Green Facility Recommendations Handbook
This handbook is part of the following report:

**Green Footwear Manufacturing in China for Deckers Outdoor Corporation:**
An Internal Business Plan to Reduce the Environmental Impact of Manufacturing Facilities

This report was prepared by students at the Bren School of Environmental Science and Management in partial satisfaction of the requirements for the degree of Master of Environmental Science and Management.

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Introduction

This handbook is designed to be used by employees and contractors of Deckers Outdoor Corporation to learn more about green buildings. According to the U.S. EPA:

Green building is the practice of creating structures and using processes that are environmentally responsible and resource-efficient throughout a building’s life-cycle from siting to design, construction, operation, maintenance, renovation and deconstruction. This practice expands and complements the classical building design concerns of economy, utility, durability, and comfort. Green building is also known as sustainable or high performance building.

As a step in implementing Deckers Ethical Supply Chain Guidelines related to environmental sustainability, Deckers is starting a program to promote the greening of its own buildings as well as those of its footwear manufacturing partners. Deckers’ Ethical Supply Chain Guidelines related to the environment are as follows:

We require a continuous effort to improve environmental performance along a defined path towards clean production. We expect our business partners to: 1) adopt environmental management systems that address key business impacts and advance sustainable environmental practices; 2) disclose environmental impacts and activities through regular reporting; 3) reduce or eliminate toxic and hazardous substances from operations and products, in accordance with the Deckers Restricted Substances Policy; 4) increase efficiency and thereby minimize pollution and waste; 5) reduce the use of natural resources including raw materials, energy and water; and 6) take responsibility for proper waste management.

By implementing recommendations in this handbook, you can take steps to improve your environmental management systems, keep track of your environmental impacts, reduce your use of toxic and hazardous substances, increase your water- and energy- use efficiency, and reduce and properly dispose of your pollution and waste.
# Acronyms

When reading this handbook and as you learn more about green buildings, you may encounter some of the following acronyms:

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CFL</td>
<td>Compact Fluorescent Light bulb</td>
</tr>
<tr>
<td>EPA</td>
<td>United States Environmental Protection Agency</td>
</tr>
<tr>
<td>GHG</td>
<td>Greenhouse Gas</td>
</tr>
<tr>
<td>HVAC</td>
<td>Heating, Ventilation, and Air Conditioning</td>
</tr>
<tr>
<td>IAQ</td>
<td>Indoor Air Quality</td>
</tr>
<tr>
<td>LED</td>
<td>Light Emitting Diode</td>
</tr>
<tr>
<td>LEED</td>
<td>Leadership in Energy and Environmental Design</td>
</tr>
<tr>
<td>LPF</td>
<td>Liters per Flush</td>
</tr>
<tr>
<td>LPM</td>
<td>Liters per Minute</td>
</tr>
<tr>
<td>ODS</td>
<td>Ozone Depleting Substance</td>
</tr>
<tr>
<td>MERV</td>
<td>Minimum Efficiency Reporting Value</td>
</tr>
<tr>
<td>USGBC</td>
<td>United States Green Building Council</td>
</tr>
<tr>
<td>VOC</td>
<td>Volatile Organic Compound</td>
</tr>
</tbody>
</table>

**Note:** All prices and costs presented in this handbook are in US Dollars.
Energy

Introduction

Energy use is often a major cost for buildings and can result in significant environmental effects depending on the source of energy. This section presents several steps you can take to reduce the energy use of your facility. The easiest step to increasing energy efficiency is to promote conservation behavior and policies among employees. Simple retrofits to lighting systems can also greatly reduce energy use. This can be achieved by switching out lightbulbs for more efficiency models, installing automatic dimmers, motion sensors, and/or timers to promote more efficient use of existing lighting, and installing solar tubes for natural light to reduce the need for artificial lighting. Improvements in equipment energy efficiency can also save energy at your facility.

In addition to improving lighting and equipment efficiency, energy efficiency can be improved through adjustments to heating, cooling, and ventilation systems. These adjustments can include painting the roof white, installing a green or living roof, and/or installing a solar chimney to reduce cooling costs, installing a geothermal heating and cooling system, and taking action to reduce the thermal transfer of the facility. Energy can be saved by using modern water heating technologies such as geothermal, solar thermal, or tankless water heaters and by insulating water heaters and pipes. In addition to improving energy efficiency, the environmental impacts of energy use can be reduced by sourcing renewable energy that is either produced on- or off-site.

These recommendations are described in more detail on the following pages.
Conservation Behavior and Policies

An important and often underrated part of energy conservation is human behavior. Employee education about conservation behavior can reduce energy waste on every level of use. In addition to overall employee training, designating a specific individual or group of individuals to be in charge of making sure that all lights and equipment are turned off at the end of each day can help reduce waste. Throughout the day, this team can monitor light and equipment use to make sure nothing is on that is not being used. Another simple measure is to adjust temperature control on the HVAC system to reduce over heating or over cooling. For example, setting the thermostat a few degrees cooler in the winter and a few degrees warmer in the summer can save a significant amount of electricity. Education can also improve workers’ interaction with their work environment.

Training

A training program for employees and managers to educate about and encourage conservation behavior is an important step in reducing a facility’s environmental footprint. This program should explain why conservation behavior is important, focusing on environmental issues relevant to the area of the facility. Additional details on training programs can be found in the Employee Health and Productivity section.
Lighting Systems

Lightbulbs
The three main types of light bulb are incandescent, compact fluorescent (CFL), and light emitting diode (LED), which range in cost and use lifetime. CFLs and LEDs are more energy efficient than incandescent bulbs, and switching to these bulb types can ultimately save you money.

Below is a table that explains the different cost variables in choosing a light bulb, specifically for a 65-watt equivalent flood lamp bulb in use for 60,000 hours. As the table shows, the initial cost per bulb ranges from $2.91 for an incandescent to $52.00 for an LED, and the lifetime differs from 2,000 to 50,000 hours. Based only on up-front costs, the incandescent would be the first choice. After taking into account the life expectancy of the bulb, the amount of electricity it uses, and an assumed $0.16 per kWh for 60,000 hours of use, the CFL and LED become the clear winners. Lifecycle calculations such as these are important in making purchasing decisions. A slightly higher upfront cost can result in a much greater savings in the long run.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Incandescent</th>
<th>CFL</th>
<th>LED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost</td>
<td>$2.91</td>
<td>$5.97</td>
<td>$52.00</td>
</tr>
<tr>
<td>Power (watts)</td>
<td>65</td>
<td>14</td>
<td>11</td>
</tr>
<tr>
<td>Lifetime (hours)</td>
<td>2,000</td>
<td>8,000</td>
<td>50,000</td>
</tr>
<tr>
<td>Quantity (for 60,000 hours)</td>
<td>30</td>
<td>7.5</td>
<td>1.2</td>
</tr>
<tr>
<td>Total Purchase Cost</td>
<td>$87.43</td>
<td>$44.78</td>
<td>$62.40</td>
</tr>
<tr>
<td>Total Electricity Used (kWh)</td>
<td>3,900</td>
<td>840</td>
<td>660</td>
</tr>
<tr>
<td>Total Use Cost</td>
<td>$624.00</td>
<td>$134.40</td>
<td>$105.60</td>
</tr>
<tr>
<td><strong>Overall Cost for 60,000 hours</strong></td>
<td><strong>$711.43</strong></td>
<td><strong>$179.18</strong></td>
<td><strong>$168.00</strong></td>
</tr>
</tbody>
</table>
Automatic Dimmers, Motion Sensors, and Timers

Once more efficient lighting has been installed, there are various technologies to aid in reducing the number of hours the bulbs are operating unnecessarily.

An **automatic dimmer** is a devise that is best used in conjunction with natural lighting. As the amount of natural light increases, the bulb will automatically dim itself in the same proportion that the natural light is already providing. When the natural light begins to fade, the bulb will increase its output to compensate. Automatic dimmers reduce lightbulb use when adequate light is available from windows and skylights. One report claims a 10 to 30% reduction of energy consumption with daylighting controls such as these.\(^v\)

**Motion sensors, or occupancy sensors**, are another good way to reduce unneeded lighting in a room automatically. A motion sensor is connected to a light such that when someone walks into the room the light comes on automatically. After a specified period of time where the sensor does not sense motion, the light will automatically turn off. This eliminates wasted electricity from someone forgetting to turn off the lights when leaving a room. Occupancy sensors have been estimated to reduce energy use for lighting by 30 to 80%.\(^vi\)

If an area needs to be lit for specific hours during the day or night, a **timer** may be used. Like the functionality of a motion sensor, the timer will automatically turn on and off the lights and eliminate the risk of lights being left on past operating hours.
Solar Tubes
Solar tubes are a cost-effective method for indoor lighting that do not use electricity. Solar tubes are reflective tubes that extend from a hole in the roof down to the ceiling of the room to be lit. Solar tubes can extend many stories if desired. The roof opening is covered with a dome that captures more light than a regular skylight. The light travels down a mirrored tube to a lens in the ceiling that scatters the light more efficiently. Purchase costs are around $200 to $300 per tube depending on length, and solar tubes are easily self-installed.

Additional Lighting Efficiency Measures:
- Use task lighting.
- Utilize natural sunlight with windows and skylights.
- Do not over light an area. When natural light is sufficient, turn off additional lights when dimmers are not available.

Equipment
The electrical equipment used within the building can contribute to a building’s energy load. There are some simple steps to consider when purchasing and operating equipment, such as:
- Always set equipment to energy efficient settings. This applies to office equipment (such as computers, printers, and copy machines) as well as manufacturing equipment (such as cutters, sewers, and electric motors).
- Purchase energy efficient equipment that has been rated by a certification program such as the U.S. EPA’s Energy Star program.
- Turn off all equipment when not in use.
- Remove “vampire” plugs (such as chargers) when not in use. These plugs still consume energy even when not in active use.
- If a process is producing waste heat, attempt to utilize the heat from that system for some other beneficial use.
White Roofs

Painting the roof of your facility white can reduce energy costs by 20%.\textsuperscript{ix} Because of the natural reflectivity of white surfaces, the building roof will stay cooler and therefore reduce cooling costs. One article claims that a one thousand square foot rooftop painted white can have the same one-time impact on global warming as removing 10 tons of carbon dioxide from the atmosphere.
Green Roofs or Living Roofs

A green roof is a roof covered with a vegetated layer. They can range in complexity, soil depth, and plant types. More elaborate roofs with trees and deeper soils may strain the structural soundness of a building. Therefore it is important to plan a green roof and verify the load capacity of the building. A Pennsylvania State University study concluded that a standard dark roof can peak at 30°C (54°F) hotter than a green roof. A cooler roof translates into lower air temperatures inside the building, therefore reducing cooling costs. Green roofs can save electricity, provide rainwater catchment functions, and offer an area for employees to relax or plant a garden. See the Renderings Section for further examples of green roofs.

Layers of a Green Roof

Example of a Green Roof
**Solar Chimney Ventilation**

Natural ventilation should always be utilized by opening windows and skylights where possible. Another option is to construct a Solar Chimney. Also called a thermal chimney, these devices improve ventilation by natural convection of air using passive solar energy. As can be seen in the figure, the chimney is a vertical shaft with openings at the top that draw hot air from the building. This decreases cooling costs because no electricity is used in this process.

![Diagram of a Solar Chimney](image-url)
**Geothermal Heating and Cooling**

Geothermal heating and cooling systems are an energy efficient method to provide two benefits with one system. Pipes are placed deep into the earth's crust where average soil temperatures range from 50 to 70°F. A heat pump is used to circulate a heat transfer liquid through the pipes, and the natural heat from the ground is transferred into the building via the circulating liquid. During summer months, the same system can be run in reverse, and the liquid can extract heat out of the building and transfer it to the ground, thereby cooling the building. Installation of underground loops and a heat pump will cost roughly $2,500 per ton of capacity.\(^{xiv}\)

![Diagram of a Geothermal Heating and Cooling System](image)

**Heat Island Effects**

The grounds surrounding a building can contribute to a heat island effect that increases the temperature of the overall site. The following measures can reduce heat island effects and reduce cooling costs:

- Plant shade trees that cover the building
- Build shade structures
- Utilize open-grid pavement
- Properly clean and maintain structures
Thermal Transfer Reduction

Heating and cooling efficiencies of a facility can be greatly reduced by leaks in walls, doors, and windows. A few simple measures can be taken to reduce these losses.¹⁷

- **Improve building insulation:** If the facility is lacking insulation or has low-quality or degraded insulation in the walls or ceiling, install or replace the insulation. There are many varieties of insulation that are less environmentally harmful than traditional fiberglass insulation. These include recycled blue jeans, recycled paper, and soy-based spray foam insulation.

- **Seal windows and doors to reduce leakage:** Many leaks that occur around windows and doors can easily be fixed with weather stripping. Savings can be up to 10% of heating energy costs.

- **Use double paned windows or storm windows:** During new construction or retrofitting, purchase double paned or storm windows, which will greatly reduce the transfer of heat.

- **Use window shades:** To reduce cooling costs, close indoor window shades or coverings when direct sunlight is coming through the windows. Exterior window shelves and vertical shading can also reduce heat gain due to direct sunlight. See the Renderings Section for examples of exterior window shades.

**Additional Heating and Cooling Efficiency Tips:**

- Purchase more efficient HVAC systems.
- Maintain heating and cooling systems to reduce waste and leakage.
- Use ceiling fans or individual station fans instead of air conditioning.
- Reference energy efficiency programs such as Energy Star.
Water Heating

Geothermal Water Heater
Heat pumps utilizing geothermal energy from the ground (see the Heating, Cooling, and Ventilation section on Geothermal Heating and Cooling for further information) can also be an efficient method to heat water. The energy savings come from the principle that heat pumps do not create heat but rather move heat from one reservoir to another. These systems can be two to three times more efficient than traditional water heaters.\textsuperscript{xviii}

Diagram of a Heat Pump Water Heater\textsuperscript{cix}

Solar Thermal Water Heater
In addition to creating electricity, the sun can also naturally warm water sufficient to provide hot water needs. A solar thermal water heating system consists of a solar collector, typically located on a roof, which contains a liquid to be heated by the sun. This liquid travels into a well-insulated water tank that holds the hot water and dispenses it to the building. It is also common to not use a separate heating fluid, but instead heat the water directly. After installation costs, there is very little or no energy used depending on whether or not the system requires a pump.\textsuperscript{xx}

Diagram of an Active, Closed-Loop Solar Water Heater
Tankless Water Heater

Tankless water heaters (also known as instant water heaters) employ the idea that water should be warmed only when it is needed. Traditional water heaters heat water and then store it in a tank that must also be kept constantly heated. This wastes money in the form of heat loss from the tank. The tankless water heater will super heat water on demand when it is needed. It is important to purchase the right size heater for the intended use because the capacity of the heater is limited by its flow rate. Therefore, as demand for hot water increases, the temperature of the hot water will decrease. Gas powered tankless water heaters are typically more efficient and can produce a higher flow rate than electric systems.
Water Pipe and Heater Insulation

One method to reduce heat lost during water transport and therefore increase the resulting water temperature is to insulate exposed hot water pipes. Water temperatures can be 2 to 4°F warmer than uninsulated pipes. Insulation sleeves are most often made from polyethylene or neoprene. The areas of piping used to directly heat the building should not be insulated, but the pipes leading to or from those areas could benefit from insulation. This insulation can allow a lower heat setting on the water heater, and hot water will come to the faucet more quickly. This can also result in decreased water use. The cost to insulate pipes can be as little as $0.30 per foot.

Water has a very high heat capacity, so keeping the temperature high over a long period of time takes a significant amount of energy. Insulating hot water tanks with an insulation blanket can reduce standby heat losses by 25 to 45%. Additional Water Heating Energy Saving Tips:

- Reduce the temperature of the water heater to 120-130°F or 49-54.5°C.
- Clean and remove sediment at the bottom of water heater tanks to increase efficiency.
Renewable Energy Generation

Electricity shortages and increasing electricity costs are an ongoing concern that can be solved by installing on-site renewable electricity generation systems. If the upfront costs of installing a total wind or solar system are too expensive, a smaller system can offset some electricity usage. In order to determine how much wind and solar power could be retrieved from the facility site, an on-site examination must be performed. If renewable installation is determined to be cost prohibitive, contact your local utility provider and ask to purchase electricity generated by renewable sources. If this is not possible, carbon offsets can be purchased from third party organizations to make up for the greenhouse gas emissions that result from the facility’s energy use.

Wind Turbines

Wind turbines are a very simple technology to create renewable electricity. Once purchased, the “fuel” to run the turbine is wind and is completely free. It is important to consult specialists before installing a wind turbine to make sure the area is suited for a turbine and to specify direction and placement on or near a building. The size of the turbine directly corresponds to its power output rating in watts. The larger the turbine, the more power it can generate with proper wind conditions. Additionally, due to economies of scale, larger turbines cost less per watt than smaller units.
Photovoltaic Solar Panels

The greatest energy source available to humans is the sun, and it is clean and renewable. Solar radiation can be captured for beneficial use in many ways, including generation of renewable electricity. One form is the very portable photovoltaic solar panel, which can easily be installed on a rooftop or parking structure. Photovoltaic panels create electricity when solar radiation interacts with the material, often silica, and strips away electrons, creating electricity. Some systems are still very expensive, but competition is driving down prices each year. National governments are also starting to provide financial incentives to companies to install solar systems.

Biofuels

When using liquid petroleum based fuels for transportation or back-up generators, consider using biofuels instead. These fuels are derived from plant-based material and may have a smaller overall greenhouse gas impact. It is essential that any biofuels (such as ethanol and biodiesel) be sustainably manufactured and that the agricultural practices used when growing the fuel source are not harmful.
Water Consumption and Reuse

Introduction

A facility’s water withdrawal, use, and discharge can play a large role in its overall environmental impact. Withdrawal of groundwater can lead to aquifer overdraft, which can permanently harm long-term water supply and cause ecological harm. Water discharged from facilities can carry toxins and sediments that may harm people as well as plants and animals. Further, water costs money. Even if your facility is currently able to cheaply extract groundwater for everyday use, long-term water shortages are predicted for many parts of the world. In a world of decreasing water supply, regulatory requirements will become stricter and fees will become higher, even for personal wells. Further, the cost of buying water from a municipal water management district will also increase as supply diminishes. Putting measures in place to ensure that water use is minimized in terms of consumption and maximized in terms of efficiency will lead to greatly decreased resource consumption as well as greatly decreased long-term risk.

All calculations in this section use the fluid measurement units of liters and meters. The following formulas can be used to convert units of measure:

\[
\frac{\text{Liters (L)}}{3.785} = \text{Gallons (G)}
\]

\[
\text{Square Meters (m}^2\text{)} \times 10.76 = \text{Square Feet (ft}^2\text{)}
\]
Indoor Plumbing Fixture Efficiency

Many buildings in the United States and abroad are utilizing outdated plumbing fixtures that have very high water consumption rates. The table below shows the water consumption averages for fixtures from different time periods.

As you can see, even relatively modern fixtures may fall well below the efficiency standards set by those specifically manufactured to be high efficiency or ultra-high efficiency. Replacing these fixtures with those of higher efficiency can produce significant water savings, though the exact extent of the savings will depend on the fixture being replaced as well as the frequency of use. For example, consider the following two hypothetical situations:

**Toilet**
Replacing a pre-1980 toilet with an ultra-high efficiency toilet will save approximately 1,700 liters of water per 100 flushes.

**Faucet**
Switching from a pre-1980 faucet to an ultra-high efficiency faucet will save between 946 and 2082 liters of water per 100 minutes, depending on the age and efficiency of the faucet replaced.

### Water Efficiency of Plumbing Fixtures in Different Time Periods

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Toilet</th>
<th>Urinal</th>
<th>Showerheads</th>
<th>Faucets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit of Measure</td>
<td>LPF</td>
<td>LPF</td>
<td>LPM</td>
<td>LPM</td>
</tr>
<tr>
<td>Pre-1980</td>
<td>20.8</td>
<td>NA</td>
<td>15.1</td>
<td>11.4 - 18.9</td>
</tr>
<tr>
<td>1980-1994</td>
<td>13.2</td>
<td>NA</td>
<td>10.4</td>
<td>10.4</td>
</tr>
<tr>
<td>Post 1994</td>
<td>6.1</td>
<td>1</td>
<td>9.5</td>
<td>9.5</td>
</tr>
<tr>
<td>High-Efficiency</td>
<td>4.8</td>
<td>NA</td>
<td>8.5</td>
<td>1.8 - 5.7</td>
</tr>
<tr>
<td>Ultra High-Efficiency</td>
<td>3.8</td>
<td>0.1</td>
<td>4.5</td>
<td>1.9</td>
</tr>
<tr>
<td>Dual Flush (Avg.)</td>
<td>4.5</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>
**Sustainable Landscaping**

Landscaped areas *generally* require a substantial amount of water to maintain, and for many facilities, this can make up a significant proportion of overall water consumption. Altering vegetation types and changing irrigation practices for landscaping can play a significant role in lowering the water consumption of a facility. The specific cost savings associated with this decrease in water consumption will depend upon the vegetation and irrigation types replaced.

Landscaping can also be used to enhance the natural cooling effects of vegetation on buildings. This can be accomplished by planting trees and shrubs with dense foliage downwind of or above air inlets. In summer months, the trees act as natural evaporative coolers, reducing energy costs. Water requirements of vegetation should be considered as some plants can be very water intensive.

**Zero-scaping**

Zero-scaping is the use of native plants or succulents in lieu of water intensive non-native varieties of vegetation in landscaping. Many landscaped areas utilize exotic plants for their aesthetic value rather than considering the amount of water they consume. Using plants native to your region should allow your landscaping to go without watering or with very little watering, as they are adapted to the local climate and should be able to survive on the area's natural rainfall. Zero-scaping can also involve minimal vegetation use and focus on utilizing rocks, gravels, sands, and other natural materials in the landscaping to further lessen water and fertilizer requirements.

**Invasive Species**

In many areas of the world, invasive species are becoming a large problem, as they are often able to out-compete local fauna, leading to uncontrolled spreading. Many of these invasive plants come from landscaping at private homes, commercial lots, and even industrial facilities. Ensuring that your landscaping is free from non-native plant species can help combat the spread of these ecologically-harmful plants.

Utilizing rock for ground-cover in conjunction with succulents minimizes irrigation requirements.
Irrigation

For those areas which are not zero-scaped and require watering, switching from traditional sprinklers or hand-watering to drip irrigation systems can increase water efficiency by 30 to 50%.\textsuperscript{xix} Drip irrigation systems can be as simple as piping which is perforated or has nozzles located at the base of each individual plant. This allows water to be applied directly to the plants roots, greatly decreasing the amount of water which is evaporated before it can be used by the plant or infiltrate into the soil.\textsuperscript{xxi} Drip irrigation systems can even be used for lawns, with the pipes being buried every few feet. The cost for most facilities should be relatively low for the benefit achieved. Oregon State University estimates the costs at $500 to $1,200 per acre, only $100 to $300 more than comparable sprinkler systems.\textsuperscript{xxii}

To Further Your Efficiency:

Use soil moisture sensors in conjunction with soil moisture meters.

These devices measure soil moisture content so that you only water when your plants truly need it. These systems cost from $25 to $80 per monitoring head, depending on the type of system you install. Specific information regarding different types of sensors, their pros/cons, and their costs can be found at: http://attra.ncat.org/attra-pub/soil_moisture.html
**Stormwater Management**

Stormwater discharge can be a problem at many industrial and manufacturing facilities. This is because many of these sites are composed largely of impermeable surfaces, which water cannot penetrate. This prevents water from being absorbed by the soil and draining naturally. As a result, stormwater moves over land and into the municipal sewers, which, in most places in the world, can quickly become overwhelmed during a large rain event. In many cases, large rain events have the potential to cause sewers to spill untreated wastewater into otherwise uncontaminated environments. Limiting your facility’s discharge can help ease this load on municipal systems.

One way to limit your facility’s impact from stormwater discharge is through constructing a bioswale on the premises, as described in the next section. Reducing the amount of impermeable surfaces on your property can also result in decreased stormwater runoff. This can be achieved in various ways, including through the use of porous pavement, infiltration basins/trenches, or sand filters.
**Bioswale Construction and Benefit**

A bioswale is a landscape element designed to filter sediments and pollutants from stormwater runoff before entering a municipal sewer system. They allow this water to infiltrate into the soil and return to the groundwater system. This helps filter contaminants from the water as well as ease stormwater loads on municipal sewer systems. The diagram below shows how a swale is constructed. In general, it is constructed next to an impervious surface where stormwater will run during a rain event. Flow through gravel and vegetation clarifies the water, particularly while it moves through the root-zone of the vegetation. Bioswales are built for a certain capacity, and if this is exceeded, there is an outflow pipe which will discharge excess water into the municipal storm sewer or overflow pond. See the Renderings section for a visual depiction of an overflow pond.
Rainwater Harvesting

Rainwater harvesting is a highly effective and simple means of lowering water withdrawals from private wells or municipal water systems. The simplest means of harvesting rainwater is to install gutter systems on the eaves of facility roofs. This allows you to capture any rain that falls onto the facility roof and divert it through a filtering system into a cistern for storage and later reuse. This water cannot be used for potable uses unless it is tested and treated first. Rather, harvested water is typically used for irrigation and maintenance purposes.

The cost of cisterns varies depending upon materials used, as well as size, and are outlined in the table below. Cisterns are the largest cost associated with rainwater harvesting, though the gutters, piping, and filters all have additional capital costs. However, they are negligible in comparison to the cost of the cistern.

The amount of water which can be harvested depends directly on the amount of roof-space available for collection, as well as the amount of rainfall in your particular location. Once you have determined this, the calculation is fairly straightforward and is outlined in the box to the right.

### Cistern Costs by Size and Material

<table>
<thead>
<tr>
<th>Material</th>
<th>Cost, Small System</th>
<th>Cost, Large System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Galvanized Steel</td>
<td>$225 for 757 liters</td>
<td>$950 for 7,570 liters</td>
</tr>
<tr>
<td>Polyethylene</td>
<td>$160 for 625 liters</td>
<td>$1100 for 6,813 liters</td>
</tr>
<tr>
<td>Fiberglass</td>
<td>$660 for 1,325 liters</td>
<td>$10,000 for 37,850 liters</td>
</tr>
<tr>
<td>Ferro-cement</td>
<td>Price variable upon location</td>
<td>Price variable upon location</td>
</tr>
<tr>
<td>Fiberglass/Steel Composite</td>
<td>$300 for 1,136 liters</td>
<td>$10,000 for 18,925 liters</td>
</tr>
<tr>
<td>Aluminum</td>
<td>Cost prohibitive for water use</td>
<td>Cost prohibitive for water use</td>
</tr>
</tbody>
</table>

If there is 2.54 cm (1 in.) of rainfall over 1 m² of roof space, we can expect a volume of 26.5 liters of water to fall within this area.

Given this, we can calculate the rain volume that falls over the entire roof using the following formula and assuming a 1,000 m³ roof:

\[
1,000 m^3 \times 26.5 \frac{L}{m^3} = 26,500 L
\]

For a 1,000 m³ roof and a rain event totaling 2.54 cm of rainfall, we can expect that 26,500 L of water will fall over the given area. However, water harvesting systems are not perfectly efficient and there will be losses from leaks, overflow, and evaporation. Thus, you should assume a 10 – 25% loss for any system. What is left over for physical use will be referred to as usable yield. So, for 1 m² of roof space you can expect 19.9 to 23.9 liters of usable yield. For a 1,000 m² roof you can expect 19,900 to 23,900 L of usable yield.
**Wastewater Testing**

For manufacturing facilities, any wastewater discharged from the facility can potentially contain substances that are hazardous to both people and ecosystems. Further, depending on local laws, this discharge may be illegal and result in significant financial penalty. For these reasons, we recommend that if your facility is discharging any water used within an industrial or manufacturing context that you regularly test your discharged water using a third-party testing service. This will decrease the risk of discharging potentially harmful substances into the public water system.

**Wastewater Reclamation and Reuse**

Some water used by a facility can be collected, reclaimed, and reused, assuming it is not contaminated with human waste or potentially hazardous chemicals. Wastewater which is not able to be reclaimed, known as “black water,” generally comes from toilets, though most water used in industrial processes also falls under this category. A typical system for wastewater reuse, known as a greywater system, is discussed in the next section.
Greywater Systems

Greywater recycling systems divert water from facility showers, sinks, dishwashers, or laundry facilities for reuse in flushing toilets and landscaping irrigation. Water collected from a greywater recycling system is NOT potable and should not be used for direct human contact or consumption. Greywater systems can vary dramatically in design and cost.

We recommend contacting a consultant or company who specializes in grey-water systems to discuss the feasibility of installing a system. Utilizing a consulting company is important for several reasons. First, the regulatory environment regarding greywater systems is highly heterogeneous and it may in fact be illegal in your area to install one. Further, systems must be specially designed depending on how your facility is constructed, the source of grey-water and its intended use to ensure that human health and safety is protected at all times. However, greywater systems can contribute to substantial water resource savings, a benefit in areas which are experiencing increasing water prices resulting from water shortages.
Materials and Resources

Sustainable Purchasing Policy

Develop and implement a sustainable purchasing policy. The following characteristics should be maximized to the extent possible in purchased products:

- recycled content (post-consumer and post-industrial)
- biodegradability
- use of renewable materials
- use of local materials
- energy efficiency
- water efficiency
- certification by relevant organizations (e.g., Forest Stewardship Council, Energy Star, Green Seal, Carpet and Rug Institute)

The following substances, which purchased products can contain, should be avoided to the maximum extent possible:

- mercury, lead, and other hazardous substances
- volatile organic compounds (VOCs)
- use of ozone depleting substances (ODS) and high-global-warming-potential (GWP) gases

Make sure to consider all of the following types of products when creating a sustainable purchasing and solid waste management policy:

- regularly-purchased consumables
  - paper
  - batteries
  - cleaning supplies
  - trash bags
  - lightbulbs
- durable goods
  - furniture
  - equipment
  - carpet
- materials for renovations
  - paints
  - adhesives
  - sealants
Waste Stream Audit and Solid Waste Management Policy

Conduct an audit of all waste generated at the facility. Consider how waste is currently being managed and develop a solid waste management policy to divert waste from landfills and/or incinerators. This policy should prioritize waste minimization, followed by reuse and composting, followed by recycling. If any waste is already being reused or recycled, determine how much is actually being reused or recycled. Include in the solid waste management policy a plan to improve this percentage.

Any products containing toxic materials, such as mercury-containing CFLs, should be disposed of properly. For more information on proper disposal of CFLs, see the following websites:

http://www.epa.gov/epawaste/hazard/wastetypes/universal/lamps/index.htm

For food waste, implement a composting program. In conjunction with an onsite garden, composting has several economic advantages. It lowers waste removal costs by reducing solid waste. Also, it is a low cost fertilizer, eliminating the cost of purchasing fertilizer. Lastly, it can reduce the need for pesticides and water.
Sustainable Food Policy

Develop and implement a sustainable food policy. Organic, fair trade, and local food sources should be prioritized when making food purchasing decisions. If possible, grow food onsite in an organic garden. This accomplishes several goals. First, it reduces the environmental footprint of the food, as it does not have to be transported. Second, the quality of the food is improved due to freshness and elimination of harmful pesticides. And third, residents of the campus are able to participate by choosing which foods to grow and possibly tending the garden themselves.

- **Local food** is grown in the local area surrounding the location where it is consumed.
- **Organic food** is grown, stored, processed, packaged, and/or shipped using a set of standards, which vary by country and certification body. Typical characteristics of organic food include minimal or no use of synthetic additives (such as fertilizers, pesticides, and antibiotics), genetically modified organisms, irradiation, or sewage sludge.
- **Fair trade food** is produced to certain social and environmental standards, which vary by the certification body.

### International Organizations
- Organic Trade Association
- Organic Crop Improvement Association
  - ECOCERT
- International Federation of Organic Agriculture Movements

### Country-Specific Certifications
- EU-Eco-regulation
- US Department of Agriculture National Organic Program
  - China Green Food Development Center
  - Japanese Agricultural Standard
Sustainable Sites

Site Management Plan

Develop and implement an environmentally-minded management plan for building exteriors (e.g., walls, roof), hardscaping (e.g., sidewalks, paved areas), and landscaping on the site. This plan should focus on minimizing energy, water, and chemical use, as well as the generation of wastewater, air pollution, solid waste, soil erosion, and chemical runoff.

Minimization of environmental effects can be achieved in a variety of ways, including:

- using energy-efficient and water-efficient equipment
- using environmentally-friendly paints, sealants, and cleaning supplies
- using an automated dispenser for concentrated chemicals, which allows proper dilution, cleaner operation and reduced costs
- using non-chemical methods of pest management
- if using chemical methods of pest management, minimizing the use of pest management chemicals, using least-toxic chemical pesticides, and using only in targeted locations for targeted species
- controlling dust and particulates during maintenance activities
- minimizing erosion and restoring eroded areas
- reusing landscape waste
- minimizing or eliminating chemical fertilizer use; landscaping with native or adapted plants and removing invasive species
- protecting or restoring open spaces

This plan should cover equipment, supplies, and maintenance activities, such as the following:

- equipment and supplies
  - pressure washers
  - cleaning supplies
  - paints and sealants
  - pesticides and fertilizers
- maintenance activities
  - cleaning of building exteriors
  - hardscape cleaning
  - construction cleaning
  - painting and sealing
  - pesticide and fertilizer application
**Transportation**

Encourage and incentivize the use of carpooling and alternative transportation (e.g., mass transit, bicycling, walking) for employee commuting and other transportation needs. If vehicles are owned and used by the company, consider purchasing/renting low emission, fuel efficient and/or alternative fuel vehicles.

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**Commissioning**

If the building was not commissioned when built, implement an existing building commissioning (EBCx) process for the building to ensure that all building systems are functioning optimally. According to the Building Commissioning Association, EBCx (also known as retro-commissioning, re-commissioning, and ongoing commissioning) is "a systematic process for investigating, analyzing, and optimizing the performance of building systems by improving their operation and maintenance to ensure their continued performance over time. This process helps make the building systems perform interactively to meet the owner’s current facility requirements". More information on commissioning can be found at the website of the organizations listed in the text box to the left.

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**Environmentally-Friendly Vehicles**

- Hybrid Vehicles
- Flex-Fuel Vehicles
- Alternative Fuel Vehicles
  - Ethanol
  - Biodiesel
  - Natural gas
  - Propane
  - Hydrogen
- Electric Vehicles
- Fuel Cell Vehicles

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**National Environmental Balancing Bureau:**
[http://www.nebb.org](http://www.nebb.org)

**Building Commissioning Association:**
[http://www.bcxa.org](http://www.bcxa.org)

**PECI Commissioning Resource Center:**
[http://www.peci.org/cx_resources.html](http://www.peci.org/cx_resources.html)

**Hong Kong Building Commissioning Center:**
[http://www.hkbcxc.org](http://www.hkbcxc.org)

**Building Services Commissioning Association:**
[http://www.bscja.or.jp/english/english_top.html](http://www.bscja.or.jp/english/english_top.html)
Employee Health and Productivity

Air Quality and Noise

- Minimize fume exposure to employees when using toxic/harmful chemicals, cleaners, degreasers, pesticides, etc.
- Make sure filtration media is installed at all outside air intakes and inside air recirculation returns and that it has a minimum efficiency rating (MERV) of at least 13.
- Prohibit smoking inside buildings and designate smoking areas outside that are at least 25 feet away from building entrances and windows.
- Complete indoor air quality and indoor noise level testing. Contact one of the consultants recommended through the American Industrial Hygiene Association (AIHA) website (http://www.aiha.org) to complete testing.
- Place houseplants throughout work areas.

Plants, Lighting, and Productivity

Studies have shown that worker productivity can be measurably improved by both the presence of plants and natural light. One study has shown that increased natural daylight could increase worker productivity by as much a 13%.\textsuperscript{xl} Indoor plants, a relatively low cost investment, have also been shown to not only increase productivity, but to reduce the occurrence of a variety of complaints including fatigue, headaches, and sore throats by 25%.\textsuperscript{xli}
Daylighting

Maximize natural daylight illumination for occupied areas. For example, LEED recommends maintaining a minimum natural daylight illumination of 25 foot-candles (269 lux) for 50% of all regularly occupied areas. This can be measured with a standard light meter.

For building occupants, maximize direct lines of sight to the outdoor environment. For example, LEED recommends at least 50% of regularly occupied areas have a direct line of sight.

Measuring Daylighting
Daylighting is measured with the use of a light meter – a hand held device that can be used to measure the amount of light in an area normally occupied by workers. There are many types of light meters available, but for measuring daylight in the workplace, a simple model, such as the one shown to the right, will work well.

Training

Develop a training program for employees and managers to educate about and encourage conservation behavior. This program should explain why conservation behavior is important, focusing on environmental issues relevant to the area of the facility.

The program should including the following activities:

- Ensuring the building management systems are used as effectively as possible to obtain the highest possible energy and water efficiency.
- Using only as much heating and cooling as is needed to reduce water and electricity usage.
- Using only as much lighting as is needed.
- Turning off all lighting and electronics when not in use and at the end of each day. Designating one person to ensure that everything is turned off.
- Using only as much water as is needed.
- Recycling.
Resources

The following organizations provide excellent resources for green buildings:

- U.S. Green Building Council (www.usgbc.org)
- Building Research Establishment Environmental Assessment Method (www.breeam.org)
- The Hong Kong Building Environmental Assessment Method Society (www.hkbeam.org.hk)
- Green Star Building Council of Australia (www.gbca.org.au)
- China Business Council for Sustainable Development (english.cbcsd.org.cn/themes/buildingenergy)
- Alliance for Sustainable Built Environments (www.greenerfacilities.org)
- Global FM (www.globalfm.org)
- International Facilities Management Association (www.ifma.org)
- U.S. EPA Green Building website (www.epa.gov/greenbuilding)

The following organizations and programs offer additional energy-related information:

- U.S. EPA Energy Star Program (http://www.energystar.gov/)
- U.S. EPA eeBuildings Program (www.epa.gov/eeBuildings)
- Alliance to Save Energy (ase.org)

The following companies specialize in water efficiency and reuse:

- Brac Systems BC
- Free Water UK Ltd.
- Nubian Water Systems
- Aqua Pro Solutions
- Espiritus Water Systems Ltd.
The following diagrams demonstrate the characteristics of an ideal green footwear manufacturing campus. The renderings highlight the manufacturing facility, which utilizes the following green building technologies:

- Vertical shading
- Light shelves
- Green roof
- Solar panels
- Local materials
- Natural light and ventilation

Two versions of the building are shown, each using a different type of natural light and ventilation technology. One building uses large atria while the other uses multiple solar chimneys.

In addition to the manufacturing facility, the renderings highlight several green aspects of the campus, including the following:

- Constructed wetlands
- Bioswale

The first diagram explains these technologies in further detail.
Diagram of a Green Footwear Manufacturing Facility

**Light Shelves**
Natural light can be bounced further into a deep building by using light shelves. When designed correctly, they can also help to block undesirable south sun during warm seasons.

**Atriums**
By providing atrium spaces towards the center of the building, there is more opportunity for natural daylight and ventilation to reach the interiors of large buildings such as this one.

**Green Roof**
A green roof can assist with rain water absorption and heat gain/loss, as well as provide an outdoor space for the building users to enjoy. The planters also provide an opportunity for onsite food production.

**Vertical Shading**
Blocking East & West sun helps to reduce heat gain and glare. It may be achieved in part by providing vertical shading such as these bamboo slats.

**Swale**
By directing water runoff on the site, the swale allows for filtering and collection of rainwater.

**Constructed Wetlands**
Exposing water to a natural setting allows for a more natural filtering process to occur.

**Photovoltaic Panels**
By absorbing sunlight, the PV panels can assist in providing energy needs for the building.

**Local Materials**
Using materials that are produced and manufactured locally helps to reduce the carbon footprint of the building.
Front View of the Facility, Highlighting the Vertical Shading and Light Shelves
Green Facility Recommendations Handbook

Front Views of the Facility
Front Views of the Facility
Close-Up Front View of the Facility, Highlighting the Constructed Wetlands
Overhead View of the Facility, Highlighting the Green Roof, Atria, and Solar Panels
View of the Green Roof Being Used by Employees
Overhead View of the Facility with Solar Chimneys
View of the Campus Grounds, Looking Toward the Bioswale
View of the Campus Grounds, Bioswale Overflow Collection Area
Real World Examples

The following section highlights several companies that have implemented green building retrofits and policies, as well as built new facilities in the last few years. These examples highlight the environmental improvements that can be seen and the potential cost savings that can be realized by greening a manufacturing facility. In addition to these green facilities, the following companies have also retrofitted existing buildings to be greener or recently opened green stores, facilities, and offices:

- REI
- Office Depot
- Target
- Best Buy
- JC Penny
- Walmart
- Staples
- Macy’s
- Kohls
- Safeway
- Kettle Foods
- Contessa

MAS Holdings

In 2008, MAS Holdings—India’s biggest apparel company—opened a green clothing manufacturing facility in Sri Lanka. This facility was constructed to manufacture lingerie exclusively for Marks and Spencer and was initiated as part of "Marks and Spencer’s five year plan to make their operations more environmentally friendly.” The facility cost 25% more to build than a traditional factory of similar size, but MAS expects this initial investment to pay off within five years. The facility uses 40% less electricity than a similarly-sized plant, and the remaining electricity needs are sourced from an on-site solar power systems and an off-site hydropower plant. Electricity needs are reduced through the use of green roofs and highly reflective roofing materials, which allows to facility to forgo air condition. The facility also utilizes natural light and focused task lighting using LED lightbulbs. xlii, xliii
Bentley Prince Street Facility

In November of 2007, Bentley Prince Street’s California carpet mill became the first carpet manufacturing facility in the U.S. to receive a LEED certified silver rating. Company President Anthony Minite said, “Not only is it in line with our mission to eliminate any negative impact our company may have on the environment by 2020, it’s also a way we can influence others to take action. We believe we have a responsibility to demonstrate that the perceptions of what types of facilities can – and should – be LEED certified need to be expanded to the manufacturing sector. We hope our LEED-EB certification will encourage other manufacturers to follow our lead and attempt to do the same”.

Some of the 280,000 square foot facility’s features include: the construction of a solar power array to help power the manufacturing process, a sustainable purchasing policy, 95% of waste is diverted from landfills, and reduced water usage through improved practices. The result has been a 50% reduction in energy use and a 57% reduction in water use.

Dansko Headquarters

Recently, Dansko showed its commitment to being environmentally responsible through the construction of their 80,000 square foot corporate headquarters. LEED certified gold, the office building/retail space complex has many sustainable features. These include rain irrigated gardens, permeable paving, green roofs, rainwater harvesting, recycled construction materials, Forest Stewardship Council certified wood products, displacement heating and cooling, automated lighting controls, and a Living Wall for bio-filtration of indoor air. Additionally, Dansko purchases 100% of the building’s electricity from wind power sources. “The result is a site and building design that reduces environmental impacts, uses less energy, enhances marketability, and increases user sense of well-being.”

ISA Tan Tec

ISA Tan Tec is a leather tanning company primarily operating in China and Vietnam that has taken many actions to mitigate its environmental impact with regard to building operations. ISA has achieved a 30% reduction in electricity usage, a 35% reduction in carbon dioxide emissions, and a 50% reduction in water consumption at their Guangzhou, China, location. These reductions were gained primarily through energy efficiency, alternative energy sources, water recycling, heat recycling, and internal process improvements. Solar water heaters are used to generate 30,000 liters of hot water per day, thereby reducing energy needs. The buildings also use energy-efficient lighting. The leather drying is accomplished using low-temperature drying equipment that then recycles the warmed water. Finishing processes have been altered to use fewer chemicals and
reduce the need for energy in drying. A bioswale has also been constructed to help filter wastewater. It appears that most of these improvements have been realized by strong support of executive management, daily data recording and analysis, employee training, and extensive process review for ongoing improvements.xlix

These efficiency measures are providing lessons for the new plant that will be constructed in Ho Chi Minh City, Vietnam. The facility is expected to be completed in the third quarter of 2009 and is named “Project 2030.” Because leather tanning is very water intensive, ISA has focused on a green water treatment process that utilizes plants for water purification and uses no electricity or chemicals. The purified water will be delivered to the live bamboo fencing surrounding the property. ISA expects to avoid over 2,000 tons of carbon dioxide emissions from this water treatment system. Other process improvements aim to reduce the amount of fresh water needed by using a closed-cycle-reuse process that will save 60,000 liters of fresh water per day.¹
Green Facility Recommendations Handbook

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Available online at http://www.concretedecor.net/All_Access/506/CD506-New_Technology.cfm.

Available online at http://www.washco-md.net/public_works/engineering/swmstruct.htm.

Available online at http://www.washco-md.net/public_works/engineering/swmstruct.htm.


