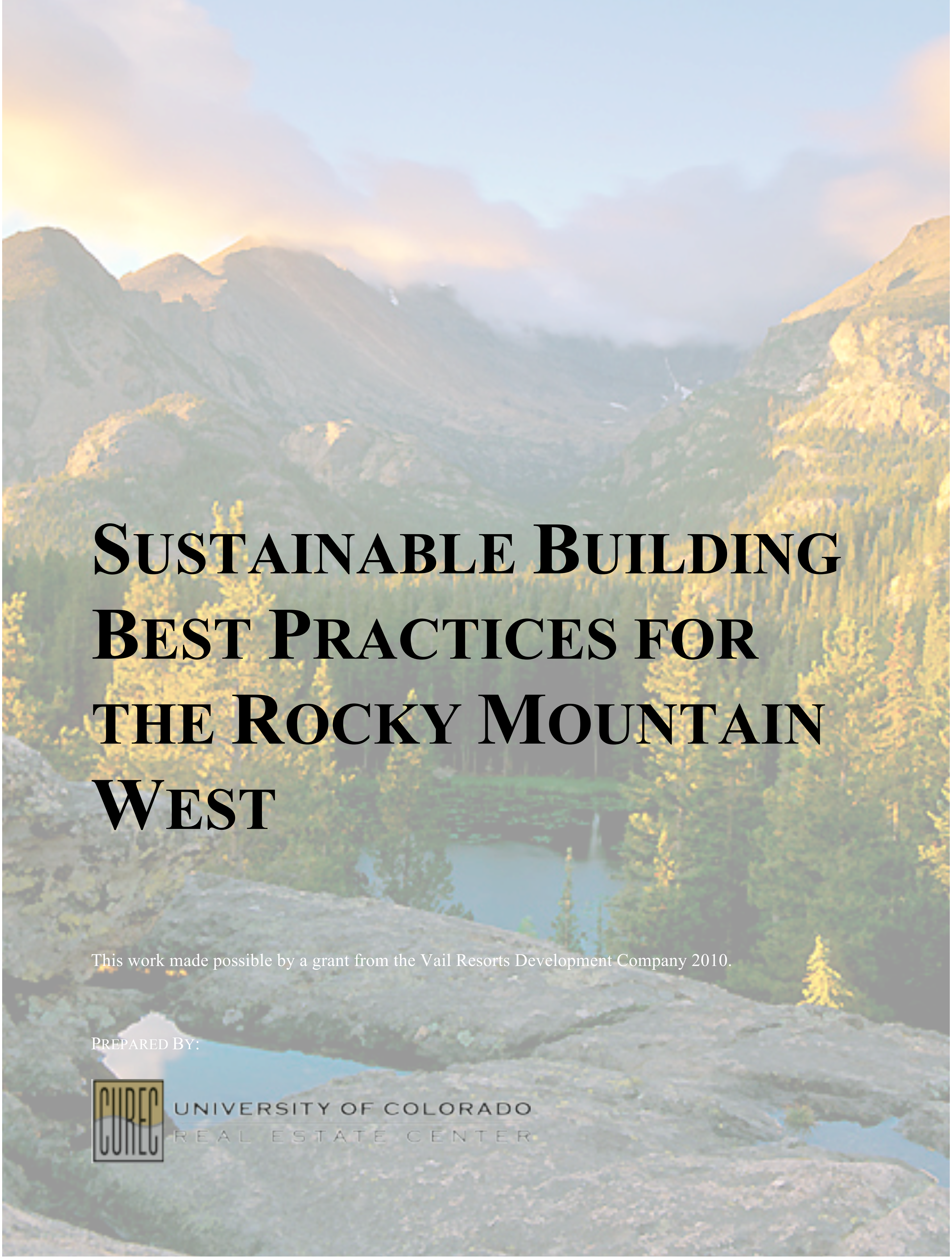

Sustainable Building Best Practices for the Rocky Mountain West

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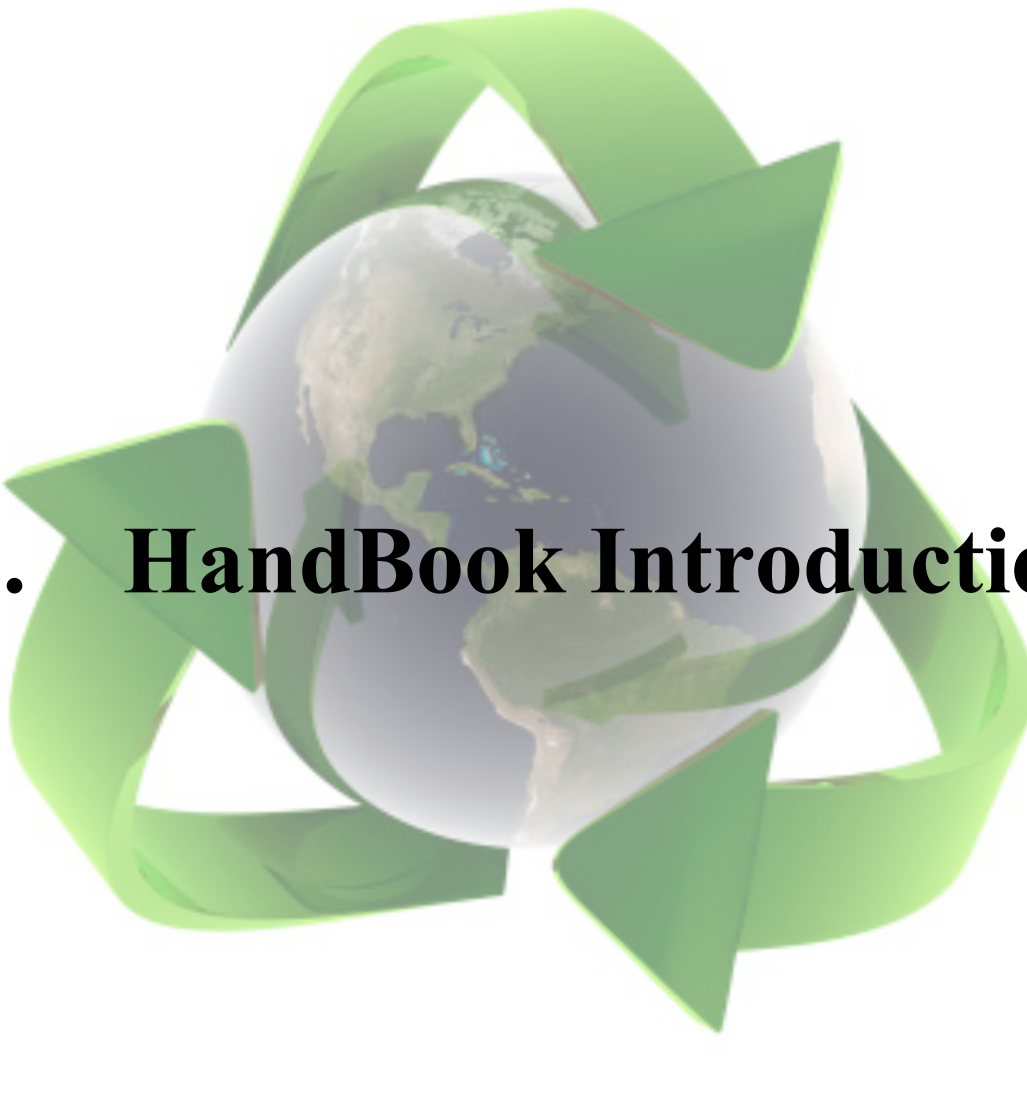


1. HandBook Introduction

1.1. The Handbook

The Sustainable Development Handbook provides a comprehensive introduction and analysis of sustainable development concepts for the Rocky Mountain region. The University of Colorado Leeds School of Business Real Estate Center in conjunction with some of the brightest minds in commercial real estate development, sustainable practices, and building systems have collaborated to develop a first-of-its-kind resource. This text does not consider sustainability in a vacuum; rather it examines sustainable concepts from a viewpoint that stakeholders in the development process can relate to. Paramount to the discussion will be how sustainable technology impacts the bottom line and how consumers perceive it.

The Handbook is meant for all audiences interested in commercial real estate development. It is written so that an individual with little sustainability knowledge will find the guide helpful. The following sections contain the handbook's scope and how to use the handbook, including chronological reasoning, its audience, and introduce the accompanying database, The Sustainable Technologies Database.

1.2. Handbook Scope

To provide the appropriate level of information that is useful to developers in mountainous regions, the breadth of information had to be constrained. This handbook's scope is defined geographically to include high elevation regions in the American west that have similar topography and climate. Additionally, the technologies and sustainable systems studied are those that are most applicable to commercial real estate – specifically resort, office, and retail. This focus allows the handbook to go into greater detail regarding the systems and technologies it discusses. For additional information regarding the scope of the handbook please see appendix section A.2, Explanation of Handbook Scope.

1.3. How to Use this Handbook

This handbook's chapters are organized based on the development process. A developer should consult this resource at every development phase. While not meant to comprehensively examine every sustainable technology with a technical manual's detail, the handbook will give developers sufficient background to discuss the inclusion of sustainable technologies with contractors, consultants and regulatory officials.

1.3.1. Chronology

This handbook is designed to follow the development process. The goal is to present the material in a sequence that allows the developer to address issues and opportunities during development. Each chapter considers a developer's concerns associated with specific technologies at any development stage. Where appropriate, each subsequent chapter will discuss considerations for sustainable technologies at that development stage

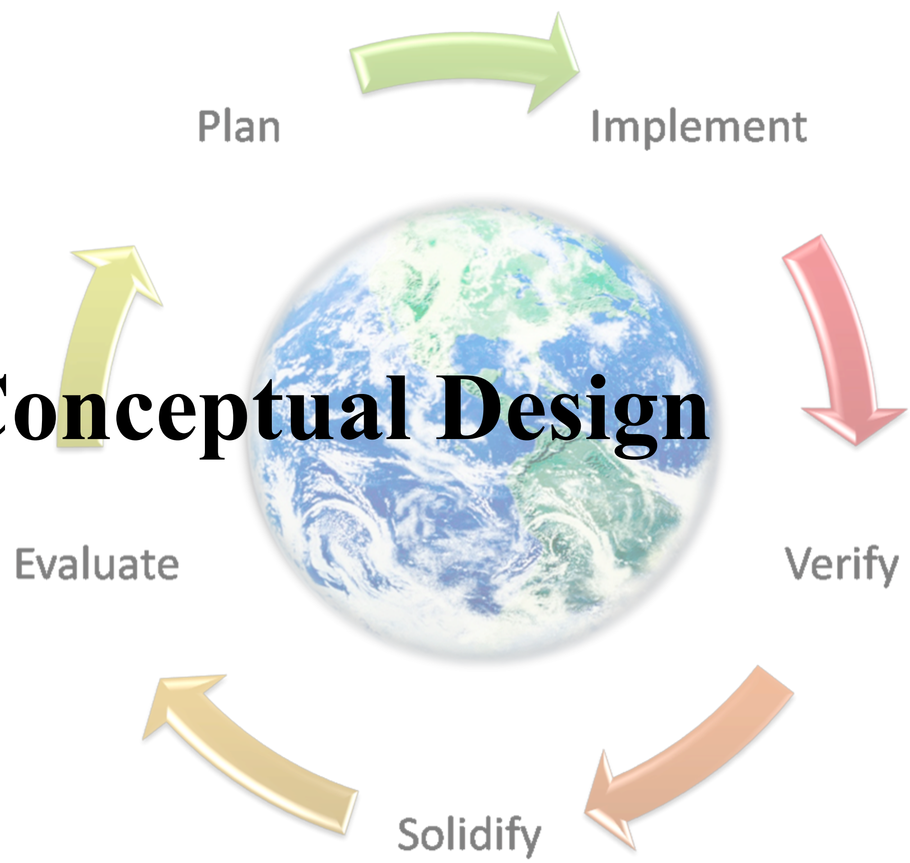
1.3.2. Audience

This handbook is meant primarily for individuals interested in sustainable principles. This handbook is meant to serve as a sustainable boot camp for the uninitiated and as a helpful reference for those interested in learning about sustainable principles. Executive level summaries give broad direction on sustainable actions.

1.3.3. Companion Database

The handbook links to a companion resource, The Sustainable Technologies Database. The Database provides additional details not contained within this handbook, including multiple rating categories and case studies that provide details about implementation. Where appropriate, the Handbook will direct readers to the Database for additional information. The Database is keyword searchable and the Handbook will highlight which terms should be used for which technologies.

2.Conceptual Design



2.1. Definition

This chapter's goal is to give developers an understanding of the advanced planning required for complex systems installation. Early planning will help mitigate the need for the developers to revise decisions to include sustainable and energy saving technologies.

2.2. Site Analysis

The following sections and subsections address factors that developers should consider when first inspecting a potential development site. These factors include water, transportation, building orientation, and adaptive reuse. Each section provides a brief overview and future potential. In some subsections, the benefits, drawbacks, and financial implications are addressed for several technological options (e.g., renewable energy sources).

2.2.1. Water

Brief Overview

Water conservation and efficiency is becoming increasingly important throughout the United States. Increasingly, developers have to secure water rights before they can obtain approvals for development as well as addressing any issues of wetlands, floodplains, and the ground water table. These concerns play a critical role in mountainous region development. Although most mountain developments are not large enough to require substantial water rights, their locations are often at, or near, the headwaters of important watersheds. Concerns about water quality and environmental impact on mountain rivers and ecosystems abound.

Future Considerations

While regulations regarding flood plains, wetlands, and water rights are extensive, there is a growing consensus that basic changes will allow the use of graywater and rainwater harvesting, which is collecting runoff rather then divert it into streams and tributaries. Many western states are participating in pilot programs to determine the effect of allowing developments to reuse potable water brought to the site or captured and reused rainwater. Concerns about water conservation have fueled new, technologies that increase water fixture and appliance efficiencies.

2.2.2. Transportation

Brief Overview

A development's location is central to the discussion about the project's sustainability. Paramount to this discussion is transportation. The LEED rating systems awards points for developments close to public transportation. Recent research has illustrated that energy use at an efficient suburban single-family residence is higher than an inefficient apartment near the city center due to the energy required for transportation at the suburban location. Developers wishing to build sustainable projects should keep transportation at the forefront during the acquisitions and planning process. This includes public transit, transportation modes, and transportation capacities in addition to parking. The United States' automobile dependent land use pattern that currently exists will remain the predominant land use plan moving forward. Steps to increase pedestrian, bike, and public transit access in the existing street network will play an important role in decreasing energy use.

Future Considerations

Mountain communities generally have adequate public transportation, especially during peak seasons to facilitate tourist and seasonal workers' movement throughout the villages. Larger developments should place a bus stop within, or adjacent to, the project where possible. Already, bigger metropolitan areas are relaxing developments' parking requirements with easy public transit access. Such considerations should be taken into account when developers are determining how much on-site parking is required.

2.2.3. Renewable Energy

2.2.3.1. Wind Power

Brief Overview

Using wind power as a renewable energy source is becoming an increasingly popular trend among winter resorts throughout the United States. The majority of the nation's wind resources come from the Great Plains, with North Dakota containing the most potential for wind harvest. Resorts are currently using wind power in two ways: buying credit from off-site wind farms (e.g., the Plains) and harvesting their own wind power on-site.

Future Considerations

According to the National Renewable Energy Laboratory (NREL), the Rocky Mountains have high enough average wind speeds (measured at mountain crests) to make wind harvesting a profitable energy option. Wind could be harvested using a variety of turbine designs described later in this handbook. Potential concerns, depending on the turbine design, include maintenance, freezing, wildlife dangers, deforestation, and general aesthetics.

2.2.3.2. Solar

Brief Overview

Solar power is frequently used as a renewable energy source in winter resorts throughout the United States. Solar power can be used both "actively" and "passively". Active solar power includes using photovoltaic (PV) panels and/or heat engines. These generate power or heat for buildings and are currently used in resorts to power chairlifts and heat lift houses. Passive solar radiation is using a building's orientation to heat a structure and to provide natural lighting in place of or in conjunction with conventional lighting.

Future Potential

Some of the mountainous regions discussed in this handbook receive up to 300 days of sunshine per year. PV panels are becoming more efficient in gathering and storing energy, which makes them a potentially profitable renewable energy option in mountainous regions. There is also opportunity to power lifts and heat lift houses using photovoltaic panels.

When considering PV panels, the developer should examine which location on the site gets the most year round solar irradiance. PV cells are most efficient when facing south and tilted at an angle equal to the latitude where they are placed.

2.2.3.3. Geothermal Energy

Brief Overview

Geothermal energy is extracted from heat that is stored in the Earth, either through the planet's core, radioactive mineral decay, or from solar energy absorbed at the surface. Geothermal plants are built to distribute power obtained from geothermal energy or the energy can be used as direct geothermal heating, as used in spas or space heating for houses. Until recently, geothermal energy and geothermal plants were only viable in the United States near tectonic plates (e.g., along the west coast of California); however, this has changed as the technology has become more affordable.

Future Considerations

Drilling and extraction technology improvements, coupled with binary cycle power plant developments may enable geothermal systems to a greater geographical range that would include high elevation and mountainous regions. These new power plants allow for extracting cooler water (i.e., 175 degrees Celsius) than traditional power plants for use in heat exchangers to create power. This new technology increases potential locations where geothermal can be used. However, testing a site for geothermal capability is expensive. Thus, a developer should consult an expert before continuing with geothermal power.

2.2.3.4. Micro-hydropower

Brief Overview

Hydropower has provided power for decades; however, micro-hydro power is a cutting-edge technology whose design provides one of the most cost-effective and reliable energy sources. Micro-hydro relies on falling water, so sites are specific and limited. The farther water falls, the more powerful the system. Micro-hydro systems can provide around the clock and year-round energy, provided there is a running water source. Micro-hydro systems consist of piping, a turbine generator system and, if desired, an integration with a regular power system. These systems can be freestanding, hybrid or grid-integrated.

Two turbine types can be used for micro-hydro systems: impulse turbines and reaction turbines. Impulse turbines are more commonly used and spin freely in the air and water is directed toward them. Reaction turbines are fully submerged and are enclosed. Reaction turbines are used where water flow is consistent throughout the year and pressure is low grade.

Future Considerations

Micro-hydro power systems require a stream of falling water to generate power. Snowmelt provides large volumes of water in spring months, and could provide significant power at a low cost. Site feasibility is determined by the head (i.e., height at which water falls), water flow, and energy output.

2.2.4. Building Orientation

Brief overview

Building orientation is a building's situation on a land parcel to maximize natural lighting, views, and space while reducing related energy costs. Sustainable goals of building orientation include situating a building such that its orientation reduces energy costs, maximizes natural lighting, passive heating and cooling, and minimizes construction costs, including grading and material removal. Proper building orientation reduces energy costs, which include heating/cooling costs and electrical costs associated with lighting.

Future Considerations

When considering a building's orientation on-site, the developer should first examine the potential for a southern exposure. "In general, a south-facing orientation within 30 degrees east or west of true south will provide around 90% of the maximum static solar collection potential."[1] However, a developer

[1] Utah Green Homes (http://www.utahgreenhomes.com/?page_id=19)

should be aware and account for obstructions such as trees, other buildings, and mountains that could affect a building's ability to generate passive solar energy.

Climates will determine whether an obstruction is a help or hindrance. For cold, northern climates, buildings should be oriented with its widest portions facing south. Large windows should be incorporated on south facing walls to maximize solar energy while smaller windows should be placed on north-facing walls to prevent heat loss. "A good rule of thumb for south-facing overhangs (assuming that the overhang is level with the head of the window) make the overhang as deep as the window is high. Developers should use precaution against the potential to overheat. Southern facing windows capture a great deal of the sun's heat and if not properly managed can actually overheat a building. Therefore, developers should include both interior and exterior shading devices to mitigate against overheating.

2.2.5. Adaptive Reuse

Brief Overview

An existing building's adaptive reuse or reusing building materials on site is an important component to building sustainable projects. The energy savings created by adaptively reusing materials are determined by examining embodied energy, which refers to the energy required to construct a building. It encompasses the energy required to gather materials, process the materials into building products, transport the products to the building's location, and construct the building using the products. Due to the high energy use of most commercial and residential buildings, the quantified embodied energy is usually a large number. Therefore, any opportunity to reuse a building or materials on the site can substantially decrease the energy used during construction.

Future Considerations

Whenever possible, developers should reuse existing on site buildings; however, if that is not feasible, opportunities abound to reuse building material. Historically, developers have used discarded asphalt and concrete as aggregate to shore up unstable soil. Reusing tile, brick, and doors has also been successfully completed. Developers should therefore perform an on-site material inventory analysis to determine what materials can be re-used appropriately.

2.3. Mechanical, Electrical, Plumbing

2.3.1. Heating, Ventilating, Air-Conditioning (HVAC)

Definition

Heating, Ventilating, Air-Condition (HVAC) refers to all systems used to heat, cool, and circulate air throughout a building. It encompasses both the mechanical devices used to heat and cool the air as well as the ductwork used to transport the air throughout the building.

Sustainable Goals

As with most sustainable technologies, a HVAC system's sustainable goal is to increase energy efficiency while providing adequate heating and cooling. However, the potential savings are much higher for HVAC systems because they account for the majority of the energy use associated with building operations. No building is able to make significant energy efficient gains without investing in a sustainable HVAC system.

2.3.2. Passive Solar Heating

Definition

Passive solar heating refers to using a building's orientation and window placement to achieve solar gains within a building's exterior.

Benefits

Passive solar heating is free. The amount of heating provided is determined by building orientation, fenestration, and window glazing. If properly modeled and implemented, passive solar heating can help decrease the need for traditional HVAC energy use during winter months. It can be easily incorporated into a site design and with proper planning can help decrease the HVAC heating load and energy use in traditional lighting systems.

Drawbacks

Care must be taken to ensure that rooms that utilize passive solar heating do not overheat in the summer or on warm winter days. This can be accomplished by building fenestration that decreases the light that penetrates the windows during summer months, but allows more light in during winter months. Southern facing windows should be provided with adequate shading opportunity for use on days where building fenestration is not enough to prevent overheating.

Financial Considerations

Passive solar heating is a cost effective measure to decrease winter heating costs. It is imperative that developers consider this possibility early in the design process, and energy modeling may be required to ensure proper energy savings and prevent overheating. Additionally, the developer may want to incorporate specialized windows in winter time.

Consumer Appeal

Ideally, consumers are unaware of solar gains and passive solar heating's effects. It should appear only in their energy bill since their automated thermostat does not need as much heated air to maintain a consistent temperature.

2.4. Water

The following sections and subsections define stormwater, highlighting sustainable goals, and discuss sustainable options to manage stormwater and run off. They include bioretention cells, cisterns, and green roofs. Each option's benefits and drawbacks are discussed as well as their post construction, financial, and regulatory considerations.

2.4.1. Stormwater

Definition

Stormwater is rainwater and melted snow that runs off streets, lawns, farms, construction, and industrial sites. Mountainous region's most abundant stormwater source is snowmelt. Under natural conditions, the ground absorbs stormwater, where it is naturally filtered and then either replenishes aquifers or slowly flows through forest and meadow areas into nearby streams and rivers. However, in developed areas, impervious surfaces such as pavement and building roofs prevent this natural absorption. Instead, water runs into storm drains, sewer systems and drainage ditches. Large stormwater volumes can cause infrastructure damage, downstream flooding and erosion. For this reason, stormwater management techniques should be used to control runoff. Efficient stormwater systems can involve site engineering and creative landscape planning.

Sustainable Goals

The stormwater management's sustainable goals are to use low impact development (LID) techniques. These techniques aim to restore the natural watershed functions through small-scale treatment at the runoff source. Ultimately, the goal is to create a site design that mimics predevelopment conditions.

<u>*Bioretention Cells*</u>

Definition

Bioretention Cells, which can act as retention ponds, are small landscaped, graded areas constructed with a special soil mix and lined with a porous medium. Designs frequently use low maintenance water-tolerant plants waterproof liners and under drains. The figure below represents an example of a bioretention cell.

Figure 1, Bioretention

Benefits

If using under drains, stormwater can be collected and reused for irrigation or other purposes. Runoff collection can also prevent potential soil contamination (if stormwater is contaminated for any reason). Bioretention cell design is fairly simple and easy to construct.

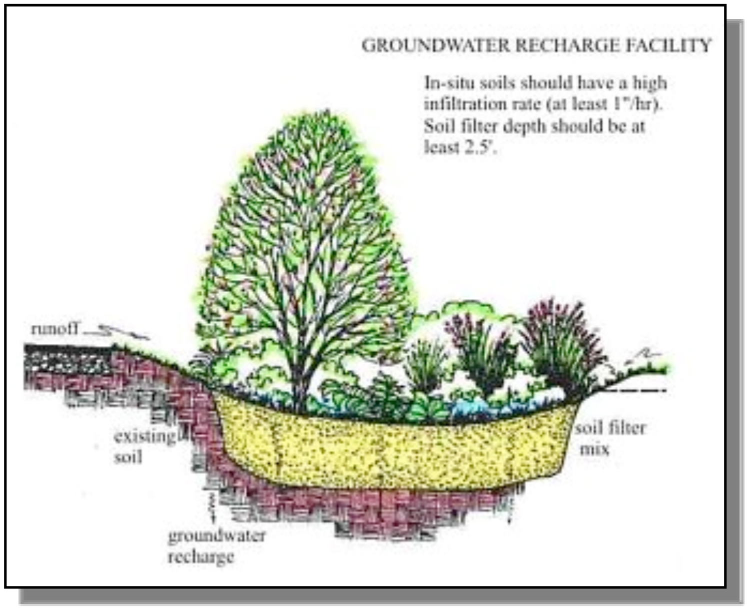
Drawbacks

Using low-maintenance, water-tolerant plants is the optimal design for mild climates, but there are few plants that are tolerant of a mountain valley climate, low-maintenance, and water tolerant. Due to these factors, liners are a more viable design.

Post-construction considerations

Bioretention cells, like eves on a residential building, need to be periodically checked for blockage. The soil absorption capacity should be tested annually to ensure that the bioretention cell is still operating as it was designed. Figure 2, Bioretention , provides cross-sectional detail as to how a bioretention cell recharges groundwater.

Figure 2 Bioretention



Financial Considerations

If properly designed, bioretention systems can cost less than traditional curb and gutter systems. They require more maintenance, but at a lower cost. The lifespan is an estimated 25 years.

Regulatory Considerations

Less sophisticated municipalities may rely on antiquated formulas to determine the detention amount required based on the impervious surface size. Bioretention cells act differently than traditional concrete detention ponds and local authorities may have to be educated on their benefits and capabilities.

Consumer Appeal

Bioretention cells can be disguised if they are merely liners. If using the plant bioretention cells, the cells can blend easily with the landscape and provide additional green space.

Considerations for this Development Phase

If a developer wishes to explore the possibility of an on-site bioretention cell, they should be sure to have the following information available:

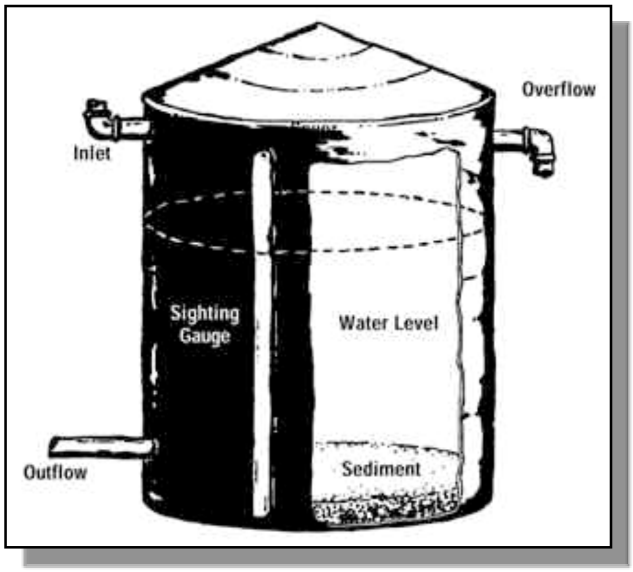
- Groundwater Table – the water table depth will affect the bioretention cell's performance and feasibility (Cells that are at or below the ground water cannot effectively manage storm water runoff.)
- Soil characteristics – Soil conditions vary from site to site. Some soil types (i.e., clay) do not absorb water runoff and may inhibit bioretention cells.
- Slope – bioretention cells have difficulties when they slope at greater than 5%.
- The developer should consult local building codes to determine if the regulatory entityy allows bioretention cells as an effective stormwater mitigation technique. If local building codes require traditional detention ponds, the developer may want to begin discussions with the local authorities to either have the code changed or acquire a waiver for their site.

Cisterns

Definition

Cisterns are storage tanks designed to capture stormwater runoff. They have maximum volumes on the order of 10,000 gallons and a higher storage capacity than typical rain barrels. In areas where high real estate prices, poor soil infiltration capacity, or little available open space preclude using bioretention stormwater management techniques. A cistern may be an option for water quality and quantity control. Figure 3, Simple Cistern, shows a basic cistern design.

Figure 3 Simple Cistern



Benefits

Cisterns could potentially lower a building's potable water demand (and costs) in addition to lowering the stormwater volume that leaves the site as runoff. In many cases, cisterns can be used to supplement or replace existing potable water for uses such as irrigation, toilet flushing, and cooling towers.

Drawbacks

Cisterns are tanks that, in most cases, must be installed beneath the ground and involve ways to divert stormwater runoff into the cisterns, such as piping, runnels or other drainage systems. There are cistern designs that can be installed on rooftops and are drained via gravity. The current regulatory structure in most western states only allows using cisterns for storm water management and excludes their use to store water for other uses.

Post-construction considerations

Cisterns have the potential to clog or overflow, and thus must be maintained over time to prevent flooding. Water quality assessments and inspections for clogging and structural soundness should be conducted twice per year.

Financial Considerations

Cistern size and location, prefabrication or custom designed, can effect cost. A local professional should be consulted. The system is assumed to have a 25-year lifespan.

Regulatory Considerations

In most communities, cistern use is permitted. One consideration that should be addressed is the pollutant amount in the water that is collected and will be reused as gray water. Additionally, using cistern water for any application that discharges into a sanitary sewer may be complicated by local regulation. Please check the local codes and regulation to determine any restrictions.

Consumer Appeal

Cisterns can generally be installed to be aesthetically pleasing.

Considerations for this Development Phase

If a developer wishes to explore the possibility of a cistern, they should be aware of the space and structural capacity. Cistern size varies based on the amount and rate of stormwater captured and the demand to reuse the captured stormwater. Cisterns should be installed where there is a reliable end use for any collected water to prevent water backup.

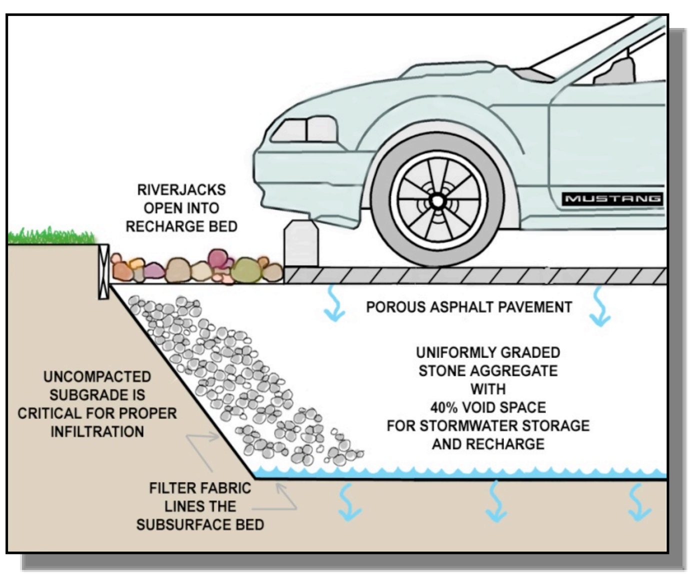
The developer should consult local building codes to determine if the municipality allows cisterns as an effective stormwater mitigation technique. As with bioretention cells, if local building codes only allow traditional detention ponds, the developer may want to begin discussions with the local authorities to either have the code changed or acquire a waiver for their site.

Permeable Concrete & Pavers

Definition

Permeable concrete is a specially mixed concrete product with most of the fine aggregates, or stones, removed from the concrete mixture. Eliminating these aggregates creates pores that permit water to travel through the concrete to a stone reservoir underneath the pavement. Another way to create this affect is by using paver blocks, which are not permeable, but create gaps between pavers that allow water to penetrate into the subsurface. Underneath the permeable concrete is geotextile fabric that filters and stores runoff. Figure 4, Basic Permeable Surface Diagram, illustrates the basic workings of permeable surfaces with respect to stormwater management.

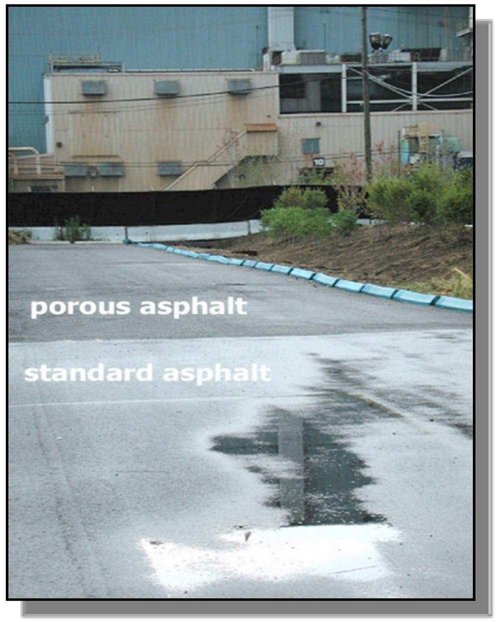
Figure 4 Basic Permeable Surface Diagram



Benefits

Permeable concrete works well with snowmelt runoff as it will occur near, or on the concrete itself. As snow melts on these walkways, water will be directly absorbed as illustrated in Figure 5, Permeable Surface Absorption.

Figure 5 Permeable Surface Absorption



This direct absorption will prevent icing on pathways. Permeable pavements could be used anywhere conventional pavement is used. However, permeable concrete surfaces should not be used for roadways larger than local or residential roads due to traffic frequency.

Drawbacks

Permeable concrete involves additional development costs and time because liners and drainage systems must be installed beneath the concrete.

Post-construction considerations

Permeable pavement must be maintained to prevent clogging by fine sediment particles. The pavement should be vacuumed 3-4 times per year to prevent sediment loading. This procedure is especially important if snow treatment is used on the pavement.

Regulatory Considerations

Municipalities usually do not regulate permeable pavement, but the developer should check the local regulations prior to installing permeable surfaces.

Consumer Appeal

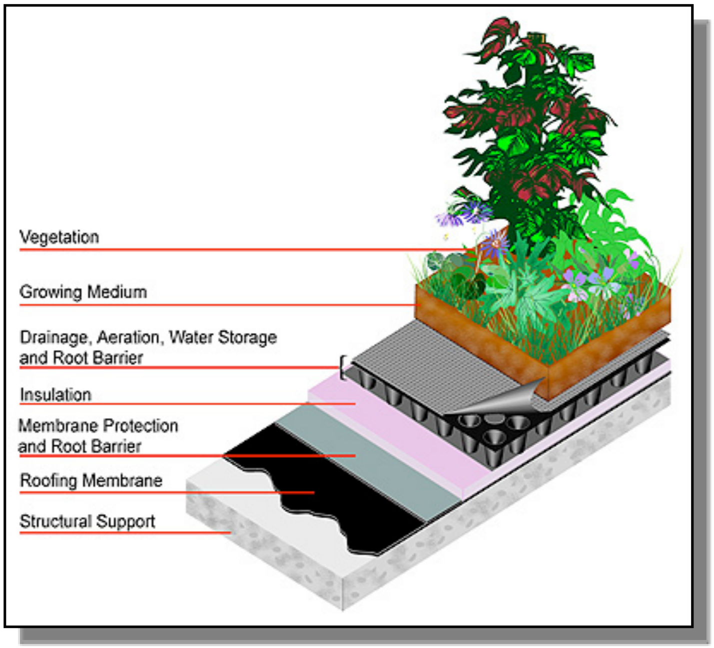
Permeable concrete does not look unlike other concrete walkways and will not disturb the area's aesthetics.

Green Roof

Definition

Green roofs are elevated layers of soil and vegetation that lie above the traditional roof surface. There are two types of green roofs: intensive and extensive. Intensive green roofs require a minimum depth of one foot of soil that will create a roof garden with larger plants, shrubs and other landscapes. Intensive green roofs can be used for parks or building amenities. A detailed example of a green roof, and its required layers, is illustrated in Figure 6, Green Roof Layers.

Figure 6 Green Roof Layers



Extensive green roofs range from as little as one to five inches in soil depth and cannot sustain larger plants. Extensive green roofs are used strictly for their environmental benefits, and not as amenities.

Benefits

Without using any additional land, green roofs improve a building's energy performance, air quality, and may add aesthetic value or rooftop parks.

Drawbacks

Depending on the green roof type, there can be considerable load considerations (i.e., 15 to 150 pounds per square foot) and may require the use of "light soil" and intensive maintenance. Additionally, a green roof can be hard to maintain in cold climates when snowmelt is the primary stormwater concern.

Post-construction considerations

Intensive green roofs require higher maintenance levels than extensive green roofs. Intensive green roofs involve a new landscape that requires vegetative maintenance. Extensive green roofs only require maintenance once a year.

Financial Considerations

Green roofs can be costly since they require a building's walls and foundation to sustain heavier loads. Additional costs include materials and maintenance. Green roofs have been shown to slow building heat gain and loss and therefore reduce building energy costs.

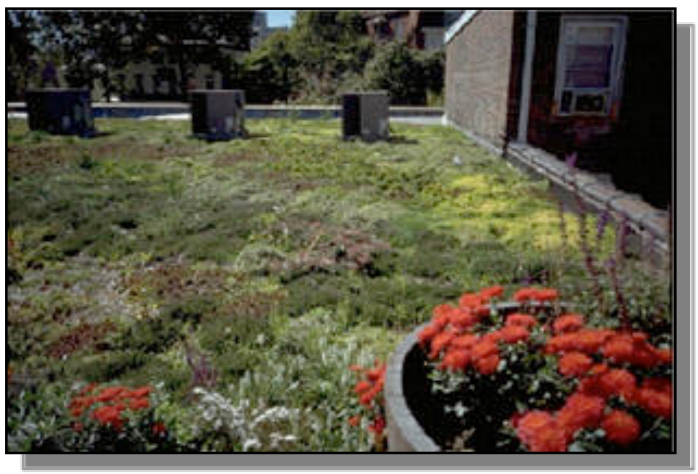
Regulatory Considerations

Municipalities do not usually regulate green roofs, but the developer should check the local regulations for confirmation prior to installing a green roof.

Consumer Appeal

A well designed and maintained green roof can be aesthetically pleasing and can attract consumers in the form of gardens, as illustrated in Figure 7, Green Roof Garden.

Figure 7 Green Roof Garden



Considerations for this Development Phase

The developer should consult local building codes to determine if the municipality allows green roofs as effective stormwater mitigation technique. As with bioretention cells, if local building codes only allow traditional detention ponds, the developer may want to begin discussions with the local authorities to secure amendments and waivers if necessary.

2.5. Building Core & Shell

The following sections primarily pertain to a building's structural integrity, highlighting specific sustainable goals. Subsections discuss building material options such as wood framing, straw bale, masonry, steel, and concrete. Each option's benefits and drawbacks are discussed as well as their post construction, financial, and regulatory considerations.

2.5.1. Structure

Definition

It is important to consider sustainability in a building's structure. Sustainable building structure focuses not only on recycled or certified materials, but also a reduction in embodied energy, or energy used in the production of the materials.

Sustainable Goals

The sustainable goals for the building structure are to have the lowest possible embodied energy and to use professionally certified products.

Wood Framing

Definition

Wood framing is wood that is used as the structural basis for building's walls. This includes posts, wall studs, and beams. Wood frames are connected to the floor and roof with joists. Traditional wood frames are constructed with softwoods like spruce, pine, and fir.

Benefits

Wood framing is readily available, cost effective, and rapidly erected. The United States and Canada currently have stable or increasing forestation rates. They are also viable options if the construction area is located such that local wood sources can be used. The Forest Stewardship Council (FSC) certifies wood, assuring that the wood was obtained using sustainable harvesting methods.

Drawbacks

Using non-certified wood can mean that wood was obtained from deforestation. FSC Certified wood is more expensive than non-certified wood. Additionally, FSC Certified wood is the only type of certified wood accepted for LEED certification. All wood framing is subject to deterioration, rot, fungi, and insects (e.g., beetles and termites).

Post-construction Considerations

Deterioration and insect infestation may occur.

Financial Considerations

Wood framing is often the cheapest structural material; however, FSC Certified wood is significantly more expensive than non-certified wood.

Regulatory Considerations

Due to infestation concern, some wood types may not be used due to infestation concern. FSC Certified wood is the only recognized certification for sustainably harvested wood.

Considerations for this Stage of Development

If a developer wishes to use wood framing on-site, he or she should be sure that they have the following information available:

Local timber regulations

Certification.

Straw Bale

Definition

There are two major building categories with straw bales: load bearing and non-load bearing. A post and beam framework that supports the basic building structure with bales of straw used as infill and is the most common on loading bearing approach. This is also the only straw bale building method that many building authorities allow. Figure 8, Straw Bale Construction, depicts a structure using straw bales as the primary material used for the building's structural material.

Figure 8 Straw Bale Construction

Benefits

Straw is highly sustainable, extremely cheap, very malleable, and quick to erect. Straw also acts as excellent insulation.

Drawbacks

Using straw in load-bearing walls could cause the straw to compress. Straw is breathable and therefore condensation can collect and undermine the straw's structural integrity. Rodents and insects pose a significant threat to straw bales, thus quality skin over the straw structure is essential.

Post-construction Considerations

Deterioration and insect infestation could occur, so the outer skin should be periodically checked. If straw bale walls are used as load-bearing walls, developers should be aware of potential straw compression from structural load.

Financial Considerations

Straw is very affordable and is considered the cheapest of the structural options.

Regulatory Considerations

Some building codes restrict using straw bales as insulation as opposed to being the sole structural material.

Consumer Appeal

Straw bales can be molded into any shape and can be aesthetically pleasing.

Considerations for this Stage of Development

If a developer wishes to use straw bales on-site, he or she should be sure that they have the following information available:

- Local building code restrictions
- Moisture risks.

Masonry

Definition

Building structures comprised of masonry include brick and block. An example of a building construction with masonry's 'brick and block' technique is depicted in Figure 9, Residential Masonry.

Figure 9 Residential Masonry

Benefits

Brick and block buildings are extremely durable and long lasting. Masonry and brick are energy-efficient materials that have high insulating values and high thermal mass. This may allow a reduction to a building's HVAC system. There are minimal maintenance issues with masonry and brick. Ingredients of masonry and mortar are inert, non-toxic and promote excellent indoor air quality.

Drawbacks

Most masonry walls require some reinforcement; usually an anchoring system that utilizes manufactured steel fabricated from post-industrial recycled material. Moisture infiltration can compromise the structure if proper precautions are not taken.

Post-construction Considerations

Block and/or brick require minimal maintenance.

Financial Considerations

Masonry longevity offsets slightly more expensive initial costs.

Consumer Appeal

Architectural expression can be achieved to include block and/or brick and colored mortar can match or complement the look of masonry.

Steel

Definition

Steel is inherently sustainable. When building sustainably, the developer must consider a building material's site impact including, but not limited to noise, dust, pollution, and congestion. Since steel is manufactured off-site, the above aspects are minimized. Further, off-site prefabrication reduces waste during the manufacturing process. Steel is the most popular structural material to withstand heavy loads and thus, developers can build vertically on a smaller building footprint. Lastly, steel is 100% recyclable.

Benefits

Steel fabrication is offsite and under factory-controlled conditions that are safer than the construction site working conditions. Steel products are quickly and simply erected. Steel construction generates less waste than other structural materials and any waste is easily segregated and recycled. Construction is relatively quiet and involves fewer material deliveries.

Drawbacks

Steel is generally the most expensive structural material. It is a thermal conductor and does not provide any natural insulation.

Financial Considerations

Steel has the longest possible lifecycle and requires the largest initial cost.

Concrete

Definition

Concrete can be precast, cast off-site, or cast in place. Concrete's predominant raw material is limestone, the most abundant mineral on Earth.

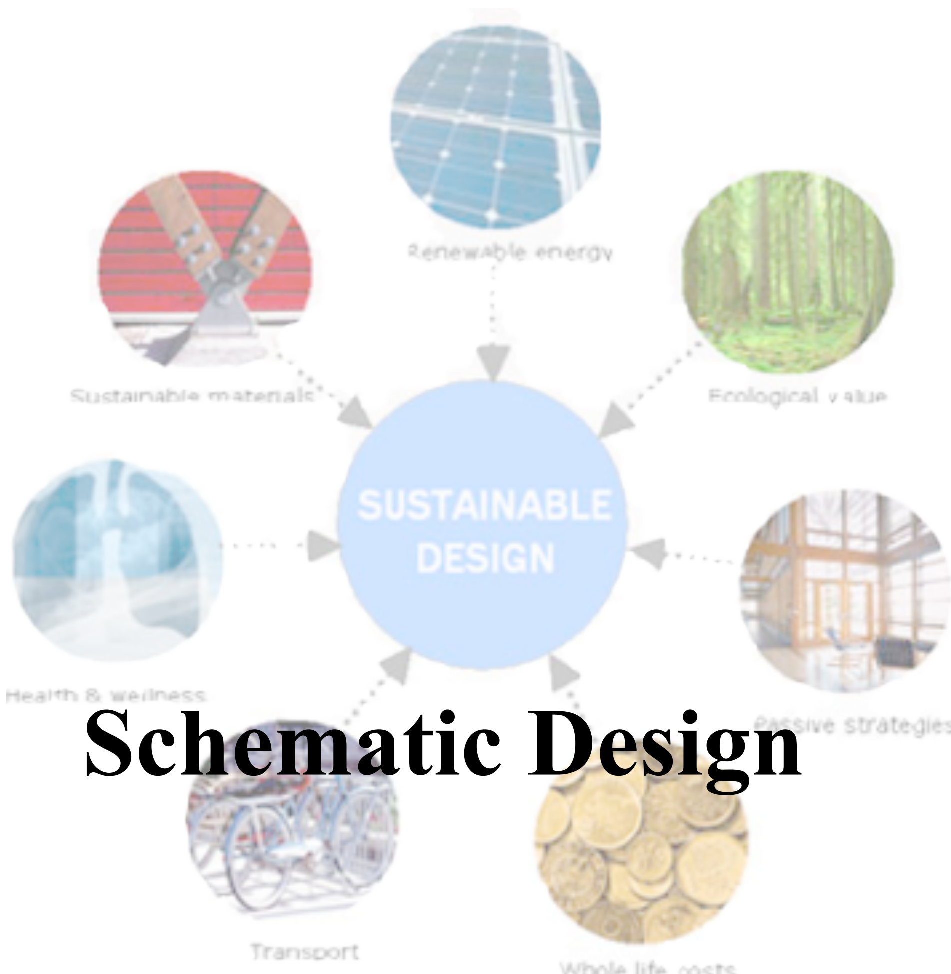
Benefits

Aside from being readily available, concrete is durable and long lasting. It does not rust, rot, or burn. Structures with concrete walls, foundations, and floors are highly energy efficient, which means that smaller-capacity HVAC equipment can be used. Concrete is also inherently light colored and therefore reflects more solar radiation than dark-colored materials, reducing the heat island effect.

Drawbacks

Temperatures during casting and construction must remain constant or cracking can occur.

3. Schematic Design



3.1. Definition

During this planning phase, the developer is determining building location, size, footprint, and uses. The architect will assist the developer by preparing a series of rough plans, which will show the general idea of the location of rooms and sizing. Many models and illustrations are prepared to help visualize the project. The main purpose of this phase is to define the scale and relationship among components of the project while exploring multiple alternatives. The end of this phase is determined when the developer selects the schematic drawings.

3.2. Mechanical, Electrical, & Plumbing (MEP)

The following sections and subsections discuss lighting, water, and interior design as they relate to building schematic design. In addition to defining sustainable goals, subsections examine the benefits and drawbacks, post-construction and financial considerations, and consumer appeal.

3.2.1. Lighting

Definition

Lighting refers to any system used to provide illumination to building interiors during the day and evening as well as those systems used to illuminate exterior areas at night.

Sustainable Goals

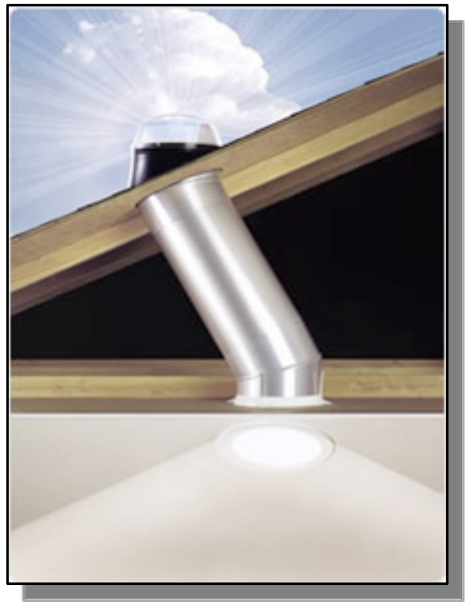
Sustainable lighting's main goal is to minimize the electricity required to provide light. Lighting is a major component of most commercial building's energy use and many of the techniques used to increase lighting efficiency are cost effective. Most lighting systems use high efficiency bulbs or find ways to maximize natural light brought into the building.

Natural Lighting

Definition

Natural lighting uses sunlight to illuminate homes and offices in place of incandescent lighting in the form of windows, and skylights, both tubular and traditional. Unlike a traditional skylight that is essentially a window on the roof, a tubular skylight, as illustrated in Figure 10, Tubular Skylight, has a glassed opening on a roof or outer wall that funnels light via a tube covered in highly reflective material to an inner room or corridor.

Figure 10 Tubular Skylight



Benefits

Using natural light does not add additional energy costs to a building and, in some cases, may help reduce energy costs. Additionally, numerous studies have indicated the natural light's positive effects in both commercial and residential buildings. The benefits include, but are not limited to:

- Increased motivation
- High productivity levels
- Better employee health
- Greater employee happiness while at the workplace.

Drawbacks

Unfortunately, there are some drawbacks to natural lighting that a developer should understand. First, natural lighting is only beneficial in areas that receive ample sunlight. Buildings in heavily wooded shaded, or cloudy areas will not receive as great a benefit from using natural light. Secondly, when building a building with numerous windows, the developer must make sure the windows are energy efficient so that additional heating and cooling costs are not incurred. Third, tubular skylights lose effectiveness the longer the tube due to the light having to travel further. Care should be taken when selecting the reflective material the tubes will use. Lastly, skylights must maintain water – tight seals or they risk leaking and rotting.

Post-construction Considerations

As with windows, skylights will require maintenance to ensure that seals prevent leaking and rotting.

Financial Considerations

Installing additional windows and skylights will require additional costs that vary based on the size, location, and features used.

Consumer Appeal

Natural lighting is very popular to consumers. It has numerous positive health benefits. Additionally, the incorporation of more windows allows for greater views and vistas. Lastly, tubular skylights are a small novelty item and are an attractive feature to users.

Considerations for this Stage of Development

Additional windows and skylights will need to be factored in to the project's development as early as possible to account for potential structural changes. With skylights, and in particular tubular skylights, these features will have to be designed to ensure there are no obstructions of MEP systems and that it is feasible.

3.3. Water

The following sections and subsections discuss stormwater management techniques that should be considered during the schematic design phase and considerations for spas and hot tubs. In addition to defining sustainable goals, subsections examine the benefits and drawbacks, post-construction and financial considerations, and consumer appeal.

3.3.1. Stormwater

Each of the following stormwater water management strategies was examined in Chapter 2, Conceptual Design. The following sections raise issues the developer should consider during the schematic design development phase. Please refer to Chapter 2 for details concerning installation, post-construction and financial considerations, and consumer appeal.

Bioretention Cells

Considerations for this Development phase

The developer should examine the site's impervious surface. As a general rule, bioretention cells should be equivalent to 1% of the total area from which they receiving runoff. Additional designs may be needed to accommodate larger impervious surfaces. Further, the slope and locations on which the buildings will be built. While bioretention cells should not control a building's location, they can dictate the pedestrian orientation. As with all stormwater mitigation strategies, bioretention cells should be designed to account for water's natural flow across the site.

Cisterns

Considerations for this Development phase

If using cisterns, the developer should examine the expected amount of stormwater collection capacity and the potential demand for collected water reuse. Additionally, the developer should consider the location proximity to water demand and whether the cistern should be located underground or on a rooftop.

Permeable Concrete & Pavers

Considerations for this Development phase

Permeable pavement has similar characteristics to conventional pavements. If using paver blocks, the developer should allow additional time for placing the blocks. Additional considerations should be given to the aggregate sub-base depth and the geotextile material addition.

<u>*Green Roof*</u>

Considerations for this Development phase

If the developer plans to incorporate a green roof on the development, he or she should first examine the expected stormwater amount to be collected. This will aid the developer in choosing the best plants to use on the green roof. Additionally, the roof's slope should be examined to ensure that a green roof is not only viable, but the correct vegetation is used.

3.3.2. Spa & Pool

Definition

Spas & Pools refers to any indoor or outdoor facilities that hold a body of water for swimming and/or relaxing. These are important features to the resort industry and are included in almost all-new hotel development. While there are ways to make pools and spas more sustainable, these recommendations may not be practical based upon the demands of the hotel's visitors.

Sustainable Goals

Sustainable goals for pools and spas revolve around the energy costs associated with keeping these facilities at a specified temperature. There are several ways to control these energy costs, most notably by positioning the pool to have a southern exposure for natural heating and by covering pools when not in use to prevent evaporation, which increases water consumption. Another way to reduce energy related costs is with heat recovery systems.

3.3.2.1. Wastewater and Sewer Heat Recovery System

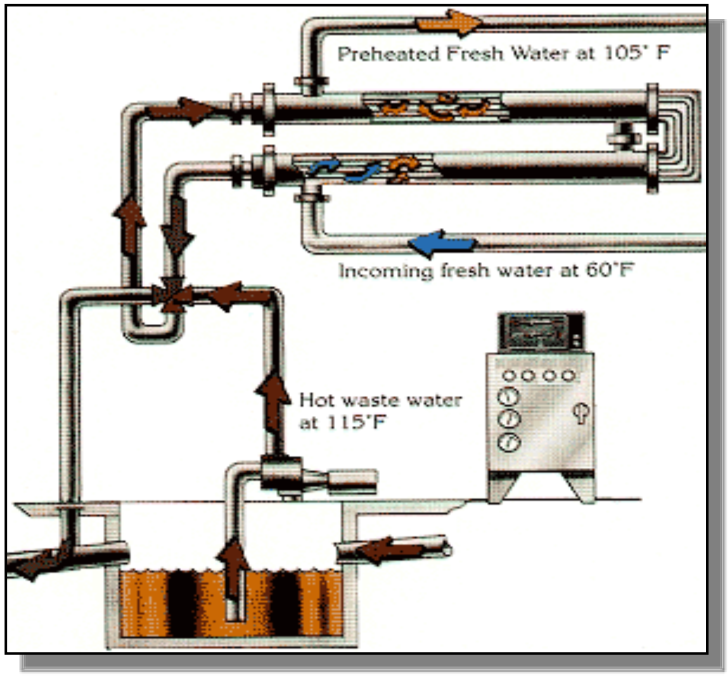
Definition

These systems are similar to geothermal heat pumps in that thermal energy is captured via a heat exchanger, in this case from sewer or wastewater lines, as opposed to soil, and is then used for heating purposes. These systems are primarily seen in residential heating, but may also be used to heat a pool.[2]

"Wastewater is pumped to the tube side of the heat exchanger. Fresh water enters the heat exchanger shell and flows around the tubes in a direction counter to the wastewater within the tubes. As the fluids pass one another in opposing directions, heat is transferred through the walls of the stainless steel tubing preheating process water typically to over 100 degrees Fahrenheit. The cooled wastewater can be reused, recycled, treated or discharged."[3] An illustrative example of a Heat Recovery System is shown in Figure 11, Wastewater & Sewer Heat Recovery System.

[2] Greenline Blog http://greenlineblog.com/2007/12/2010-olympic-village-using-sewage-heat-recovery/
[3] Ibid.

Figure 11 Wastewater & Sewer Heat Recovery System



Benefits

Hotels produce large amounts of wastewater. Using this wastewater is an innovative way to reduce spa and pool heating costs by harnessing energy from the liquid effluent that the hotel disposes. Currently, there are three major cities-Oslo, Tokyo, and Vancouver-that have incorporated a sewer heat recovery system into their respective energy infrastructures. Most notably, the city of Vancouver incorporated one of these systems in the Olympic Village for the 2010 winter Olympics.

Excess energy produced from a wastewater and sewer heat recovery system could be used to defray other energy costs associated with hotel operations.

Drawbacks

There are very few instances where these systems are currently used, particularly the sewer heat recovery systems, to heat pools. Furthermore, the sewer heat recovery systems may require coordination with local utility companies.

Post-Construction Consideration

As with geothermal heat pumps, these systems require annual maintenance.

Financial Considerations

Kemco, a provider of wastewater recovery systems, estimates that these systems provide a return on investment after 12-24 months.[4] These system's cost estimates vary based on size and location.

Regulatory Considerations

Consultation with local utility companies could be required for the sewer heat recovery system.

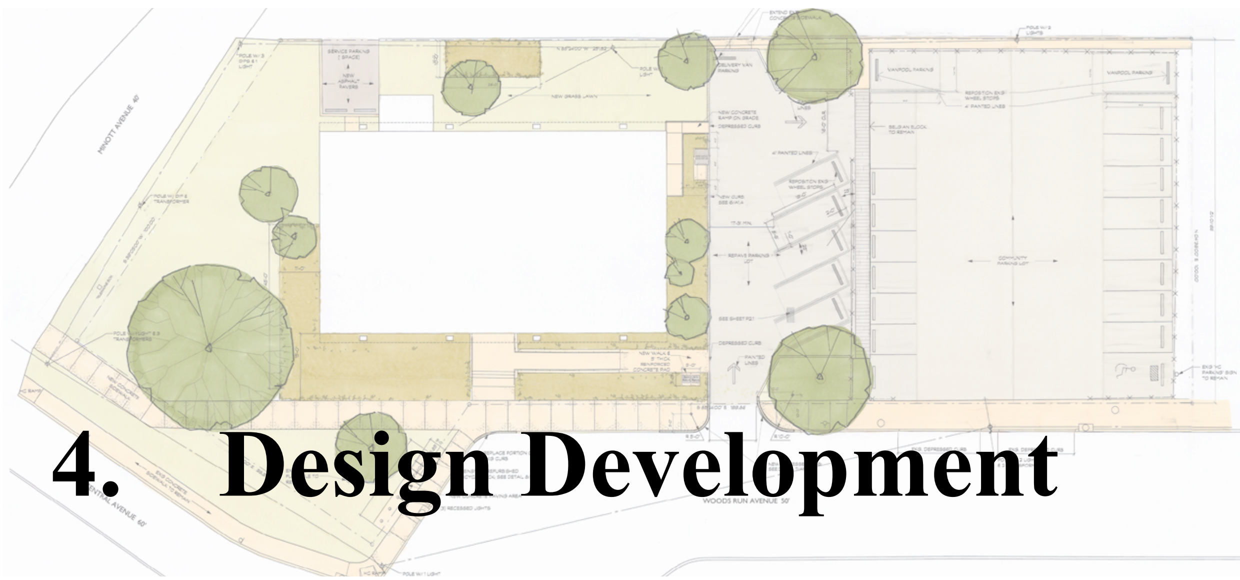
[4] Kemco Systems http://www.kemcosystems.com/Water-System-Components/Wastewater-Heat-Recovery.html

Consumer Appeal

These products have a relatively low consumer appeal. While consumers will be pleased to hear that the hotel has taken steps to reduce energy costs, the fact that these costs are defrayed using sewer and wastewater is not the most appealing of sustainability measures.

Considerations for this Development phase

The Developer should contact local authorities to examine the possibility of incorporating a sewer heat recovery system.



4. Design Development

4.1. Definition

During this development phase all drawings are verified that they conform to building codes and other systems, such as structural, mechanical, and electrical systems. This phase concludes when the developer approves the development design document. Technologies in this chapter do not require major building or site revisions and in many cases are more focused on a product or material type.

4.2. Mechanical, Electrical, & Plumbing

The following sections and subsections discuss technologies to enhance HVAC systems and building lighting as they pertain to development design. In addition to defining the technologies and highlighting sustainable goals, subsections examine the benefits and drawbacks, post-construction, financial, and regulation considerations, as well as consumer appeal.

4.2.1. HVAC

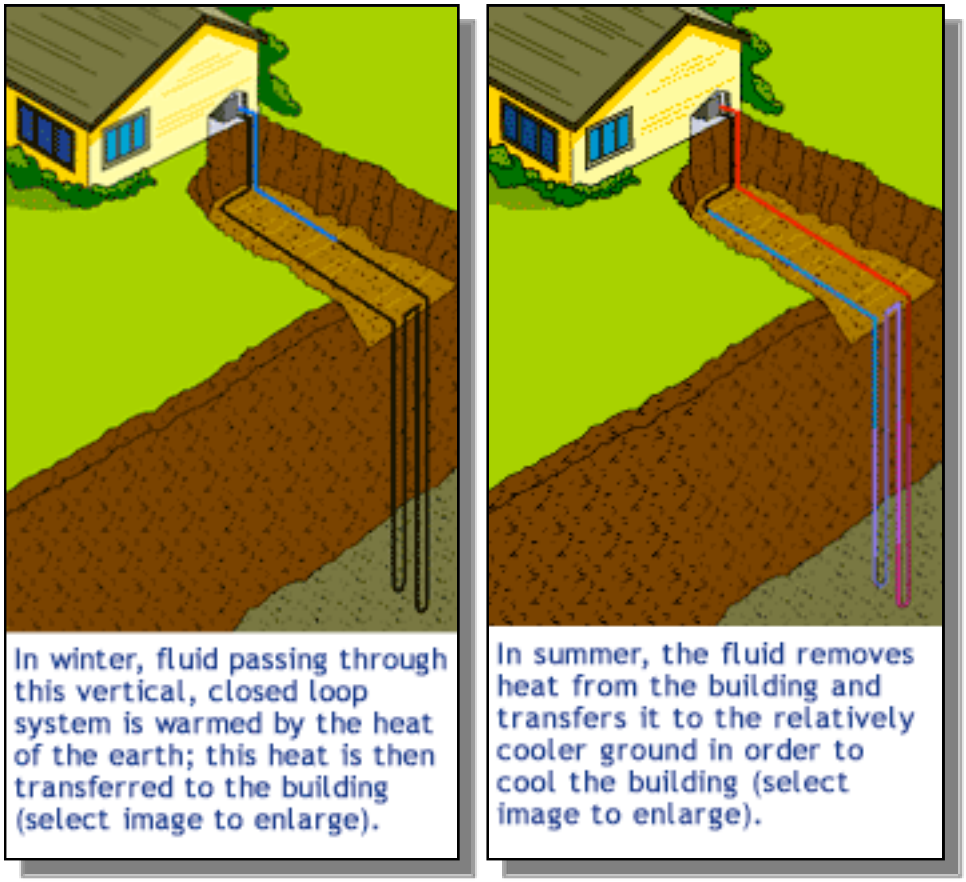
There are two technologies this section examines to aid HVAC systems: Geothermal heat pumps and Heat and Energy Recovery Ventilators. Subsections examine each technology in depth and analyze their benefits, drawbacks, and specific considerations of which the developer should be aware.

Geothermal Heat Pumps

Definition

Passive geothermal energy is defined as, "geothermal heat that is used in any other way other than for electricity." Passive geothermal heat is used directly for heating or even steady temperature management. Geothermal heat pumps take advantage of stable ground temperature near the Earth's surface. Though ground temperature varies around the globe, a few feet from the surface is a steady temperature ranging between 45-58 degrees Fahrenheit. Heat pumps use this steady temperature by burying pipes in looped formations next to, or below, building structures. Depending on the season, these pipes can be used to either heat or cool the building. Figure 12, Geothermal Heat Pump Piping, diagrams an example of the piping needed for geothermal heat pumps.

Figure 12 Geothermal Heat Pump Piping



Benefits

Any time geothermal heat is used, there is for a smaller reliance on electrical heat, allowing for smaller HVAC systems and less electricity use. This heating and cooling method also provides a constant temperature without the need to have a conditioning or heating unit start and stop throughout the day. Additionally, passive geothermal energy can also be used to heat water.

Drawbacks

Pipes must be excavated to a depth where ground temperature is constant otherwise the system may be inefficient and pipes could freeze under extreme winter conditions. Geothermal initial installation costs are significant.

Post Construction Considerations

Geothermal systems are relatively low maintenance.

Financial Considerations

Geothermal initial costs will be higher than a conventional HVAC system, but the maintenance and energy savings will be on the order of 30-60% less than a traditional HVAC system. The payback period will then be a function of initial cost, which is dependent on the site's geology. Shallow bedrock can make a horizontal system, which requires extensive excavation, expensive. Additionally, digging up large pieces of land in environmentally sensitive areas can do serious harm to the local ecosystem. Therefore, an alternative approach is vertical loops installed up to 400 feet deep. Local faults, differing bedrock materials, and groundwater are examples of the complications that can arise in a mountain environment. Because of these possible complications, the payback period could varied from two to ten years, with the possibility that conditions are so severe that there would be no payback over a conventional HVAC system. A developer should obtain a competent geothermal consultant prior to excavation for a proposed geothermal system to identify the exact costs and payback period associated with geothermal. Tax incentives and rebates are widely available for geothermal systems, which can assist in the system's upfront implementation costs and reduce the payback period.

Regulatory Considerations

Regulations vary depending on region.

Consumer Appeal

Passive geothermal heating is an appealing addition for consumers due to the consistency of temperature and the lack of blowing air through the buildings. Temperatures in buildings that contain passive geothermal heating and cooling routinely maintain a temperature of 65 degrees Fahrenheit.

<u>Heat & Energy Recovery Ventilators</u>

Definition

Heat recovery ventilators are a technology that decreases the energy needed to warm or cool fresh outside air used to circulate airflow in a well insulated building. This is accomplished by using the outgoing stale air to warm or cool the incoming fresh air (season dependent). There are several different technologies that allow these systems to work; however, all require similar design considerations in the ductwork layout such as:

- Heat Recovery Ventilator – This technology uses heat from stale indoor air to preheat incoming fresh outdoor air. The process can be used to either heat or cool incoming air.
- Energy Recovery Ventilator – Energy recovery ventilators transfer moisture and to energy from conditioned air.

Benefits

Heat recovery ventilators can save money by using previously conditioned air to lessen the heating needs of the incoming air. Ventilators focus on efficiency and do not remove the need for a boiler or air conditioner. Ventilators perform best in well-insulated buildings because they can increase airflow at costs low.

Drawbacks

This is a technology that works best in dry environments. In dry climates, cold weather may drive the need for a damper to prevent condensation from freezing in the ventilator.

Post-construction Considerations

Heat and energy recovery ventilators require maintenance schedules similar to those required by traditional furnaces and air conditioners.

Financial Considerations

The system's cost is dependent on the size needed. In some cases, several ventilators will be needed for larger buildings; however, this is not a technology that requires a major initial outlay. There are several manufactures that produce this technology for use at a commercial scale. Payback is dependent upon the climate. The greater the difference between the inside and outside air temperature, the more efficient the system will be, and thus, the shorter the payback period.

Consumer Appeal

A well-insulated building will, by definition, decrease the amount of incoming fresh air. This will lead to stale air within the building. A heat recovery ventilator can allow the building to increase airflow while keeping air conditioning costs low.

Considerations at this Stage of Development

At this stage of development it is important that the buildings are designed to allow for efficient air flow. This will decrease the need for numerous fans to force air circulation.

4.2.2. Lighting

4.2.2.1. Natural Lighting

Considerations for this Stage of Development

Natural lighting and skylight location and logistic considerations should be considered during this stage of development. Developers should be aware of how changes in other overhead systems, such as MEP, may affect natural lighting's viability from skylights or day lighting tubes.

4.2.3. Water

The following sections examine the stormwater management and water fixture considerations developers should take during the development design phase. The sections build upon the discussion of these technologies in previous chapters.

4.2.3.1. Stormwater

Cisterns

Considerations for this Development phase

Development design depends on the cistern's size and location. If connecting the reusable water to a potable plumbing system, a parallel plumbing system needs to be installed.

Green Roof

Considerations for this Development phase

Adding additional soil depth will increase the storage capacity and therefore the following equation should be considered:

*Storage volume = (green roof area) * (soil depth) * (soil porosity)*

When considering the storage volume, the developer should also evaluate the maximum load that the structure could withstand.

4.2.3.2. Water Fixtures

Definition:

Every development, whether commercial or residential, will include a waterworks system consisting of plumbing, toilets, showers and kitchen/bathroom sinks. In Colorado and the Mountain West, water is a precious commodity that must be used responsibly. Controlling the water flow using efficient fixtures is an easy and responsible way to limit water consumption. Reduced water usage benefits owners in many ways. When looking for products, it is recommended that only products with the WaterSense label be selected.

Sustainable Goals

The goal in selecting efficient water fixtures is to reduce water consumption, minimize maintenance and repair costs, and elongate the fixture's life cycle.

<u>*Low Flow Toilets*</u>

Definition

Current federal mandates require that toilets meet at least a 1.6 gallons per flush standard. To meet the EPA's Watersense standard, toilets must have a 1.28 gallons per flush, or less, capacity, which are commonly referred to as High Efficiency Toilets (HET).

Benefits

There are significant benefits that developers can capture by using water efficient fixtures. Toilets use significant amounts of water, often accounting for almost 30% of total water use.[5] Installing WaterSense low-flow toilets can reduce water use by 11 gallons a day, which translates into nearly $90 in annual savings. According to the EPA WaterSense website, certain utility companies offer rebates and vouchers for installing low flow toilets. It is recommended the developer contact the local utility prior to installing low-flow toilets.

Drawbacks

Currently, there are no drawbacks to using low-flow toilets, which are available in several different models to match any bathroom's aesthetics. Initial flow toilets were stigmatized with the notion that it took multiple flushes to evacuate toilet contents. Today, that is not the case. Most low-flow toilets can dispense with waste in one flush. To examine the effectiveness of certain toilet models, please consult the Maximum Performance (MaP) Testing of Popular Toilet Models.

Post Construction Consideration

Low-flow toilets require the same cleaning and maintenance as traditional toilets.

Financial Considerations

As previously noted, many utility companies provide incentives for businesses and homeowners to install these efficient toilets. Additionally, the EPA estimates that a family of four that replaces its home's older toilets with WaterSense labeled models will, on average, save more than $90 per year in reduced water utility bills, and $2,000 over the lifetime of the toilets.[6]

Consumer Appeal

Given hotel patron's high demands, it is of paramount importance that these high-efficiency toilets perform as advertised and not require multiple flushes. Veritec Consulting Inc. and Koeller and Company publish a report on the efficiency and effectiveness of toilets known as the Maximum Performance (MaP) Testing of Popular Toilet Models. This free report is updated several times a year and assesses numerous toilet brands and models. It can be obtained from the following organizations:

- Canadian Water and Wastewater Association (CWWA)

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[5] U.S. Environmental Protection Agency WaterSense Website (http://www.epa.gov/watersense/products/toilets.html)
[6] Ibid.

- The California Urban Water Conservation Council (CUWCC)
- The U.S.-Canadian Alliance for Water Efficiency (AWE)
- Veritec Consulting Inc.

Considerations at this Development phase

Low flow toilets do not require or impose any additional considerations for plumbing systems in terms of piping size or materials.

<u>*Low-Flow and Waterless Urinals*</u>

Definition

Federal guidelines mandate that new commercial urinals use 1 gallon per flush. The Environmental Protection Agency's (EPA) WaterSense program's guidelines recommend urinals use 0.5 gallons per flush. Waterless urinals, as the name implies, use gravity and special filters in lieu of flushing water.

Benefits

A waterless urinal saves, on average, up to 45,000 gallons of water per year. WaterSense low-flow urinals that use 0.5 gallons per flush, as opposed to 1 – 1.5 gallons per flush regular urinals, can save 4,500 gallons of water per urinal, per year.

Drawbacks

A common complaint against waterless urinals is that these urinals emit an odor. If liquids other than urine or the prescribed cleaning elements are poured down a waterless urinal, it can potentially cause a clog and require immediate maintenance.

Post Construction Consideration

As with any toilet, these fixtures will require periodic maintenance. An additional consideration is that waterless urinals require different maintenance than traditional flush urinals and vary depending upon brand. The maintenance generally requires changing the filters and the application of certain chemicals.

Financial Considerations

No-Flush™ urinals' operating costs are about $1.00 per 1000 uses. The payback period for a Waterless No-Flush™ retrofit is usually between one and three years. With increasing water and sewer costs, paybacks will be even faster. There are numerous urinal brands and models in today's marketplace. A developer can easily find a model that meets financial constraints and achieves the desired performance and aesthetics.

Consumer Appeal

Waterless urinals appeal to consumers, as male patrons do not have to touch any handle after use, which results in a more sanitized experience. Besides the cleanliness and to a lesser extent aesthetics, it is hard to assess to what degree urinals appeal to consumers.

<u>*Sink Faucets*</u>

Definition

Faucets account for more than 15 percent of indoor household water use—more than 1 trillion gallons of water across the United States each year. The U.S. Environmental Protection Agency's (EPA) WaterSense program has tested sink faucets and accessories, and those receiving the WaterSense seal of approval are those capable of reducing a sink's water flow by 30 percent or more without sacrificing performance.[7]

Benefits

By installing WaterSense labeled bathroom sink faucets or faucet accessories, an average household can save more than 500 gallons per year. These water savings translate into increased energy savings as demand for hot water is reduced. If every household in the United States installed WaterSense labeled bathroom sink faucets or faucet accessories, more than $350 million could be saved on water utility bills and more than 60 billion gallons of water annually—enough to meet public water demand in Miami for more than 150 days.[8]

Drawbacks

While aerators work well in bathroom sinks, these fixtures can be a hindrance in the kitchen as the reduced water flow results in longer times to fill up pots for cooking.

Financial Considerations

Aerators are relatively inexpensive and can be easily attached to most fixtures. These aerator attachments are generally a few dollars. Depending on the fixture's style, new faucets can be quite expensive when purchased at retail prices. However, when used in large-scale projects, these items are comparable to other faucets with differing gallon per minute (gpm) ratings. Again, the lower gpm rating, the less water will be used.

Consumer Appeal

The two major consumer appeal aspects are performance and aesthetics. With numerous models varying in shapes and sizes, it is easy to please consumers.

<u>Shower heads</u>

Definition

According to the EPA, showering represents roughly 17% of residential indoor water use, which equates to about 1.2 trillion gallons of water each year. The Energy Policy Act of 1992 mandated that all shower heads have a maximum flow rate of 2.5 gpm. The EPA WaterSense program requires shower heads seeking the WaterSense seal of approval emit no more than 2 gpm.

Benefits

By installing efficient shower head, households could save more than 2,300 gallons per year. Reduced water consumption, particularly hot water consumption, will reduce energy use as well. The EPA estimates that switching to a WaterSense shower head can result in annual savings of 300-kilowatt hours of electricity.

Drawbacks

One concern with low-flow shower heads is the scalding potential when other devices, such as faucets, divert water from the shower. Low-flow shower heads are more sensitive to changes because they use such small water quantities that the temperature in the shower is amplified when water is diverted. To address the scalding problem, an automatic-compensating valve should be used. Most United States plumbing codes require these valves; however, there are two concerns with these valves:

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[7] http://www.epa.gov/watersense/pubs/ws_bathroom_faucets.htm
[8] Ibid.

First, automatic compensating mixing valves are currently only required to be tested and certified at a flow rate of 2.5 gpm. When these devices are outfitted in conjunction with a showerhead that has a lower flow rate, there may not be adequate assurance that the valve is sensitive enough to provide the required protection.

Second, not all homes are equipped with an automatic-compensating mixing valve. This is of particular concern for showerhead retrofits in homes built prior to the mid-1990s.[9]

Most importantly, developers should consult with plumbers and MEP technicians to ensure that scalding will not be an issue with using low-flow showerheads. While low-flow showerheads are available with many features and models, hotel patrons may not want efficiency, but rather a luxurious shower that is not sparring with its water.

Financial Considerations

Like other water fixtures, showerhead costs vary based upon model, performance, and brand. As noted above, using low-flow showerheads reduces both water and electricity bills.

Consumer Appeal

Showerheads should be selected that maximize the necessary shower experience while minimizing the costs associated with its use. Low-flow showerheads are available in many models and can be selected to accommodate the needs of consumers.

4.2.4. Building Core & Shell

This section focuses primarily on insulation. The subsections discuss blanket, concrete block, foam board, and lose fill insulation technologies. Each insulation type is defined and, as with other sections of this handbook, their drawbacks and benefits discussed along with various considerations.

4.2.4.1. Insulation

Blanket Insulation

Definition

Blanket insulation is one of the most common insulation forms that is used in walls, attics and floors, and is generally procured in blankets or rolls. Blanket insulation can be made from fiberglass, mineral wool, plastic fiber, which is composed from recycled plastics, and natural fibers, which include cotton, sheep's wool, straw and hemp. R-values vary greatly with the batting's size and performance. In the financial considerations section, there is a standard R-value chart and associated fiberglass insulation cost. This chart can serve as a rule of thumb for other insulation forms.

For recommended insulation levels please consult the U.S. Department of Energy Zip Code Insulation Program:

http://www.ornl.gov/~roofs/Zip/ZipHome.html

Benefits

A properly insulated building will save on heating and cooling costs. Using reusable and natural materials reduces the environmental impact associated with its production. The following list highlights the materials that can be used in blanket insulation:

[9] http://www.plumbingengineer.com/feb_09/watersense_feature.php

Cotton Blanket

Cotton blanket insulation is an excellent sound absorber, is safer to handle, better for the environment, provides the same fire safety rating as fiberglass insulation, and has comparable energy efficiency to fiberglass insulation. Cotton blanket insulation does not contain formaldehyde-based binders that can be harmful to laborers installing it. Furthermore, it does not off gas after installation. Cotton blanket insulation is easier to install than fiberglass insulation.

Plastic Fiber

Generally made from recycled materials and can achieve a comparable energy efficiency to fiberglass insulation.

Natural Fibers

Sheep's wool boasts similar thermal resistance to other fibrous materials. It also has the ability to absorb moisture, but if left unchecked or there is a significant amount of water, natural fiber insulation can mildew, mold, and rotting. Hemp insulation is largely unused and untested in the United States. Straw insulation has existed in the United States since the 1800s. It does not achieve as high a thermal resistance to other insulation forms.

Drawbacks

There are some drawbacks that developers should consider when choosing insulation. Cotton insulation can absorb more moisture than fiberglass. As such, precautions should be taken to ensure that mildew and mold do not become a problem. Cotton insulation is roughly twice as expensive as fiberglass insulation. Although Plastic Fiber insulation is non-irritating, working with it is more cumbersome than traditional fiberglass. This type of insulation is not readily available throughout the U.S.

Financial Considerations

Blanket insulation generally costs less than other insulation types. Cotton blanket insulation is roughly twice as expensive as fiberglass insulation, though cost estimates will vary based on project size, type, and insulation use. The following table, Fiberglass Batt Insulation Characteristics, is from the EnergySavers.gov website.

Table 1 Fiberglass Batt Insulation Characteristics

Thickness (Inches)	R-Value	Cost (Cents/Sq. Ft)
3 1/2	11	16 – 20
3 5/8	13	15-20
3 1/2 (High Density)	15	34-40
6 to 6 1/4	19	27-34
5 1/4 (High Density)	21	33-39
8 to 8 1/2	25	37-45
8 (High Density)	30	45-49
9 1/2 (Standard)	30	39-43
12	38	55-60
**This table is for comparison only. Determine actual thickness, R-Value, and cost from manufacturer and local building supplier.*		

Concrete Block Insulation

Definition

Concrete block insulation includes foam-insulated material installation into the concrete block gaps, with the exception of those blocks where steel or other structural supports are located, to improve the overall building's insulated shell. This insulation is appropriate for unfinished walls and on new construction projects. The insulation is commonly poured, foam injected or inserted with rigid pieces into the concrete blocks. R-values range from 1 to 2 per inch of thickness.

For recommended insulation levels, developers should please consult the U.S. Department of Energy Zip Code Insulation Program:

http://www.ornl.gov/~roofs/Zip/ZipHome.html

Benefits

If developers are constructing a building and/or foundation with concrete blocks, using concrete block insulation will enhance the building's energy efficiency. Additionally, there are several types of concrete insulation enabling the builder to choose an option best suited for the project.

Drawbacks

Using concrete block insulation generally requires a certified mason for installation. Furthermore, according to the U.S. Department of Energy, "even though filling the block cavities and special block designs improve a block wall's thermal characteristics, it doesn't reduce heat movement very much when compared to insulation installed over the surface of the blocks either on the exterior or interior of the foundation walls. Field studies and computer simulations have shown that core-filling of any type offers little fuel savings since the majority of heat is conducted through the solid parts of the walls such as block webs and mortar joints."[10]

Post-construction Considerations

As this insulation must be installed during the construction process, there are no post construction considerations.

Financial Considerations

The additional cost of using this insulation is minimal.

Consumer Appeal

As long as the insulation ensures a properly heated or cooled building, and because this product is out of the consumer's daily view, it is not a sustainability priority.

Foam Board & Rigid Foam Board

Definition

Foam boards provide good thermal resistance and can be used in almost any insulating application, ranging from the attic to the foundation and have R-values range from 3.8 to 4.4 per inch of thickness

For recommended insulation levels, developers should consult the U.S. Department of Energy Zip Code Insulation Program: *http://www.ornl.gov/~roofs/Zip/ZipHome.html*

[10] http://www.energysavers.gov/your_home/insulation_airsealing/index.cfm/mytopic=11570

Benefits

Foam boards are a widely used form of insulation that can be used in numerous applications.

Drawbacks

Foam board insulation generally requires professional installation. If the insulation is subject to prolonged exposure to moisture or sun, the insulation could fail. This is easily fixed, however, by applying a protective membrane or coating.

Financial Considerations

It is recommended that a developer obtain a cost estimate to compare foam board insulation to blanket or batt insulation.

Consumer Appeal

As long as the insulation ensures a properly heated or cooled building, and because this product is out of the consumer's daily view, the consumer appeal factor is minimal.

Loose Fill

Definition

Loose-Fill insulation is comprised of small foam bits, fiber, and any other insulating material. Because of its ability to fit into unconventional spaces, Loose-Fill insulation is ideal for insulating difficult spaces, such as enclosed spaces, open areas, renovations, and refurbishments.

For recommended insulation levels, developers should consult the U.S. Department of Energy Zip Code Insulation Program:

http://www.ornl.gov/~roofs/Zip/ZipHome.html

Benefits

Loose-Fill can be comprised of recycled materials, including newspaper and industrial waste, and is ideal for difficult installation jobs.

Drawbacks

Lose fill insulation requires using a blower to push the insulation into the designated space. Additionally, over time loose-Fill insulation will settle, which can result in a reduced R-value. This can be particularly troublesome for walls, though some proponents claim that with proper installation settling will never be a problem. Lastly, if not properly installed, the insulation can have gaps and voids, which reduce its effectiveness. Another concern is fluffing, which is an unscrupulous practice by contractors that provide insulation of a minimum thickness but not of a minimum weight. This results in gaps, which as noted, reduces the insulation's effectiveness.

Financial Considerations

Because loose- fill insulation requires a blower to disperse the insulating material, it will generally have a higher labor cost. Again, it is recommended that developers obtain cost estimates prior to selecting an insulation method.

Consumer Appeal

As long as the insulation ensures a properly heated or cooled building, and because this product is out of the consumer's daily view, the consumer appeal factor is minimal.

5. Construction Documentation

5.1. Construction Documents Definition

During this phase, the architect and design team prepares detailed drawings based on the approved specifications and design documents. This phase prepares for the actual product that the developer will be permitting and building. These documents should help the contractors determine actual construction costs and become part of the construction contract.

The final stage before the construction process will provide the developers a final opportunity to review their design's viability. No major revisions should be necessary, but any potential problems not already addressed should be solved at this juncture.

Since major design features have already been decided, this chapter will discuss smaller problems that have been observed with previous projects. Although this is an important and necessary aspect of the development process, no major decisions are made. Minor concerns will be commented upon where appropriate; however this chapter will not be as comprehensive as previous chapters.

5.2. Mechanical, Electrical, Plumbing

5.3. Electrical (non-lighting)

The following subsections discuss techniques to decrease energy consumption: energy demand management and using power conditioners. Each is defined and their benefits and drawbacks are discussed. Additional factors the developer should consider at this development stage, such as post-construction, financial, and regulatory are also noted.

Energy Demand Management

Definition

Energy Demand Management is a method of regulating a building's energy demand to avoid high peak-time electricity charges. As electrical utilities begin moving toward "smart grid" technology, it is likely that a peak demand pricing structure will be instituted, which typically raises electricity use costs during peak loads. Energy demand management can automatically turn off appliances when prices increase. This technology is currently being tested in various pilot programs around the country. Below, in Figure 13, Energy Monitor, an example energy monitor is depicted.

Figure 13 Energy Monitor

Benefits

On average, Energy Demand Management reduces building electrical costs by 10-40%. These reductions are achieved by regulating energy consumption to minimal levels during peak times.

Drawbacks

The main drawback to this system is the additional costs incurred to install energy monitors.

Post Construction Considerations

Similar to any product, energy monitors should be maintained on an annual basis.

Financial Considerations

Using energy management could result in large energy savings that outweigh the initial upfront costs to install energy monitors. The payback period on energy monitors is estimated to be three to six months.

Consumer Appeal

Energy Demand Management may prohibit consumers from using large energy loads during peak hours.

Power Conditioner

Definition

A power conditioner is a device that delivers the correct voltage level that enables load equipment to function properly. Power conditioners are intended to improve the power quality delivered to electrical load equipment. Power conditioners' size and functionality vary. Some provide minimal voltage regulation, while others provide protection from many different power quality problems. Units may be small and rated in volt-amperes, or large and rated in kilovolt-amperes. Units could be installed on specific power outlets, like the one pictured in Figure 14, Power Conditioner Example

Figure 14 Power Conditioner Example

Benefits

Power conditioners work as a filter to eliminate electrical noise and interference, which leads to more efficient power usage.

Drawbacks

Power conditioners are expensive and because there are many options, picking a quality product is difficult.

Post Construction Considerations

Power conditioners should to be maintained and replaced as needed.

Financial Considerations

Power conditioners are high quality products and therefore expensive. Power conditioners result in higher efficiency and reduced overall energy costs.

5.3.1. Lighting

The following subsections discuss lighting products that will decrease energy consumption: compact florescent light bulbs (CFLs) and efficient traditional light fixtures. Each is defined and their benefits and drawbacks are discussed. Additional factors the developer should consider at this development stage, such as post-construction, financial, and regulatory are also noted.

5.3.1.1. Compact Florescent Light bulbs

Definition

CFLs are highly efficient light bulbs that use less energy than traditional incandescent light bulbs. When looking to purchase CFLs, developers should only consider those that are Energy Star rated.

Benefits

According to Energy Star, a single CFL will save its user approximately $30 over its lifetime, has a payback period of six months, uses 75% less energy, and has an average life cycle that is ten times greater than a traditional incandescent bulb.[11]

Drawbacks

Although concerns about mercury content have been prominent in the discussion of CFLs the amount used is miniscule. Mercury has been used in neon signs for years and no such concerns have been raised. Additionally, newer CFLs produce light similar to traditional incandescent light bulbs so most consumers cannot tell the difference between the two.

Post-construction Considerations

When selecting a CFL, one should first examine the fixture to ascertain the correct bulb needed. For example, an outdoor bulb would not be selected for a bathroom vanity. There are numerous light bulb types including Spiral, A-Shape, Globe, Tubed, Candle, Indoor, Outdoor, 3-Way, and Dimmable.

Financial Considerations

As noted, CFLs do have a slightly higher cost, but this cost is outweighed by a CFLs benefits. CLFs are considered energy saving "low hanging fruit" due to CFLs low initial cost and quick payback period.

Consumer Appeal

Generally, consumers are unaware of the light bulb used in light fixtures. Their only concern is if it provides the requisite lighting amount.

5.3.1.2. Lighting Fixtures

Definition

Energy efficient light fixtures are another way to reduce lighting costs. When looking to purchase CFLs, developers should only consider those that are Energy Star rated. Figure 15, Sample Light Fixtures, details the variation among energy star rated fixtures.

[11] Energy Star (http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=LB)

Figure 15 Sample Light Fixtures:

Benefits

According to Energy Star, energy efficient light fixtures use ¼ the energy of traditional lighting.[12] Additionally, these fixtures extend a light bulb's life cycle, are readily available in several models, and are found in most hardware and lighting stores. Lastly, Energy Star rated fixtures have longer warranties, typically averaging two years.

Drawbacks

These fixtures have few drawbacks. Most manufacturers trend toward producing Energy Star rated and energy efficient light fixtures. The energy consumption difference is negligible when comparing Energy Star fixtures that use CFLs and standard fixtures that use CFLs. Thus, a traditional fixture with a CFL bulb or light emitting diode (LED) bulb could achieve almost the same energy efficiency level as an Energy Star fixture.

Post-construction Considerations

There are no additional post-construction considerations using energy efficient fixtures opposed to traditional fixtures.

Financial Considerations

Like most household amenities, these fixtures' price and quality range. Energy Star estimates that energy efficient fixtures can save users $70 in energy costs.

Consumer Appeal

These fixtures are available in many sizes and finishes, which allows the developer to maximize consumer appeal.

[12] http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=LF

Light Emitting Diodes (LED)

Definition

LEDs, like those shown in Figure 16, LED Bulb, are small light sources that become illuminated by electrons' movement through a semiconductor material[13]. Although they have existed for decades, LEDs have only recently been used in resident projects.

Figure 16 LED Bulb

Benefits

According to Energy Star, LED Lighting will reduce energy costs by 75% and last up to 25 times longer than traditional incandescent lighting. High-powered LED lights are used for illuminating homes and residences. Low-powered LED lights are used in electronic devices, such as cameras and remotes.

Financial Considerations

Though LEDs cost more than CFLs, LEDs have a longer life. Technology advances will cause LED prices to continue to drop. LEDs may soon become more popular than CFLs and incandescent light bulbs.

5.3.2. Water

5.3.2.1. Stormwater

The following subsections examine the stormwater management techniques discussed earlier in this handbook, and the factors that should be considered during the construction documentation process.

Bioretention Cells

Considerations for this Development phase

Developers should determine what plant life the bioretention cell will contain. Where possible, local plants should be used. The plants should be water tolerant and capable of covering much of the swale's

[13] http://energystar.custhelp.com/cgi-bin/energystar.cfg/php/enduser/std_adp.php?p_faqid=5528&p_created=1230917444

surface area. In addition, the developer should have the landscape architect determine which plants are most efficient at removing impurities and pollutants from storm water runoff.

Cisterns

Considerations for this Development phase

As mentioned above, cisterns are prefabricated. If installed on rooftop, the developer should be aware of the load the building must hold when the cisterns are full. Additionally, if connecting the reusable water to a potable plumbing system, a parallel plumbing system needs to be installed.

Permeable Concrete & Pavers

Considerations for this Development phase

Development design will vary based on whether or not paver blocks are used due to the difference in fill and infrastructure required under the asphalt.

5.4. Building Core & Shell

This section considers the buildings exterior (e.g., roofing system and finishes) and the building's interior (e.g., flooring, millwork, etc.). Each section is subdivided to more closely examine sustainable options for each building piece. An option's benefits and drawbacks, post-construction, financial, and regulatory considerations, and consumer appeal are identified and discussed.

5.4.1. Roofing Systems

There are four roofing systems discussed in the following section: reflective roofing, metal roofing, recycled material roofing, and PV roofing solutions.

Definition

As sustainability grows as a major building consideration, roofing systems are also becoming more sustainable. Popular sustainable roofing solutions include, but are not limited to:

- Cool, highly reflective roofing
- Metal roofing
- Modified bitumen membranes that incorporate post-consumer recycled materials, adhesives and other roofing materials and products that eliminate or reduce hazardous fumes,
- Photovoltaic panel systems,
- Green roofs.

LEED and Energy Star are the two most common standards of measuring roof sustainability.

Sustainable Goals

Achieving roofing sustainability can be accomplished using the following strategies:

- Using recycled materials
- Using materials that are recyclable
- Extending a product's service life
- Promoting more efficient use of energy and other natural resources.

Reflective Roofing

Definition

Reflective roofing utilizes lighter colors that reflect sunlight, rather than absorb it. Buildings that reflect ultraviolet light do not cause heat buildup. Typically, reflective roofing involves applying a highly reflective topcoat or mineral surfacing. Materials used as roof coatings include, but are not limited to:

- Elastomeric
- Polyurethane
- Acrylic paints
- Single-ply roofing sheets made of rubber
- Plastic or PVC
- Clay or concrete tiles
- Metal sheeting.

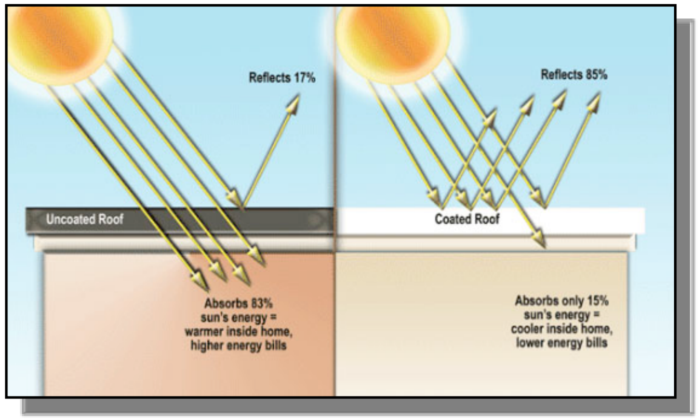
Some materials can be easily applied with a roller, while others require the use of caulk or heat sealing. Figure 17, Reflective Roofing, depicts a reflective roof in use.

Figure 17 Reflective Roofing

Benefits

Building roofs that reflect ultraviolet rays typically require 40% less energy for cooling. Reflective roofing, through its ultraviolet reflection, prevents degradation and therefore has a longer lifespan than traditional roofing. A depiction of how a reflective roof works, as opposed to a normal roof, is shown in Figure 18, Reflective Roof Comparison.

Figure 18 Reflective Roof Comparison



Drawbacks

Although reflective roofing can be beneficial to any development type, the most effective reflective roofs are installed on single-story, air-conditioned buildings with large roof surfaces. There may also be some fume concerns during application.

Post-construction Considerations

Reflective roofing has demonstrated that UV-related failures are not common until 20 years or longer beyond their installation.

Financial Considerations

If cost is a consideration, white titanium dioxide paint and aluminum sheets are the best inexpensive choices. Both are easy to apply and require little maintenance. Reflective roof coatings costs vary from $0.75 per square foot to over $3.00 per square foot.[14]

Regulatory Considerations

There are no known regulations restricting the use of reflective roofing.

Consumer Appeal

Reflective roofing consumer appeal varies with consumer exposure and tolerance to light colored roofs.

<u>*Metal Roofing*</u>

Definition

Metal roof is a roofing system made from metal pieces or tiles and is a component of the building envelope. Metal roofing is the fastest growing segment of sustainable roofing market. The reason for their sustainability is that they are typically 100% recyclable.

Benefits

Metal roofing systems not only act as reflective roofing, but are also the longest lasting roof with known warranties between 20 and 50 years. Metal roofing eliminates any installation fume concerns associated with other roofing types Metal roofing offers architects and designers more diverse aesthetic features. Metal roofs weigh between 50-150 pounds per square foot, while tile roofing is 750 pounds per square

[14] 2010 values

foot, and concrete roofs weigh 900 pounds per square foot. Metal is also fire resistant and easily installed compared to other options.

Drawbacks

The two biggest drawbacks are cost and noise. Costs are on par with other premium quality roofing, but are considerably more expensive than traditional asphalt shingles. Rain and hail may be noisy for people inside the structure. Hail may also dent metal roofing.

Post-construction Considerations

If expecting any weather damage to the metal roof, smaller metal sheets should be used during construction. Smaller sheets are cheaper to replace and easier to install then large metal sheets.

Financial Considerations

Metal roofing is more expensive than asphalt roof shingles. As with many sustainable products, the high initial costs are offset by low maintenance costs and have longer life spans.

Consumer Appeal

Metal roofing can be aesthetically pleasing, but rain and hail can be loud to patrons inside the buildings.

Recycled Material Roofing

Definition

This sustainable roofing category uses materials that might otherwise be overflowing in landfills. For example, some built-up, multi-ply modified bitumen roofing systems replace conventional filler with post-consumer crumb rubber from recycled tires. Another popular recycled roofing material used is ethylene propylene diene terpolymer, commonly referred to as EPDM. Traditional EPDM that is used is not recycled, however, there are now recycled EPDM products available.

Benefits

Using recycled materials reduces landfill loads. In 2010, non-recycled EPDM has been estimated to account for 4% (5.5 million tons) of landfill waste in the US.

Drawbacks

Recycled roofing can cost as much as other premium style roofing, but only has the lifespan of traditional asphalt roofing.

Financial Considerations

All recycled roofing materials are premium roofing types and cost significantly more than traditional asphalt roofing.

Consumer Appeal

Recycled roofing materials can be aesthetically pleasing and most do not look different than traditional styles.

Photovoltaic Solutions

Definition

PV roofing is not a total roofing solution, but rather it is used in conjunction with other roofing types. PV roofing can be built in smaller, individual shingles or in large panels.

Benefits

PV roofing can provide electricity to its host structure in addition to qualifying the owner for significant tax rebates. They are attractive and can fully integrate with a traditional shingle-style roof. PV roofing also includes manufacturer-backed warranties.

Drawbacks

PV roofing is expensive to purchase and install. Although many companies are developing new PV roofing technology, efficiencies can be low and durability could be an issue.

Financial Considerations

PV roofing has higher initial costs, but can greatly reduce energy consumption during building operations. There are national and state government tax incentives for installing PV roofing.

Consumer Appeal

PV roofing is aesthetically pleasing and can blend in with traditional roofing styles.

5.4.2. Exterior Finishes

Definition

When considering what materials to select for exterior finishes, a developer should consider the following questions:

- What is the source?
- How was the product manufactured?
- What is the lifespan?
- How will the material be disposed?
- Does it require maintenance?

These are all appropriate questions to determine what the best and most sustainable material to use is. With respect to selecting exterior finish materials, the following three categories were identified.

- Paint – most development projects use paint as some form of exterior finish. Using paint that has low or zero VOCs reduces harmful side effects to painters and the environment.
- Wood– when considering what type of lumber and where to source it, a developer adhering to sustainability guidelines should use lumber certified by the FSC. Other woods sourced through sustainable means are also advisable.
- Masonry – brick and stone are two common exterior finish materials. The goal with sustainable masonry is to source from local quarries and brick producers, thereby limiting vehicle miles traveled and masonry supplies are abundant.

<u>*Sustainable Paint*</u>

Definition

When completing a building's exterior finish, paint is generally used in some way. Using certain paints adversely affects the environment and painter's health, which can be mitigated by using Green Paint.

Green Paint is a paint type that emits fewer harmful VOCs than regular paint. Regular paint generally has higher VOC levels, has harmful side effects, and contributes to environmental degradation via greenhouse gases and it's removal. Green Paint can be low VOC, zero VOC, recycled paint, or natural paint.

Recycled paint is made from re-blending existing paints or reprocessing new paint. Natural paint is very similar to zero VOC paints, but the key differentiation is that natural paint is made from all natural ingredients.

Benefits

Green paints do not emit harmful greenhouse gases that contribute to ozone depletion and reduce the environment's exposure to harmful compounds when regular paint is used, removed, or discarded. Additionally, green paints are safer to use and reduce or eliminate the harmful health side effects. Lastly, green paints are available in several colors and styles.

Drawbacks

Many of the disadvantages with green paints are similar to those of regular paints. For instance, green paints may be:

- Available in only a few select colors
- More expensive than the traditional counterparts
- Have a shorter lifespan and are prone to cracking and peeling
- Packaged in powder form, requiring onsite mixing
- Have a short time frame for use.

As with any paint, it is recommended that the developer consult an expert to advise what is best.

Financial Considerations

The primary costs associated with paint are labor related. Using Green Paint is slightly more expensive, but when compared to the total job cost is minimal.

Consumer Appeal

The primary driver is whether the paint is attractive to consumers. As long as the finished product looks attractive and ages well, consumers will be happy.

<u>Wood</u>

Definition

When sourcing wood for exterior finishes, the developer should seek out wood in abundant supply or sustainability harvested. In particular, FSC certified wood is a good source for all uses in a development project. For additional information, please consult the FSC website (www.fscus.org). The Sustainable Forestry Initiative Certification Program provides information on sustainable lumber and wood products.

Benefits

Using sustainable lumber is better for the environment, contributes to sustainable building practices, and creates healthier living and working environments.

Drawbacks

There are no major drawbacks to using sustainably sourced lumber.

Financial Considerations

Depending on the wood type and where it was sourced, lumber can range in price. Generally, there is a slight premium associated with sustainable lumber.

Consumer Appeal

As with other exterior finishes, the primary consumer driver is aesthetics. If the finished product looks good, consumers will be pleased. While it is true that consumers are increasingly placing an emphasis on sustainability, it is almost impossible to discern whether wood was sustainably harvested.

Considerations for this Stage of Development

Identify the wood products needed for the project. Once identified, search for manufacturers and suppliers of these wood products through FSC or the Sustainable Forestry Initiative (SFI) websites.

<u>Masonry</u>

Definition

Masonry includes the structural construction with bricks and/or stone that is bound together by mortar. The primary green building masonry best practices includes using bricks and stone sustainably sourced from nearby facilities. With respect to brick, reused brick is a popular way to achieve a desired aesthetic using readily available materials. It also reduces the need to manufacture new brick.

A popular stone alternative is to use stone veneer, which weighs about 75% less and is 50% cheaper than normal stone. Another option is to source stone from nearby quarries, which reduces vehicle miles traveled. Stone has an extremely long life span, often more than 100 years, and is a widely used building material.

Benefits

Bricks and stones are extremely durable and have lengthy life spans, which make both ideal green building products. Brick and stone generally have lasting appeal, thus ensuring the buildings have lasting appeal.

Drawbacks

Extreme weather fluctuations can damage a masonry project's structural integrity Precautions can be taken to mitigate this damage. Masonry projects are labor intensive and require stronger foundations.

Post-construction Considerations

While not an immediate post-construction concern, masonry projects should be inspected to ensure that there is no brick or mortar degradation. Generally, this will be undertaken several years after construction is completed.

Financial Considerations

Because of the labor, transportation, and sourcing requirements, stone and brick masonry projects tend to have higher financial costs.

Consumer Appeal

A brick or stone facade is a very popular consumer choice. Stone is popular among mountain resort communities.

5.4.3. Interior

Definition

Popular flooring finishes include bamboo, tile, vinyl, linoleum, carpet and cork. Of these, bamboo, wool-based carpet tiles, and cork are sustainable choices. Ceramic tile, wool based carpeting, true linoleum and concrete are also low volatile organic compound (VOC) emitting flooring options. Sustainable flooring finishes are becoming more popular due to their aesthetics and consumer appeal.

Sustainable Goals

Flooring's sustainable goals include using low VOC emitting materials, recycled materials, or sustainably harvested materials.

5.4.3.1. Flooring

There are three flooring options discussed in the following section: bamboo, cork, and carpet tiles. Each option's benefits and drawbacks are discussed along with post-construction and financial considerations the developer should examine. Lastly, the consumer appeal for each option is also highlighted.

<u>Bamboo</u>

Definition

Bamboo is one of the most sustainable wood types. It is plentiful, grows quickly, and easily harvested. Manufacturers are able to take uneven cane or round poles and construct high quality, ultra smooth flooring. Bamboo flooring is an ideal way to get the beauty of hardwood or laminate flooring, while being environmentally conscious.

Benefits

Bamboo flooring is readily available from many different manufacturers including: Bamboo Garden, Envirochoice, Premium Green, Westhollow, Woodstock, and Panda Lumber. Bamboo floors are more resistant than softer floors like pine or vinyl. It is strong, durable, and easy to handle, and is easily installed. Mitered plank flooring sections are installed in an adhesive-less process.

Drawbacks

High-grade solid bamboo planks can be expensive. For hardwood, bamboo floors are fairly brittle, meaning that they may crack if a heavy object is dropped on them.

Post-construction Considerations

Bamboo is considered fairly brittle and can crack under heavy impact. Bamboo, like most wood flooring can expand and contract with humidity changes.

Financial Considerations

Bamboo flooring costs can vary greatly depending on grade, finish, material percentage, and veneer. High grade, imported solid bamboo planks are more expensive, while veneered floating floors are more affordable.

Consumer Appeal

Bamboo can match almost any décor with mellow light hues and colors. Bamboo can also have high gloss finish, matte, and semi-gloss varieties.

<u>Cork</u>

Definition

Cork is harvested from the Cork Oak tree that grows primarily around the Mediterranean basin. Cork bark is harvested from the tree allowing the tree to grow and reproduce bark. This makes cork a very sustainable resource. Almost of 85% of cork tissue is comprised of an air-like gas that makes the material very lightweight and low density. Cork floors can be glue-down tiles, which are 100% cork, or cork floating floors which are constructed with more fiberboard than cork.

Benefits

Cork is durable and popular in public buildings like banks and libraries. Cork flooring has a very long life and can be repaired if damaged. Cork reduces the sound transmission (both impact sound and sound transmission), vibration, heat, and thus a great insulator. Cork reduces heat loss in rooms and even body heat loss through the feet. Bugs, mold, mites and even termites are repelled by cork due to naturally occurring substance in cork called Suberin. Cork tiles are pre-finished and pre-glued and therefore easily installed. Cork is also a natural fire inhibitor.

Drawbacks

Cork floating floors, because they are constructed with more fiberboard than cork, lose some softness, sound reduction, and green benefits of 100% cork tiles. Refinishing and re-staining cork can be difficult. To keep cork waterproof, flooring requires sealing and maintenance.

Post-construction Considerations

Cork can be easily repaired or replaced, but refinishing or re-staining cork can be difficult due to its outer layer's soft, then nature. This can cause the stain to appear uneven. For best performance, annual stripping and sealing is required. Due cork's flexibility and softness, leaving sharp and heavy objects on the floor for extended time periods may damage the floor.

Financial Considerations

Cork is more expensive when compared to flooring such as Vinyl and requires skilled installation, specifically preparing the floor.

Consumer Appeal

Cork can be an attractive choice, especially for those who are required to stand on the floor for extended time periods. The downside is that cork does not come in many color variations, although this is becoming less of an issue as cork floors become more popular.

Carpet Tiles

Definition

Sustainable carpet tiles, shown in Figure 19, Carpet Tiles, are made from sustainable resources and are manufactured, transported, installed, and disposed of using sustainable methods. Most carpet tiles have a minimum of 25% recycled material and can be reclaimed and recycled again.

Figure 19 Carpet Tiles

Benefits

Carpet tiles are a preferred alternative to broadloom carpet for the following reasons:

- Carpet tiles have a lower purchase cost because there is less waste
- Tiles have lower installation costs because tiles are easier and quicker to place
- Tiles have lower ownership costs because repairs and replacements are easier
- Tiles fit irregular shapes better than broadloom, and tiles in a high-traffic area can be replaced, rather then replacing the entire carpet.

Drawbacks

Carpet tiles don't always appear to be a cohesive, singular carpet, and therefore may not be suitable for living areas. A professional should always install the carpet tiles to prevent visible seams. Tiles are not as durable as wall-to-wall carpet, but when tiles are worn they may be individually replaced. Tiles are not suitable in areas that are damp or prone to mildew.

Post-construction Considerations

With age, tiles can pull around the edges creating an uneven appearance. Precaution and regular maintenance should be done if tiled area is damp or prone to mildew.

Financial Considerations

Tiled carpet per square foot is more expensive than traditional broadloom, wall-to-wall carpet, but there are lower associated purchase, installation, and ownership costs.

Consumer Appeal

Carpet tiles can look aesthetically appealing if designed and installed correctly.

5.4.4. Mill Work

Definition

Millwork is handcrafted and manufactured products that include moldings, doors, door frames, window sashes, stairs, banisters and cabinets. Green building best practices dictate millwork should be selected based on the materials used and where it is sourced and manufactured. It is recommended that milled wood products be sourced from either FSC certified lumber or from sustainable sources, such as bamboo. It is also advisable that any milled products selected contain low or zero VOCs. The following are sustainable millwork material types found in green building projects:

- Bamboo – a processed material made from bamboo strips. Bamboo has many uses and can be found in all millwork types.
- FSC Certified Lumber – lumber that is harvested according to FSC guidelines can receive certification, which indicates that it sustainably harvested. Manufacturing companies can receive this certification if it can prove its wood supply came from FSC certified sources.
- Kirei Board – this product is made from sorghum and is very similar to wheat board. It can be used in numerous millwork applications.
- Particle Board – a type of board made from sawdust, wood chips, and sawmill shavings. It is either laminated or painted.
- Wheatboard – a type of board made from wheat chaff. It can replace particleboard and, after lamination, incorporated in many millwork products.

Benefits

All the materials listed above are sustainable, making for a better environment and can be used in numerous millwork applications. Particle board can be laminated to disguise its exterior, if so desired. There are numerous sustainable millwork manufacturers enabling consumers to choose from a wide product array and finishes to meet almost all millwork needs. Millwork that contains low VOCs contributes to safer and healthier living environments.

Drawbacks

Particle board, wheat board and Kirei board are not the strongest or most durable material, and are prone to degradation if exposed to moisture. Fabricated boards, such as particle or wheat board, are inherently weaker than traditional wood. Furthermore, the final product depends upon the manufacturer, as some products are higher quality than others.

Post Construction Considerations

There are no major post construction considerations. These millwork materials will require the same maintenance and care as millwork manufactured in a non-sustainable process.

Financial Considerations

Generally, the sustainable millwork materials listed above are less expensive than other traditional materials, such as teak, redwood, and mahogany.

Consumer Appeal

If these sustainable millwork applications appear cheap, i.e. break, scratch, or fracture easily, consumers will not appreciate them. Depending upon the use and application, these sustainable materials can be used in lieu of more expensive finishes without any decrease in customer satisfaction.

6. Appendix

A.1 Discussion about Sustainability

Sustainability is a difficult and complicated topic to broach in any circle, especially in real estate where sizable implementation costs are combined with high risk and uncertainty. The Brundtland Commission defines sustainability as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." This vague credo has guided the sustainability discussion for the last twenty years. In real estate, the subject has evolved to mean discussion and action on everything from how the building is powered, to factory practices that manufactured the finishes.

For this handbook's purpose, sustainability encompasses environmental sustainability and financial sustainability. Financial sustainability refers to an investment that will yield a return that allows the principals to remain in business long term. Environmental sustainability is a more complicated concept; because sustainability no longer just means reducing energy and water consumption, but a host of sustainable practices that when combined together create the buildings of the future.

Over the next few pages, each of these sustainable concepts is briefly defined so that when individual technologies are encountered later in the handbook, a foundation in sustainability has already been developed. The concepts have been arranged in related conceptual groups: Operational Resource Consumption, Manufacturing Resource Consumption, Sustainable Materials, Chemical Side Effects, and Human Interaction. Any one of these sustainable concepts duly regarded will yield an improved product, but a synthesis of all concepts is necessary to truly create enduring sustainable structures.

Operational Resource Consumption

Every building consumes resources. Minimizing resource consumption is sustainable development's goal. Done properly it can decrease costs and help the ecosystem. Below are the sustainable concepts associated with operational resource consumption and the reason these concepts are important.

Energy Consumption

The most commonly recognized sustainable dimension is operational energy consumption. The holy grail of energy sustainability in the built environment is the net zero home. This home is capable of producing as much energy as it consumes. Operational energy consumption includes both general electrical power needs, and other energy needs associated with heating and cooling. For most commercial buildings, this means minimizing reliance on external energy sources by increasing energy efficiency and maximizing on-source energy production and capturing energy through geothermal or active and passive solar means.

Using renewable energy to power a structure is important due to the problems associated with continued fossil fuel use. In recent years, energy prices have become highly variable. Decreasing reliance on traditional carbon energy can remove uncertainty from operating costs associated with energy use.

Water Consumption

It is significantly easier to quantify water consumption's impact on sustainability. Water consumption includes all irrigable areas, showers, toilets, sink fixtures, and laundry facilities. The simple rule is, "conserve, conserve, conserve". This is relatively straightforward in a traditional single family home; however, in a four star hotel, a more demanding clientele may be offended by a low-flow showerhead. The key is balance and perception. Water consumption becomes a little more complex when considering post use storage, filtration and drainage. If used, graywater and blackwater must be disposed of appropriately to insure minimal environmental impact. It is possible to reuse some graywater on-site for certain restricted applications. Proper stormwater management is also required particularly with paved parking lots and other impervious surfaces. It is extremely important that leaked oil and other hazardous wastes are not diverted directly into a stream channel.

Water consumption is important for several reasons. In the arid West, the relatively small amount of freshwater is already over appropriated, thus additional development typically means purchasing water rights from farmers and the inevitable fallowing of farmland. Unmitigated diversion harms the ecosystem from which the water is removed, resulting in below normal stream levels, which can inhibit spawning or vegetation growth. Contaminated water can poison species in streams and rivers. Furthermore, water rich in nutrients from fertilizers or human waste can cause lakes and streams to become eutrophic, or so choked with vegetation that animals can no longer survive. Additionally, delivering water and treating wastewater is energy intensive. Conserving water is one way of minimizing all of these effects.

Manufacturing Resource Consumption

A building's environmental impact begins with the materials used in the foundation, walls, and roof. Every product has a history that begins with resource extraction, continues through processing, and completes with site delivery. Minimizing a product's environmental impact at each stage is another method of achieving a more sustainable built environment. Developers can influence this by carefully selecting the materials they use.

Manufacturing Energy Consumption

Manufacturing energy consumption is a much more complex sustainable dimension, because it isn't readily quantifiable for a developer. However, manufacturers on sustainability's leading edge are quick to share any information in the hopes of gaining a competitive edge.

Energy consumption in manufacturing begins with the diesel fuel to run mineral extraction equipment. At the manufacturing site, electricity is used throughout the process. Natural gas may be used for heating and diesel to operate large machinery on site. Finally, there is an energy cost associated with delivering the final product to the end user.

Manufacturing Water Consumption

Most raw materials used for construction have high water usage associated with them that are the result of mining operations, cleaning, catalyzing, steam generation, or countless other processes. The best products, by this dimension, have the lowest level of water consumption per unit. Some companies are starting to track and report their water consumption so developers can make more informed product choices; however, this practice is still in its infancy.

Using products that have lower water consumption will positively affect the environment by ensuring that river and stream ecosystems remain vibrant. Moreover, there will be more water available for agricultural uses, and limited freshwater resources will be less impacted by consumption demands. Energy requirements associated with water treatment and delivery will decrease.

Sustainable Materials

A material's life cycle must be considered completely before determining if a material is sustainable. The questions a developer must ask are simple enough: "Where did it come from?" "Where is it going?" "How long will it be here?" "Is it safe?"

Recycled

Ideally, almost every component of a construction or consumer good would be derived from a discarded product at the end of its previous lifecycle. All plastics, metals, and paper productions would be fully recycled into new useful products. While chemical and economic realities prevent full utilization of waste for recycling, processes are improving.

Recyclable

Purchasing a recycled product that will just end up in a landfill at lifecycle's end delays the inevitable. Purchasing products that have seller take back for end-of-life recycling, or can be readily recycled by some other manner is the most sustainable option. Again, this decreases the stress on landfills and reduces the need for future resource extraction.

Renewable and Compostable

Organic building materials, like lumber and bamboo are best if they come from sustainable forest initiatives. This ensures the forest's health, and a reliable future mineral supply. Compostable materials are an additional benefit because, like mineral resources, organic building materials wind up in landfills. Compostable materials can be composted and reused as fertilizers or other soil additives. Like recyclable materials, this reduces the strain on existing landfills.

Toxicity

Many manufactured products have components made with toxic compounds. Often, these compounds have no effect on the immediate environment like the mercury in a CFL. Other times, they can have associated health issues with their use. For example, lead paint's linkage to birth defects and mental degeneracy. In both cases, using toxic building materials will result in toxic chemicals being dumped into landfills, possibly contaminating ground-water supplies, or incinerated which can result in toxic chemicals and heavy metals carried on wind currents and deposited on land and surface water.

Longevity

In the United States, many buildings are planned with just a 30-year life cycle. Extending that life span to 100 years reduces the number of times buildings must be reconstructed. Constructing adaptable buildings can increase financial yields due to decreased costs associated with extensive renovation or demolition.

Chemical Side Effect

Many chemicals and materials that have beneficial uses, also have unintended side effects. Like all sustainable areas, the science is dynamic. New chemicals and new side effects are continuously discovered. Here are some of the worst, but best understood offenders.

Ozone Depletion

Ozone depletion applies primarily to commercial refrigerants, but may be an issue in other chemical intensive building processes. Chlorofluorocarbons (CFCs) have long been known to cause ozone layer depletion when disposed of improperly. Ozone layer depletion causes increased levels of ultraviolet light to pass through the atmosphere, raising the likelihood of melanoma and other diseases. As such, a number of other refrigerants have been developed that lessen this effect. A perfect refrigerant will have no chemical effect on the ozone layer and have zero global warming potential.

Volatile Organic Compounds

Volatile organic compounds (VOCs) are organic compounds that have a tendency to vaporize under normal conditions and enter the atmosphere. Many VOCs are toxic and can lead to ill health effects if absorbed by the human body. VOCs are commonly found in paints, thinners, solvents, adhesives, and fuels. Purchasing products that are low or no VOC can have a positive effect on the interior environment and the building's inhabitants.

A.2 Explanation of Handbook Scope

The Rocky Mountain Region

The "Mountain West" region, as defined in this handbook, is a semi-contiguous land region that shares several key challenges and advantages over other regions of the country. This region encompasses areas over 5,500-6,000 feet in elevation spread across nine states: Colorado, Utah, Idaho, Montana, Wyoming, New Mexico, South Dakota, Nevada, and California. These states have lowlands, typically between 3,000 and 5,000 feet in elevation where most of the development is taking place, but also contain the higher mountain climate zones that we are concerned with in this manual.

These mountainous zones are characterized by a number of shared climatic features that define the regional construction challenges. This region has a short building seasons due to seasonal temperature variations that are 10-20 degrees cooler than the surrounding lowlands. This is latitudinal dependent though, as most of the Southern Colorado snow has melted by mid-June, yet glaciers still remain year-round in Montana. Additionally, the building season is different for foothills areas than high plateaus. Higher elevations around 8,000 feet may still be dealing with the mud season during mid-June, whereas locations around 6,000 feet down canyon will already be dry and warming by mid-April.

Most development occurs in relatively remote locations with unique topographic challenges that lead to higher labor and material costs. The higher elevation leads to more intense solar radiation, making mountain regions a good solar power candidate, especially considering that many locations in the Rockies receive greater than 300 days of sun a year. However, site challenges like permanent shade from nearby mountain peaks or stands of old growth forest can reduce solar power's efficiency and cost-effectiveness. Most mountain areas are dry climates that are subject to the peculiarities of Western water rights law. Even during spring run-off, every drop of water is claimed by downstream, senior interests and cannot be interfered with by local landowners for irrigation purposes or other on-site uses. The over-appropriated water rights can cause practical drought while surrounded by mountain streams and glaciers.

This is not an exhaustive list of challenges facing developers in mountainous regions, but it does illustrate the unique, regional conditions real estate professionals must overcome. The most significant challenge, though, is dealing with the population boom in mountain areas. Population pressures in mountainous regions have expanded as population pressures in the surrounding high plains and desert regions have also expanded. Rising metropolitan areas like Denver and the Colorado Front Range, Salt Lake City, and Southern Idaho have led to unprecedented population booms throughout the Mountain West. The active populations that have settled these areas not only look to the mountains for recreation, but increasingly as stable places to live with their families. These cities recreation-oriented nature has caused an increase in the local populations by 30-300% in some mountainous areas.

Population statistics alone are deceptive, though, because they fail to consider the true "developed" regional growth. For instance, Summit County, Colorado has a year-round population of 26,000 set to double over the next two decades, but on weekends the population grows to 150,000 or more. All of those individuals need lodging and services associated with a population six times the size of the year-round population.

Commercial Real Estate

While sustainability is an issue facing every sector of real estate development, this handbook focuses on several areas of importance to the geographical region outlined above. Mountainous regions are experiencing rapid growth, especially those areas associated with recreation. Furthermore, commercial real estate provides some unique opportunities when compared to for sale product.

Commercial real estate allows developers to realize paybacks on their sustainable expenses. Most sustainable technologies have a cost premium over traditional technologies. However, over time operating expenses are lower due to the inclusion of the technology. Developers should consider each technology as an autonomous investment and ensure that payback meets either their hurdle rate or that general benefits (not necessarily monetary) outweigh the costs. Unfortunately, the for-sale real estate market is not sophisticated enough to correctly value energy savings achieved through sustainable technologies. Thankfully, in commercial real estate the developer is often the operator. Said differently, the developer is capable of realizing savings associated with efficient technologies.

This handbook focuses on resort, office, and retail commercial real estate in regions defined above. These uses provide some of the greatest potential efficiencies due to ownership structure and current energy use. Resort, office, and retail tend to be energy intensive uses, but savings can be achieved through proper planning.

A.3 Acknowledgements

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