulder, Colorado, consists of two commercial properties totaling over 100,000 square feet of professional office and commercial space. The Boulder Commons met the challenge of creating a net-zero building that is leased to tenants, who may have varying degrees of motivation to reduce energy consumption or greenhouse gas emissions. This model integrated net-zero practices into the construction and design of the building. The interior of the building is not affected by the heat of summer nor the cold of winter. Triple-element windows were installed to create a shield of protection from the weather, thereby allowing for a downsizing of mechanical system elements and decreasing the operating costs of heating and cooling the building. To maximize Boulder's sun conditions, Boulder Commons installed solar panels on the roof and also on the southeast wall of the exterior. As a result, the side panels ultimately cost less per unit of energy produced than the roof panels. The Boulder Commons office demonstrates how setting clear, clean energy goals that are maintained throughout the design process can create longstanding change and reduce carbon emissions.

> ***We have seen the future... and it is today. All electric buildings. They are the best long term investment in real estate. The most resilient and the lowest long term risk as it relates to climate change. As an institutional investor, what would you prefer to own ten or twenty years from now? An all electric building or a fossil fuel powered building? You should be building your portfolio today based on that observation. Our returns today are equal to our fossil fuel based competitors. Imagine how much better our returns will be a decade from now.***
>
> **– Andrew W. Bush, *Founder, Morgan Creek Ventures LLC***

Learn more about this project HERE.

>> Large Office:

Opened in 2018, 1144 Fifteenth (also known as the Optiv Building) is a 40-story Class A tower that is not only the tallest office building to be constructed in Denver in nearly three decades, but it also sets new standards as one of the most efficient buildings in the market. The fully electric building consumes less energy and produces less pollution than its rival structures. Operating costs are therefore reduced, and the savings can be passed on to 1144's tenants.

What makes 1144 different from most buildings in its market is its newer equipment features and system technologies such as lighting controls and scheduled HVAC systems with temperature controls. For example, 1144's HVAC systems temper all outside air coming into building with the exhaust air leaving the building. This is done through a heat recovery wheel which allows 1144 to precool hot summer outside air and preheat cold winter air—all by utilizing exhaust air that would otherwise just leave the building. Another way in which 1144 is unique are its solar sensors installed in strategic areas of the structure. They change temperature set points around the building in real time depending on the solar intensity. These automated systems are not only more environmentally friendly, but they also improve the user experience for 1144's tenants and their employees.

Learn more about this project HERE.

Photo Credit: David Sundberg: © David Sundberg/Esto

Residential Buildings

Residential buildings are where we sleep, eat, grow up, and raise families. In the wake of COVID-19, we found ourselves spending an increasingly large share of time in our homes.

An energy audit is one of the first steps one can take to discover the best way to make a home more efficient. A home energy audit creates a customized path to become more energy-efficient based on your individual home and the way you use it. Many local jurisdictions and utilities offer rebates to help offset the cost of an energy audit.

Interested in scheduling a home energy audit?
Learn more here:

> WeRenew

> Department of Energy

> MyNergyExpert

If you live in, manage, own, or are thinking of developing smaller scale multi-family housing, you can benefit your bottom line, improve the health of those who live in the building, and reduce emissions by working toward net-zero housing. These homes are less expensive to build because they don't need a gas hook up, and they have lower electric bills due to their efficient design. In some cases, homes produce more energy than they consume through on-site energy generation that exceeds the needs of the efficient home.

Best practices to make your home more energy-efficient include:

SWITCH FROM A GAS STOVE TO AN INDUCTION STOVE. Induction stoves, which look a lot like traditional electric stoves, quickly heat surfaces using magnetic energy. These stoves heat faster than traditional electric or gas stoves, thereby allowing individuals to cook faster. Induction stoves also reduce risk of burns or fires. Not only does this allow for more precise and safer cooking, but it also conserves energy and avoids harmful emissions from burning gas.

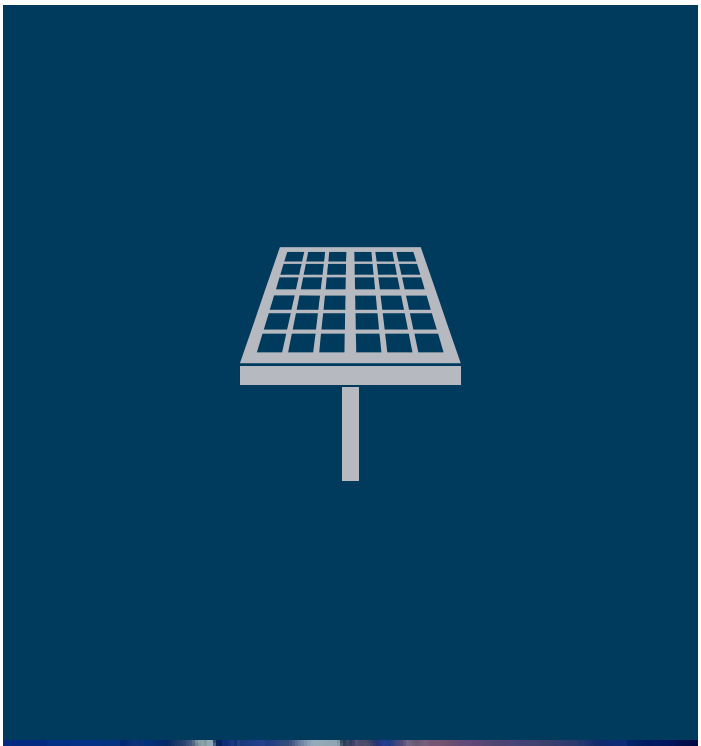
A study from RMI, Mothers Out Front, Physicians for Social Responsibility, and the Sierra Club found, "gas stoves may be exposing tens of millions of people to levels of air pollution in their homes that would be illegal outdoors under national air quality standards." The EPA also found that homes with gas stoves have roughly 50% (but up to 400%) higher levels of Nitrogen Dioxide (NO2) than homes with electric stoves.[9] This indoor air pollution has harmful effects on people, such as increasing risk for asthma.

INSTALL AIR SOURCE ELECTRIC HEAT PUMPS. Air source electric heat pumps are significantly (200-300%+) more efficient than gas equipment resulting in operational cost savings. In order for Colorado to meet its sustainability goals, electric heat pumps will need to comprise over 60% of residential heating equipment sales by 2030 and over 95% by 2040, up from about 2% today. In Colorado, Group 14 Engineering and Community Energy Inc. conducted a study that evaluated system options, economics, and strategies to achieve electrification of buildings. The study found that **for single family homes, the upfront cost of all electric space and water heaters is about 25% less expensive than homes with comparable natural gas-powered equipment.**

9 The Inside Story: A Guide to Indoor Air Quality, *Environmental Protection Agency*

INSTALL SOLAR PANELS. Solar is a clean and abundant renewable energy source. Solar panels can be easily installed in conjunction with utility providers (such as Xcel Energy). Solar panels can be an efficient way to generate electricity for your home and can be installed at any point.

Want to learn more about how you can install solar in your house? Click here.



REFRIGERATOR/AC AND HEATERS. Ask the manufacturer of your refrigerator and your AC units if they use harmful hydrofluorocarbon (HFC) chemicals. HFC chemicals have thousands of times the warming impact of CO2 and are therefore being phased out of most cooling products. HFC chemicals require proper disposal. If you are looking for new appliances, opt for an energy-efficient, climate-friendly cooling product. Explore products here.

INSTALL DOUBLE-PANED WINDOWS. Double-paned windows help insulate your home by keeping the heat or AC locked into the room, so that it will not escape through windows or insulation.

To learn more about energy efficient windows, click here.

PRACTICE ECO-FRIENDLY HABITS. Small behavioral changes can make a big difference in the grand scheme. Regulate your electricity use by unplugging unused cords and appliances and turn off lights in rooms that aren't being used. Additionally, you can install timers for lights and thermostats to only use energy when it's needed. To better regulate internal temperature, rely on shades and upgraded windows. These easy practices decrease emissions and save money on monthly energy bills.

RESIDENTIAL BUILDING CASE STUDIES

>> Single Family:

The Cohen family in Lakewood, CO built their family home with two unique systems that vastly reduce the home's emissions: geothermal heating/cooling and solar generated electricity. Well established with most electric companies and easy to install at any time, solar panels greatly reduce electricity costs and can generate rolling credits for excess electricity created. While the largest cost is the upfront installation, the return on investment for this system is typically 10-12 years, depending on the number of solar panels, the amount of sun received, and the energy needs of the home. The geothermal heating and cooling system requires upfront planning and coordination between the general contractor and utility company. While the upfront cost of these installations are quite high, the savings and impacts over time more than make up for the cost. The geothermal system, which requires significant drilling and engineering, is not economically viable for a retrofit or remodel, but coincides well with a new build. The Cohen family stresses that while they could have sacrificed these systems for more conventional choices, they could not pass up the environmental benefit and the economic pay off over time. They chose these systems not just to be green, but to increase the livability of the home, decrease ongoing energy expenses, and increase the resale value of the home.

Learn more about geothermal heating here.

To learn more about net-zero residential housing projects, click here.

> ***My recommendation is do your research in advance or you'll miss the opportunity. It's easy to miss. Our planning process took many years. This needs to be an early component of the plan.***
>
> **– Dana Cohen**

Photo Credit: the Cohen Family

>> Multi-Family Small:

Aspen Skiing Company's Willits Block 9 is a 134-bed, $22M worker housing project in Basalt, Colorado that is directly adjacent to the bus line, a 25-minute ride to Aspen, and a few minutes from company offices. The building is entirely electric and highly energy-efficient, with EV chargers and a bike share onsite.

Learn more about this project HERE.

Willits Block 9 employee housing busted two myths about electric buildings. It's an example of cold-climate use of heat pumps which is something many engineers say is not possible. That's important because the technology has arrived, but the industry is not aware of it. Second, the building's operational costs will be approximately equal to an equivalent natural gas-heated structure, even in a region with cheap natural gas.

– Auden Schendler, *Vice President of Sustainability, Aspen Ski Company*

>> Multi-Family Large:

Hirschfeld Tower in Denver, CO is a low to moderate income residential property consisting of 209 units. Originally built in 1967, the property was renovated in 2008 with the intention of increasing efficiency and comfortability while lowering costs, reducing maintenance, and minimizing the carbon footprint. After much research, the retrofitting project team utilized a closed loop ground source heat pump. The heat pump system consists of plastic pipes built underground and functions by removing heat from inside the complex to cool individual apartments or extracting heat from underground to heat the space. However, the system is designed to take advantage of natural heating and cooling whenever possible, which saves money and heavily reduces GHG emissions.

The team weighed the pros and cons of a geothermal heat pump system, a conventional mechanical heating and cooling system, and a hybrid system combining geothermal heat pumps and conventional heating and cooling. The results indicated that it would cost the same to install a traditional mechanical system as it would be to install the heat pump system. They also found that while installing a heat pump would cost the same as installing a hybrid system, the maintenance and infrastructure costs of the hybrid system would be higher. As a result, the Hirschfeld Tower's geothermal heat pump system costs less than $.50 per square foot to operate compared to the $1.00 per square foot cost that the previous mechanical system cost. Implementing this system has reduced both the operating costs and the building's carbon footprint.

To learn more about sustainable multi-family developments, click here.

The dream of my grandfather, A.B. Hirschfeld, was fulfilled in 1947 when he completed The A.B. Hirschfeld Press Building – a glowing example of timeless Art Deco architecture that was home to his 80,000 square foot state-of-the-art printing plant, the largest between Chicago and the West Coast.

A bigger dream was realized posthumously in the year 2000 when A.B.'s prized architectural possession was saved from the wrecking ball by Denver's Sage Hospitality, conserved and repurposed in the form of a 122-room extended stay hotel – Towne Place Suites by Marriott. How proud A.B. must be to have his creation preserved and utilized for generations to come.

– A. Barry Hirschfeld

A **larger-scale project** or full area redevelopment has an even greater opportunity to have an impact. You might want to consider creating a multi-building interactive system, where several buildings communicate with one another through grid interactivity to optimize performance and lower energy needs and costs. **Larger scale projects can offer a higher return** on solar and storage energy systems and can leverage thermal energy to create a more passive heating and cooling system.

Industrial Buildings

Industrial buildings include warehouses, distribution centers, and greenhouses, the latter of which has seen a boom in Colorado to accommodate cannabis grow operations. Like large-scale commercial and residential properties, industrial buildings tend to have a larger building footprint and a high electricity load. Fortunately, even industrial complexes can drastically reduce their impact through increased efficiency, grid interactive buildings, and electrification.

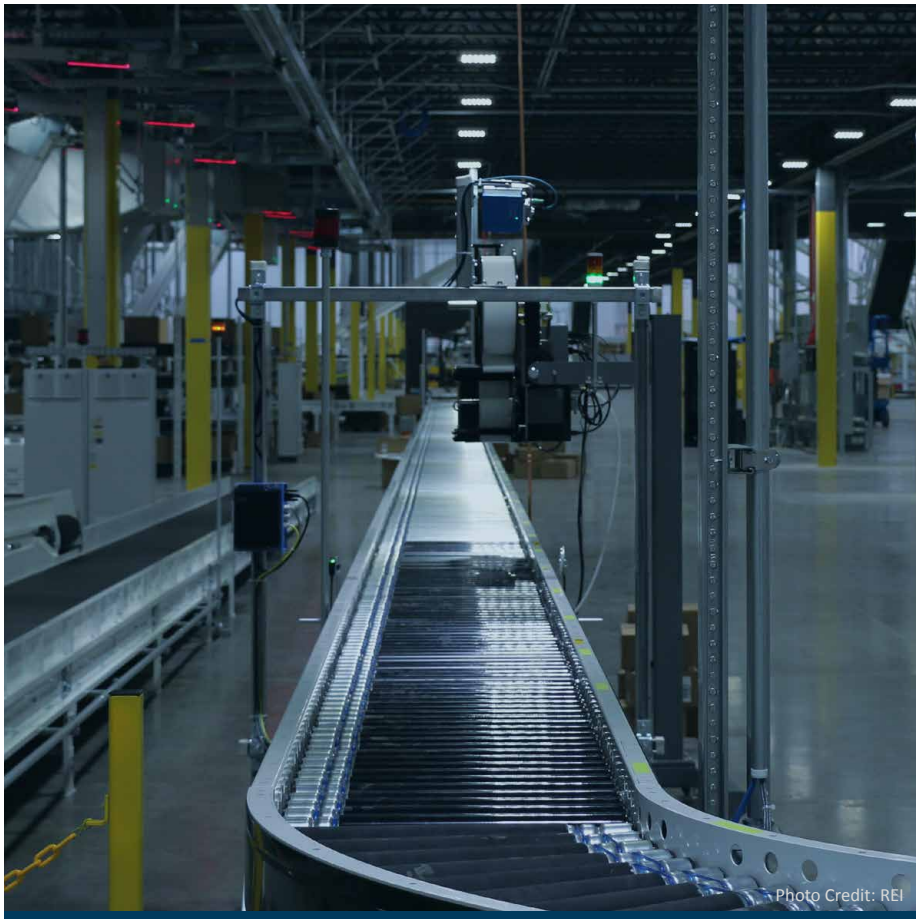
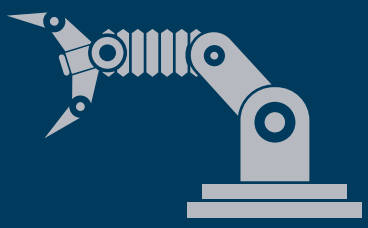


Photo Credit: REI

BEST PRACTICES INCLUDE:

- **REDUCE EMISSIONS:** Adding solar panels to the roof or planting urban gardens can prevent or offset emissions.
- **USE ELECTRIC SPACE HEATERS AND COOLERS:** For a large industrial space, consider relying on electric heating and cooling mechanisms for smaller spaces, as opposed to heating and cooling the whole area. This can help mitigate building emissions.
- **CREATE A MORE EFFICIENT BUILDING ENVELOPE:** In addition to ensuring the building envelope is properly sized, the structure itself can also incorporate strategies such as using reflective roof coatings to help minimize energy requirements.
- **REDUCE ENERGY DEMAND:** Implement demand management strategies and energy management systems to ensure energy is used efficiently. An example of this is upgrading lighting and HVAC systems.



INDUSTRIAL BUILDING CASE STUDIES

>> REI Distribution Warehouse:

In 2016, REI opened a new distribution center in Goodyear, Arizona that supports over a third of the company's sales. Distribution centers typically consume a massive amount of energy due to their large size and intense operating schedules. Accordingly, REI prioritized efficiency outcomes from the onset of design to minimize the impact of the new building. The result is one of the most sustainable distribution centers in the U.S. It is a LEED Platinum certified structure and produces all the energy it consumes via a 280,000 square foot, 2.2 MW rooftop solar installation. The facility also minimizes water waste with a non-evaporative cooling system which maintains the internal building temperature while saving millions of gallons of water. With their Goodyear Distribution Center, REI demonstrates how companies can balance business outcomes with efficient operations and clean energy goals.

> ***The building's design was a collaborative project that's meant to provide an example for other companies and manufacturers to learn from and leverage.***
>
> **– Bill Best, *Vice President of Supply Chain Operations, REI***

Learn more about this project HERE.

Photo Credit: REI

Acknowledgments

This handbook would not be possible without the work of the engineering and development firm McKinstry and the law firm Moye White LLP.

McKinstry's talented team was instrumental in the analysis and content development process and with designing the final product. McKinstry is a national leader in the design and delivery of high-performing buildings. The company is committed to innovating waste and climate harm from the built environment through a five-year strategic Action for Impact initiative. This includes working with clients on zero-carbon solutions and partnering with industry in bringing our collective zero-carbon future to life.

Thank you to Moye White for spearheading the development of a handbook geared towards sustainability in the building sector. The law firm of Moye White worked diligently on all facets of the project.

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We are enormously grateful for the assistance of McKinstry, Moye White, and all of the organizations involved in helping to produce this Building Change Handbook.

Moye White is a full-service law firm offering strategic representation in complex commercial transactions and disputes including, with respect to the building industry, representation in all aspects of design, construction, and finance in new and existing public and private sector commercial, industrial, and residential construction projects.

You can benefit your bottom line, improve the health of those who live in the building, and reduce emissions by working toward net-zero energy-use.