GLOBAL NETWORK FOR ZERO

Energy Efficiency Strategies for Existing Buildings

This resource document features a collection of energy efficiency, sustainability and green building strategies, practices and case study examples that buildings can leverage in achieving net zero. These strategies, practices and case studies were extracted from some of the leading resources available and industry-respected organizations; it focuses on sector-specific recommendations that existing buildings can implement in striving for net zero. The aim is to provide practical measures and guidelines for achieving efficiency in different aspects of building design and operation.

Covering a wide range of topics, this document addresses key areas such as building envelope, HVAC systems, lighting, water efficiency, landscape design, pumps and motors, plug loads, waste management and renewable energy supplementation, as well as the holistic approach to optimizing an entire building's energy performance.

Recognizing the ever-evolving nature of technology in the field of energy efficiency, this document will be regularly updated so it remains current and up to date. It will incorporate the latest technological advancements and emerging best practices, ensuring that it remains a valuable resource for those seeking to enhance energy efficiency in buildings and spaces.

Whether you are an architect, engineer, facility manager, sustainability consultant, or simply interested in reducing energy consumption and environmental impact, this resource offers practical insights and guidance to help improve the efficiency of buildings.

Improving building efficiency has numerous benefits including:

- **Cost savings:** Energy-efficient buildings use less energy, which can result in significant cost savings over time. By optimizing energy usage, building owners and occupants can save on their utility bills and operational expenses.
- **Environmental impact:** Buildings are responsible for a significant portion of global greenhouse gas emissions – nearly 40% of all emissions. Improving the efficiency of our existing buildings is one of our greatest opportunities in decarbonization; by reducing energy consumption, buildings can help reduce their carbon footprint and mitigate climate change.
- **Health and comfort:** Energy-efficient buildings can provide a more comfortable and healthier indoor environment for building occupants. Proper ventilation and air filtration systems can improve indoor air quality, while insulation and weatherization can help maintain consistent temperatures and reduce drafts.
- **Regulatory compliance:** Many countries and regions have implemented building energy codes and regulations that require compliance with energy efficiency standards. By following these practices, building owners and operators can avoid penalties and ensure compliance with local laws.

Overall, energy-efficient practices in building operations are essential for reducing costs, improving occupant comfort and health, and mitigating the environmental impact of buildings.

In implementing energy efficiency strategies and putting in place an effective plan to achieve this, a multidisciplinary team should create an exhaustive plan for the entire process as the different dimensions of building efficiency will have different approaches and phases for execution.

One important dimension is a Carbon Management Plan (CMP). The project team and/or the consultant can devise the Carbon Management Plan (CMP) for their project with the aid of these approaches but not limited to, as listed in the Best Practices for Existing Buildings.

A well-programmed CMP will help reduce Scope 1, Scope 2 and Scope 3 emissions based on the resource consumption and waste generation of the building.

As suggested by ENERGY STAR, a program run by the U.S. Environmental Protection Agency and the U.S. Department of Energy that promotes energy efficiency, when we integrate energy efficiency in a facility's operation and maintenance we can reduce energy use without significant capital investment. At a broad level, efficient operation and maintenance strategies can:

- Reduce operating costs
- Reduce the risk of early equipment failure and unscheduled downtime
- Increase a facility's Net Operating Income (NOI)
- Maintain comfort, leading to fewer "hot and cold" complaints

To keep expensive building equipment operating efficiently, make sure to tune it up, turn it off and check it out. That is, building equipment and systems should be appropriately calibrated and tuned to run as efficiently as possible, scheduled to run only as needed, and periodically checked to prevent performance drift.

GNFZ's net zero certification for existing buildings is designed to scale progress with existing buildings by providing an incremental approach to certification. This is done by the projects assessing their inventory emissions sources, setting their own targets, developing a plan and implementing net zero strategies – with the support of a partner who guides them through the end-to-end process of achieving certification. With the help of independent third-party reviewers, GNFZ verifies the projects achievements and recognizes them as "GNFZ certified" when they have achieved zero carbon emissions; projects are also recognized throughout the process with various certificates (assessment certificate, net zero plan certificate, carbon offset certificate, net zero milestone certificate and, then, net zero certificate and final GNFZ certification.)

ENERGY STAR states that assessing a building's current operation and maintenance practices, implementing the identified tune-ups, and documenting the actions, then tracking savings to finance future energy-efficiency work, a way forward:

- **Assess**: A rigorous tune-up requires performing a thorough assessment of the current operation and maintenance practices. It systematically looks at all aspects of the current program and may include spot-testing equipment and controls, checking pressures, temperatures, power, flows, and lighting use over time and reviewing schedules and control strategies to determine whether the building is being operated optimally. For the assessment to be successful, staff need to view the process as a means of enhancing and supporting their work and not as a fault-finding activity.
- **Implement**: Savings can only accrue if recommendations from the assessment are implemented. Once the improvements are selected and prioritized, many of them may be implemented very quickly and inexpensively. For example, control strategy or schedule improvements, where the greatest savings often occur, may only take a few hours to implement.
- **Document**: Documenting the sequence of operation and energy-efficient control strategies for the energy-using systems is essential to understanding building control. The control documentation is critical for maintaining energy-efficient operations and effectively troubleshooting operational problems. Once accurate

building documentation is obtained, keep it updated to maintain continuity. For example, sensor set-point changes, sensor location changes, and control strategy changes should be documented whenever they occur. If the changes remain in the heads of only one or two staff members, when they leave the organization, the information is lost. Relying on memory can lead to mistakes that cost time and energy.

- **Track savings**: The tune-up activities may be the first step in developing a sustainable finance mechanism for the organization. Once an organization funds the initial operations and maintenance assessment and tune-up improvements, future energy efficiency work can be funded from the savings generated by low-cost improvements. This kind of sustainable finance mechanism requires monitoring and tracking savings so that they can be dedicated to future improvements.

Typically, the primary goal of the preventive maintenance plan is reliability and increased equipment life. Buildings often have extensive preventive maintenance plans, which are rigorously carried out by the operations and maintenance staff. However, even if a piece of equipment or a system is meticulously maintained, if it is poorly operated using inadequate control strategies or improper scheduling, vast amounts of energy waste can occur. Also, poor equipment operation can lead to premature equipment failure (e.g., short cycling) and an increase in maintenance requirements. Rather than focusing on component-by-component care, operations and maintenance plans should be balanced to consider addressing the operations part of the plan as equal in importance to maintenance.

Redefining preventive maintenance to include activities critical to energy-efficient building operation:

- **Performing periodic reviews**: As part of preventive maintenance planning, perform periodic reviews of HVAC and lighting schedules, temperature setpoints and occupant/tenant use requirements to ensure that equipment runs only when needed. Develop procedures to periodically review and monitor EMS time-of-day schedules, optimum start/stop strategies, temperature setups and setbacks, lockouts, freeze protection and other strategies and parameters that stage or turn equipment on and off. Also review and monitor any other on/off controls such as programmable and mechanical time clock settings, integral equipment controls, lighting photocells, sweeps and occupancy sensors for proper operation.
- **Scheduling after-hours walk-throughs**: A quick walk through of the building after hours can be quite revealing. For buildings where equipment should be OFF after hours, managers can detect stray equipment operation by simply entering the building during unoccupied hours and listening for unexpected noise. Building staff should perform an after-hours walk-through once every six months to observe the behaviour of heating and cooling equipment, lighting and office equipment such as copiers, printers and computers. Alternatively, staff can use portable dataloggers at the electric panels to track whether the equipment is ON when it should not be.
- **Seasonally adjusting the control strategies**: Just as certain maintenance tasks are performed to prepare equipment for the heating or cooling season, control strategies should also be reviewed and adjusted. A good control strategy for the cooling season is not necessarily optimal for the “swing” season or heating season.
- **Tracking performance over time:** Develop operations and maintenance procedures and forms for tracking actual equipment performance against expected performance. Forms may include the task description, checking method and frequency for each piece of equipment, reporting formats, procedures for addressing non-conformance issues and how to resolve performance deficiencies. In many cases, the data-gathering procedures on equipment performance dovetail nicely with other preventive maintenance work adding very little staff time for accomplishing the task.

The above regular checks help to keep track of all systems and equipment and keep them updated. The operational efficiency is easily achievable with the improved performance. The designated primary responsibility of these practices is with the operations and maintenance team in the project.

Ensuring operations and maintenance staff perform these tasks on a regular, proactive basis can save staff time in the long run, because preventive maintenance helps to reduce equipment malfunction and occupant complaints. Staff who spend more time on preventive operations generally spend less time "fighting fires" and troubleshooting operational problems.

The strategies in this document cover the following core concepts:

1. Building Envelope
2. HVAC Systems
3. Lighting
4. Water Efficiency
5. Landscape
6. Pumps and Motors
7. Plug Loads
8. Waste Management
9. Renewable Energy Supplementation
10. Whole Building

Building Envelope

The envelope of a building is the predominant part that acts as a barrier between the controlled environment of the indoor and the existing conditions of the outdoor. When it comes to heating and cooling a building, a poorly designed building envelope can result in a massive increase in energy costs. A more energy-efficient envelope that has a streamlined design allows for a greater level of control over indoor air quality, temperature and humidity along with energy efficiency. Below are some strategies that can help improve the efficiency of building envelopes.

WALL INSULATION

A significant portion of the expenditures associated with conditioning a building are related to the thermal energy that is gained or lost via walls through conduction. Walls can account for about 20% of heat loss in a building. An existing wall can have its heat transfer reduced by adding adequate insulation. If the wall sections (thickness of the wall, materials used, etc.) for the building had been well designed when the building was first constructed then the need for retrofitting insulation is often overlooked. Another important aspect is window-to-wall ratio (WWR), which is the specific value of the area of the window and that of the room façade. The most energy-efficient window-to-external wall ratios for the south, east and west orientations are 20%, but for the north, orientation is 20% to 40%. Based on all of the above aspects, a building could be retrofitted with a second skin (façade) or curtain wall.

The first phase of building is the ideal time to apply insulation. However, depending on the wall section and the WWR in the building the type, the layers of insulation will vary. There are also various other alternatives available to improve insulation for existing buildings.

ROOF INSULATION

In cold areas, a roof is a substantial source of heat loss, and in warm climates, a source of heat gain. It is quite easy to add insulation to roofing systems that have insulation completely above the deck surface, which is a typical roof arrangement in existing buildings, to lessen heat transfer into or out of the building. Some of the commonly used materials that may be retrofitted under the deck for insulation include fiberglass, mineral wool, cellulose and natural fibres.

EXTERIOR WINDOW FILM INSULATION

The inside surface of the existing glass can be covered with solar control window film to minimize solar heat gain by between 35% and 65%. As a result, the HVAC system's energy consumption can be greatly reduced. These films may be more economical than replacing the windows even though their effectiveness is inferior to that of higher-performance glazing.

WINDOW ASSEMBLY REPLACEMENT

Windows contribute significantly to a structure's thermal intake and loss. Building energy consumption can be decreased by replacing outdated, ineffective window assemblies with more modern ones that provide higher thermal performance. Additionally, it can enhance occupant comfort by lowering solar radiation heat gain and view quality.

The number of surfaces (panes), insulating qualities of the frames, low-emissivity coatings, insulating fill gases, visible light transmittance, infrared transmission, interactions with daylighting systems, colour and reflective appearance are all things to consider when assessing existing window assemblies and choosing replacements.

ENVELOPE LEAKAGE

Where the building envelope's components are joined together is where air leakage through the envelope most frequently happens. Leakage frequently occurs because of poor design or construction, carelessness about maintenance, or regular wear and tear over the course of a building's lifespan. When the HVAC system is turned off and if the building is not mechanically pressured, the envelope leakage is most noticeable. When the HVAC systems are turned on during the day, due to significant night-time air loss, they must work harder to restore the building's temperature. By locating and closing air leaks in the building envelope, energy savings can be realized. Depending on the components being sealed, various sealing techniques can be used.

EXTERIOR WINDOW SHADING AND LIGHT SHELVES

Exterior windows are often installed almost flush with the exterior wall surface, with no adjacent surfaces on the exterior or interior surfaces to minimize solar heat gain and increase the depth of daylight penetration.

External shade fixtures placed close to windows that get direct sunshine in warm areas can lessen the amount of solar heat gain and, as a result, lower the cooling load on the cooling plant. For south-facing windows, projecting horizontal shelves above the windows' level, fixed louvers on the east, south and west windows, and exterior blinds are some specific shading techniques.

To increase the depth of daylight penetration, light shelves are horizontal surfaces erected on the interior face of windows. The shelves are typically built on tall windows, reaching a few feet into the interior area and a few feet down from the top of the window. In a typical installation, using light shelves can extend the depth of daylight penetration by 10 to 20 feet, improving the daylighting system's energy efficiency.

VESTIBULE

Vestibules aid in reducing the heating and cooling load brought on by the opening and closing of exterior doors. When placed in heavy traffic places, like the main building entrance, they are particularly effective.

COOL ROOF

A substance that reflects sunlight and releases thermal energy is used to build cool roofs. As a result, less heat is transported into the building because the roof is "cooler" than typical roofs. Reduced heat transfer will also result in less need for mechanical cooling in the structure. On a hot summer afternoon, conventional roofs can achieve temperatures of 150°F or higher. A reflective roof could remain more than 50°F (28 °C) cooler under the same circumstances.

HVAC Systems

The use of multiple technologies to regulate the temperature, humidity and quality of the air in an enclosed space is known as an HVAC system. Its objective is to offer suitable indoor air quality and thermal comfort. As the building sector consumes the greatest portion of global energy, HVAC plays a vital role in enhancing the energy efficiency of buildings. HVAC equipment manufacturers have been working to improve the effectiveness of the systems they create for the past four decades. This was initially sparked by rising energy prices, and more recently, it has been sparked by growing environmental consciousness. Additionally, building users' productivity and wellness can be elevated by making improvements in HVAC systems.

The following are several methods for making HVAC systems more efficient:

NATURAL GAS AS FUEL

Natural gas emits 50 to 60% less carbon dioxide (CO2) into the atmosphere compared to other fossil fuels when combusted. HVAC systems use gas or electricity to heat or cool a building. In a gas HVAC, the air conditioner uses electricity to keep the building cool, while the heating unit uses gas to warm the space. The heating unit can comprise a furnace or a boiler that burns gas to generate heat. A gas HVAC system is more economical than an electric one because natural gas is less expensive than electricity and heats spaces quicker than electricity units, making them more cost-efficient to run.

UPGRADING SYSTEMS

Updating heating and cooling systems including boilers, compressors, air handling units, variable frequency drives, heat exchangers and improved filtration on cooling towers aids in making sure unwarranted use of energy is curtailed.

RETROFITTING COOLING TOWERS

Cooling towers are heat exchangers that use water and air to transfer heat from air-conditioning systems to the outdoor environment. There are several advantages of using cooling towers:

- Continuous cooling of circulating water makes the plant run smoothly.
- In these systems, the chance of corrosion is high due to the chemicals used in water treatment and the high concentration of electrolytes in the water due to evaporation. However, this cause is being reduced with the use of corrosion-resistant parts which can also withstand heavy loads and further bringing down the maintenance requirement.

- The life of the system/equipment is increased as the cooling tower runs continuously even in challenging weather conditions.
- With low-speed motors in cooling towers, maximum air is utilized for evaporation. Water is recirculated continuously to ensure that the system is clean and works at full capacity and less energy is used to achieve better output.
- Using an effective drift eliminator system and air intake louvers, cooling towers can save huge amounts of water in the process.

SCHEDULED INSPECTIONS

Regular inspections and maintenance are required to keep cooling towers and chillers operating at peak efficiency. Fouling can lead to decreased heat transfer efficiency and higher energy consumption in the evaporator and condenser tube bundles of chillers. The facility management team must maintain an Operations and Maintenance manual that specifies the inspection, maintenance and upkeep schedules of the equipment.

PERIODIC TESTING FOR AIR QUALITY

Poor ventilation frequently leads to air quality problems, which impacts the health and productivity of building occupants. It also forces heating and cooling systems in the building to work harder. Utility bills will increase because the system is under higher stress and using more energy. Removing barriers to outside air can help lower interior pollution levels. The quality of indoor air must be maintained according to ASHRAE 62.1 standards.

CO2-BASED DEMAND VENTILATION

The control of outdoor air intake rates in mechanically ventilated buildings is based on indoor carbon dioxide (CO_2) levels. This helps in reducing the energy consumption associated with building ventilation especially when the occupancy loads inside the building keep varying.

HVAC EQUIPMENT RUNTIME

By turning the system off when not in use to reduce run time, an HVAC system can realize significant energy savings. While minimizing superfluous runtime is one of the most frequent opportunities for energy reduction, equipment scheduling is very easy to put into practice. By taking this action, the HVAC system's scheduled operating hours — which include those for fans, pumps, chillers and boilers — are lowered to better fit the building's occupancy.

A lot of HVAC fan systems run their fans with the outside air damper open, including during the warm-up and cool-down periods in the mornings before the occupied period. By shutting the outside air damper during non-economizer operations in unoccupied hours, energy consumption can be decreased. When ventilation is not necessary, this feature eliminates the energy used to cool and heat outside air.

NIGHT PURGE CYCLE

The building is pre-cooled for the following day utilizing a night purge cycle, which uses only 100% outside air and no mechanical cooling. When the conditions are favourable, the night purge cycle runs for a few hours before the occupied time and compares the average indoor temperature to the outside air temperature.

Night purge cycles can minimize the peak demand of the building in addition to saving mechanical cooling energy, which may be advantageous in regions with expensive electric peak demand costs.

COOLING PLANT AND COOLING LOAD

Facilities frequently run their cooling systems nonstop. The chiller, cooling tower and associated pumps are included. The plant can be manually started and stopped by operators. However, there may be times when the plant is not required to run, particularly when airside economizer cooling is used at the air handlers, such as during the morning when it may be cold enough outside air temperatures to adequately cool the building.

Running the cooling plant when it isn't necessary wastes energy in a variety of ways, including at the pumps, the primary cooling equipment (chiller compressors) because the chillers aren't loaded, and the heat rejection equipment (e.g., cooling tower fans and condenser fans) because waste heat from the distribution system is rejected (e.g., through the walls of the piping). Installing a tiny cooling system to serve a location that needs constant cooling – even after hours – and turning off the larger plant might be more efficient.

LOW IMPACT REFRIGERANTS

Refrigerants used in HVAC systems have the potential to harm the atmosphere and increase global warming. Replace the refrigerants used in the building's HVAC system with low-impact refrigerants. These refrigerants have the advantage of:

- The Recycling or disposal of low impact refrigerants such as HFC & HCFC is comparatively easier than disposing CFCs which has a heavy impact on atmosphere.
- These gases are typically more energy efficient than F-gases.
- These gases can be used in almost all RAC (Refrigeration and Air Conditioning) applications.
- These refrigerants are not patented by the chemical industry and are cheaper than HFCs.
- These gases do not harm the environment and can be handled safely and with care.
- These gases can also be obtained as by-products from other processes.
- It is easier to make them readily available if proper distribution structures can be established.

TEMPERATURE SET POINTS

There are several ways to keep track of indoor climatic conditions, and monitoring the internal temperature set points with the help of basic data loggers will ensure thermal comfort for occupants. This also prevents the air conditioners/heat pumps from running overtime and saves energy.

Lighting

According to the [2009 Buildings Energy Data Book] published by DOE, the average large office building (>25,000 square feet) has a lighting power density (LPD) of 1.3-1.8 watts/sq. ft. (based on 2006 data), while the average small office building has a lighting power density of 1.7-2.2W/sq. ft.

If these buildings were relighted to simply comply with the ASHRAE 90.1-2004 energy standard, which imposes a maximum allowable LPD of 1W/sq. ft. using the Building Area Method as part of AHSRAE 90.1, lighting power savings of 23 to 55% could be achieved.

Of course, this is just if we were to reduce LPD to code, which is supposed to be considered a minimum; even deeper savings are possible using paths outlined in tools such as the ASHRAE Advanced Energy Design Guides and the DOE Commercial Lighting Solutions program. The savings also does not count significant additional energy savings that can be gained using automatic lighting controls such as occupancy sensors. As the average large office building operates 16 hours/day (4,190 hours divided by 52 weeks divided by an assumed 5 days/week), such savings could be substantial.

Lighting accounts for a minimum of 20% of the energy consumed in buildings, based on the building typology and application. The activities within the building will determine the amount of floor space that must be lit and the duration of illumination, which in turn constitutes the energy consumption based on the lighting system deployed.

The most common types of lighting used in commercial buildings are:

- Incandescent
- Standard fluorescent
- Compact fluorescent (CFL)
- Halogen

- High-intensity discharge (HID)
- Light-emitting diode (LED)

In today's industry, LEDs are regarded as the most energy-efficient and long-lasting type of directional lighting. Compared to incandescent and CFL lighting, LEDs use 90% less energy and offer the same brightness. Additionally, they last 15 times longer, requiring less upkeep.

Due to the high initial cost of switching to LEDs, many building owners and facility managers put off retrofitting. However, when compared to other building energy management strategies, like upgrading HVAC systems or installing insulation, switching from energy-intensive lighting to LEDs is a simple and cost-effective improvement opportunity. While most buildings can benefit from LEDs, those with long operating hours or in areas with high electricity costs see the greatest return on investment (ROI). The following are some energy conservation measures to be considered in this context.

CALIBRATE EXTERIOR LIGHTING

Normally, exterior illumination is only required at night. Lights that are operated manually, however, have a chance of being inadvertently left on, while lights that run on a timer do not take into consideration the fact that sunrise and sunset periods vary. Photocell lighting control adjusts the lighting operation schedule to the region's particular requirements by only turning on the lights at night when they are most necessary.

Out-of-calibration photocells may result in energy waste or dangerous situations. Energy is wasted if the lights are left on when they are unnecessary. There may be harmful situations because of inadequate lighting if the lights are not on enough at night. The photocells need to be regularly cleaned and adjusted to ensure optimal operation.

INTERIOR FIXTURES TO REDUCE LIGHTING POWER DENSITY

Most of the energy used in a typical building is used for interior lighting. Significant savings in whole-building energy can be achieved by using more energy-efficient lighting technology to cut back on the energy used for lighting.

Over the past few decades, available illumination efficiency has continuously grown. To keep up with these higher efficiencies, minimum efficiencies outlined in building energy codes and federal laws are routinely raised and so the interior lighting must be retrofitted to adhere to such standards.

OCCUPANCY SENSORS TO CONTROL INTERIOR LIGHTING

Fixed lighting operating schedules use more energy than necessary in zones with intermittent occupancy because the lighting is often needed only when people are present. Installing occupancy sensors in the appropriate zones will cause the lighting to operate automatically based on occupancy. When compared to fixed operation schedules, this helps reduce the amount of time that lights are on and saves energy.

DAYLIGHT HARVESTING

Most of the energy used in a typical building is used for interior lighting. Daylighting is increasingly being used as a solution to reduce energy consumption in this end-use. To keep a constant light level in interiors, this solution entails installing photocells to sense the lighting level in the space and adjust the lighting in the surrounding areas. This measure also includes replacing the lighting with dimmable ballasts, since dimmable ballasts are necessary to realize energy savings.

RETROFIT EXTERIOR FIXTURES

Retrofitting exterior lighting fixtures to reduce lighting power density entails changing the parking lot lighting fixtures in a facility with more energy-efficient ones that will produce the same illumination with less power draw and turning down the lighting during off-peak hours.

High-intensity discharge (HID) lighting is typically used to illuminate parking spaces. Energy savings can be achieved by swapping out these lighting for more modern, energy-efficient options like LED fixtures.

Exterior lighting for buildings often comprises lights for parking lots, walkways and building facades. Based on photosensor or astronomical timeclock control, this illumination is normally switched on at sunset and turned off in the morning. Energy savings can be achieved by turning down the outdoor lighting when no one is around with the help of automatic sensors and controllers.

UTILITY REBATES AND INCENTIVES

Utilities and other energy efficiency program sponsors offer incentives (e.g., mail-in rebates, buy-downs and instant rebates) throughout the United States to promote ENERGY STAR-certified bulbs and fixtures, decorative light strings and ceiling and ventilating fans with light kits.

Similarly for the other countries, the potential client can look for suitable incentive programs offered in the respective country to take advantage of the financial assistance/ incentives offered to adopt the sustainable strategy in their set-up. This process could start with a lighting-specific audit for the building and subsequently plan these initiatives which can be the part of incentives in the respective country.

Water Efficiency

Buildings are regarded as one of the major consumers of freshwater worldwide. Massive water use during construction and operation depletes water supplies and ultimately has a negative influence on the environment. This is mostly because the water cycle in built environments, which comprises the treatment and distribution of raw water, its usage inside buildings and the treatment of wastewater, requires a lot of energy. Additionally, due to various water usage cycles, the effects of water use vary greatly among nations and locations. For instance, whereas some nations rely on sophisticated desalination, many others employ conventional water treatment methods, hence it is necessary to understand water consumption and its associated emissions. Here are a few technical suggestions to be considered in a building project.

To enlarge the water efficiency in the country, U.S. Environmental Protection Agency (EPA) has launched a program in 2006 offering the solutions. It is a voluntary program sponsored by the EPA as a by-product of the Energy Policy and Conservation Act.

WaterSense, a voluntary partnership program sponsored by EPA is both a label for water-efficient products and a resource for helping you save water.

EQUIPMENT UPGRADES

Where large amounts of water are used by equipment that has reached the end of its useful life, replacement is perhaps the easiest next step. An old equipment which has more complex run & consumes more water/ energy to conduct the process, this can be replaced by the latest innovative & more efficient system. It can be the dishwasher, laundry system or any old fixtures which are inefficient.

Water-cooled ice makers, for example, generally use about 100 gallons of water to cool the condenser per every 100 pounds of ice produced, along with 80 to 90 gallons of water to produce the ice. With Energy Star air-cooled machines, that extra 100 gallons per batch of ice is not going down the drain.

Similarly, replacing old commercial dishwashers and laundry equipment with Water Sense products are areas where hospitals, hotels/motels, and restaurants may conserve water effectively. The U.S. Environmental Protection Agency's Water Sense program claims that upgrading one older commercial dishwasher with an Energy Star model can save more than $200 on water bills by using 52,000 gallons less water per year, as well as save $900 in energy costs.

For new construction and major renovations, James E. Dipping, vice president at plumbing studio leader at Environmental Systems Design, recommends looking at hot water recirculating systems: "Currently, if the hot water source is farther than 100 feet from the fixture it needs a recirculating system." If the plumbing designer simply follows the code, there could be 100 feet of water sitting in the piping. "To get the desired temperature at the fixture means all that sitting water gets flushed down the drain," he says. So, Dipping prefers recirculating systems located much closer to the fixture wherever possible.

LEAK DETECTION

Water leaks are major issues for facility managers trying to control and monitor water use in their facilities. According to New York City's Department of Environmental Protection, a small toilet leak can waste 30 gallons daily at forty cents every day. For a medium leak of 250 gallons a day, the estimated daily cost would be $3.30. When the fill valve remains open, a large leak can waste 4,000 gallons daily, consuming $53 a day in the water. Given those statistics, it's easy to see how ignoring one running toilet could wipe out a significant portion of other water conservation savings.

Effective leak detection is important parameter to be monitored from the water cost perspective. It also helps in water saving which ultimately is the important goal towards sustainable future.

STAFF/OCCUPANT TRAINING

Facility managers need to recruit more than just their maintenance crew to alert building operators to plumbing leaks so problems can be addressed quickly. That means making sure all staff knows whom to call when they see a leak.

Building occupants also can be recruited with a simple sign on restrooms, for example, that tells them to contact any employee or the front desk when they notice a dripping faucet or running toilet.

One school district trained its janitorial staff and vice principals to report all water leaks by calling a specific number, Hoffman says. "The first year, they saved $700,000 in utility bills," he reports.

METERING AND SUBMETERING

Water metering and submetering can help in tracking water consumption and leak detection in both new and existing buildings. Both major codes have submetering in them. Ideally, water submetering could provide valuable input on cooling towers, irrigation and hot water use.

Water metering works best when it is incorporated into the building management system so that its data appear on the building operator's dashboard with other facility data. These days battery operated water submeters report their data to plugged-in transceivers. Their low-cost installation makes these smart water meters practical for existing buildings as well as for new construction.

WATER AUDITS

Experts agree that water audits, whether performed by a plumbing or utility professional or done in-house, will help facility managers determine what next steps to take and in what order. At this point, however, water audits are not like energy audits. Energy audits are standardized and follow a particular order Water audits are more recent and currently there's not a standard protocol for them. However, several groups are trying to adopt standards for water audits.

BENCHMARKING SUSTAINABILITY GOALS

The water audit will help establish where water is being used in a facility and permit benchmarking sustainability goals. For example, Snohomish County in Washington State has set a goal of reducing water use by 20 percent by 2020.

To keep track of the county's 1.5 million square feet, the Office of Energy and Sustainability chose a software platform that automatically imports utility bills, then measures and benchmarks performance across their 38 buildings. Using its yearly water benchmarking tools, the county prioritizes its retrofitting projects. As of its latest Sustainable Operations Action Plan report, Snohomish County has saved more than 2 million gallons of water.

COOLING TOWER MAINTENANCE

Commercial and institutional buildings of more than 10,000 square feet generally use cooling towers as part of their HVAC system. HVAC water use in schools, hospitals and office buildings accounts for 20 percent, 13 percent and 28 percent of total water use respectively, according to San Jose Environmental Services Department data.

"FMs need to make sure their cooling towers are kept clean, and that scale build-up is minimized," says James E. Dipping.

Properly operated towers and associated piping should not have leaks or overflows, according to Water Sense at Work: Best Management Practices for Commercial and Institutional Facilities. However, an overflow drain is provided within the tower in case of malfunction and subsequent overflow. Most green codes require overflow alarms.

IRRIGATION SYSTEMS

A range of options is available for improving irrigation systems. For new installations, drip irrigation uses significantly less water than traditional sprinkler systems. Facility managers not wishing to redo their existing systems can upgrade landscape irrigation with rain detection or soil moisture sensors.

For new installations, it is always suggested to use native plants and drip irrigation, along with rain sensors. Incorporating intelligence into the irrigation system so that it triggers an alarm on the building automation system when the water meter detects flow during periods when the irrigation system is not working is an especially effective measure. For example, Texas Wesleyan University in Fort Worth is improving its landscape irrigation system by installing new smart controls that respond to weather events.

The City of Eden Prairie, Minn., became concerned that watering 23 parks, sports fields and facilities was using 45 million gallons of water. The city decided to convert several athletic fields in 2008 to an irrigation controller with soil moisture sensors. By 2010, water use was reduced by 8 million gallons, saving the city $29,000.

RAINWATER CAPTURE

Harvesting rainwater is a great alternative to municipal water use for irrigation and some indoor uses. But this option requires considerable research with local water, environmental or development bureaus. In existing buildings also, rainwater harvesting/ storing is not difficult. It can be done in an existing set-up.

The stored rainwater can be used for irrigation in the existing building, During the new construction, this water can be used for flushing & washing the site.

For rainwater harvesting reuse on the site, the city building permit is not required. However, for the outside use the project might need permit since the system is separate from the municipal water system. Other important requirements may include backflow installation and inspection, electrical permits for any installed pumps, and/or a grading permit for underground pipe installation.

GREY WATER/RECLAIMED WATER USE

Greywater is defined as “untreated wastewater which has not come into contact with toilet waste.” Greywater can be used for irrigation or nonportable building uses such as flushing toilets and urinals. The problem with greywater’s acceptance is that it is regulated by state and local governments. Each has its definition of what constitutes greywater and what, if anything, it can be used for.

SMART WATER METERS

A smart water metering system offers benefits, such as transparent usage and billing, elimination of manual meter readings and improved leak detection, which shall be deployed in a building.

EFFICIENT WATER FIXTURES

Using dual flushes with a flush rate of 1.26 GPF, faucets with a flow rate of 1.2 GPM and showers with a flow rate of 2 GPM aids in the reduction of freshwater usage. Reducing water use contributes to climate change mitigation by decreasing energy consumption and greenhouse gas emissions. Water conservation can lead to large savings in the energy used to transport, treat, and distribute piped water.

TREATMENT OF SEWAGE WATER

Treating at least 50% of the sewage water collected on-site and supplementing it for landscape irrigation, AC water makeup and/or toilet flush will reduce the quantity of freshwater requirement of the buildings. Lesser dependency on local municipal water helps decrease operational carbon emissions.

RAINWATER HARVESTING

At least 70% of the rainwater from surface runoff (roof of the building and on-site paved areas) is to be collected and supplemented in place of freshwater for non-drinking purposes.

WATER AUDIT

A water audit — also called a water evaluation or assessment — is a comprehensive analysis of the current water use of a building or campus and the subsequent development of a strategy to increase water usage efficiency and identify alternative water resources. The goal of a comprehensive water audit is to reduce the demand for freshwater resources. The multi-step water audit process includes collecting the data necessary to estimate water use at the equipment level, surveying the equipment to understand water consumption, investigating water-conservation opportunities and conducting an economic analysis to determine the project’s effectiveness.

Landscape

Understanding the climate zone can help determine the best energy-saving landscaping strategies for your home.

A well-designed landscape not only can add beauty to your home but also can reduce your heating and cooling costs. A well-placed tree, shrub or vine can deliver effective shade, act as a windbreak and reduce your energy bills. Carefully positioned trees can save up to 25% of the energy a typical household uses in the United States, for example.

According to the U.S. Geological Survey, of the 26 billion gallons of water consumed daily in the United States, approximately 7.8 billion gallons, or 30 percent are devoted to outdoor use. The majority of this is used for landscaping. It is estimated that the typical suburban lawn consumes 10,000 gallons of water above and beyond rainwater each year.

Many terms and schools of thought have been used to describe approaches to water-efficient landscaping. Some examples include “water-wise,” “water-smart,” “low-water” and “natural landscaping.” While each of these terms varies in philosophy and approach, they are all based on the same principles and are commonly used interchangeably. One of the first conceptual approaches developed to formalize these principles is known as “xeriscape landscaping.” Xeriscape landscaping is defined as “quality landscaping that conserves water and protects the environment.” The word “xeriscape” was coined and copyrighted by Denver Water Department in 1981 to help make water-conserving landscaping an easily recognized concept. The word is a combination of the Greek word “xeros,” which means “dry” and “landscape.”

The seven principles upon which xeriscape landscaping is based are:

1. Proper planning and design
2. Soil analysis and improvement

3. Appropriate plant selection
4. Practical turf areas
5. Efficient irrigation
6. Use of mulches
7. Appropriate maintenance

The eight fundamentals of water-wise landscaping, below, illustrate the similarities in the underlying concepts and principles of xeriscape landscaping and other water-efficient approaches:

1. Group plants according to their water needs
2. Use native and low-water-use plants
3. Limit turf areas to those needed for practical uses
4. Use efficient irrigation systems
5. Schedule irrigation wisely
6. Make sure the soil is healthy
7. Remember to mulch
8. Provide regular maintenance

WATER-EFFICIENT LANDSCAPE DESIGN

Landscaping that conserves water and protects the environment is not limited to arid landscapes with only rocks and cacti. Through careful planning, landscapes can be designed to be both pleasing to the senses and kind to the environment. One simple approach to achieving this is applying and adopting the basic principles of water-efficient landscaping to suit your climatic region. The seven principles of xeriscape landscaping are used below to describe these basic concepts in greater detail.

PROPER PLANNING AND DESIGN

Developing a landscape plan is the first and most important step in creating a water-efficient landscape. Your plan should consider the regional and microclimatic conditions of the site, existing vegetation, topography, intended uses of the property and most importantly, the grouping of plants by their water needs. Also, consider the plants' sun or shade requirements and preferred soil conditions. A well-thought-out landscape plan can serve as your roadmap for creating beautiful, water-efficient landscapes and allow you to continually improve your landscape over time.

SOIL ANALYSIS AND IMPROVEMENTS

Because soils vary from site to site, test your soil before beginning your landscape improvements. The county extension service/ local laboratories can analyse the pH levels; nutrient levels (e.g., nitrogen, phosphorus, potassium); and the sand, silt, clay and organic matter content of your soil. It can also suggest ways to improve your soil's ability to support plants and retain water (e.g., through aeration or the addition of soil amendments or fertilizers).

APPROPRIATE PLANT SELECTION

The landscape design should consider your local climate as well as soil conditions. Focus on preserving as many existing trees and shrubs as possible because established plants usually require less water and maintenance. Choose plants native to your region. Native plants, once established, require very little to no additional water beyond normal rainfall. Also, because they are adapted to local soils and climatic conditions, native plants commonly do not require the addition of fertilizers and are more resistant to pests and disease. When selecting plants, avoid those labelled "hard to establish," "susceptible to disease" or "needs frequent attention," as these types of plants frequently require large amounts of supplemental water, fertilizers and pesticides. Careful analysis is required when selecting non-indigenous species as some of them may become invasive. An invasive plant might be a water guzzler and will surely choke out native species.

The key to successful planting and transplanting is getting the roots to grow into the surrounding soil as quickly as possible. Knowing when and where to plant is crucial to speed up the establishment of new plants. The best time to plant will vary from species to species. Some plants will thrive when planted in a dormant or inactive state. Others succeed when planted during the season when root generation is highest and sufficient moisture is available to support new growth.

PRACTICAL TURF AREAS

How and where turf is placed in the landscape can significantly reduce the amount of irrigation water needed to support the landscape. Lawns require a large amount of supplemental water and generally greater maintenance than other vegetation. Use turf where it aesthetically highlights the house or buildings and where it has a practical function, such as in play or recreation areas. Grouping turf areas can increase watering efficiency and significantly reduce evaporative and runoff losses. Select a type of grass that can withstand drought periods and become dormant during hot and dry seasons. Reducing or eliminating turf areas further reduces water use.

EFFICIENT IRRIGATION

Efficient irrigation is a very important part of using water efficiently outdoors and applies in any landscape — whether xeriscape or conventional.

Irrigating lawns, gardens and landscapes can be accomplished either manually or with an automatic irrigation system. Manual watering with a hand-held hose tends to be the most water-efficient method. According to the AWWA Research Foundation's outdoor end-use study, households that manually water with a hose typically use 33 percent less water outdoors than the average household. The study also showed that households with in-ground sprinkler systems used 35 percent more water, those with automatic timers used 47 percent more water and those with drip irrigation systems used 16 percent more water than households without these types of systems. These results show that in-ground sprinkler and drip irrigation systems must be operated properly to be water efficient.

To reduce water losses from evaporation and wind, avoid sprinklers that produce a fine mist or spray high into the air. Soaker hoses can also be very efficient and effective when used properly. Use of a hand-held soil moisture probe to determine when irrigation is needed. To make automatic irrigation systems more efficient, installing system controllers such as rain sensors that prevent sprinkler systems from turning on during and immediately after rainfall, or soil moisture sensors that activate sprinklers only when soil moisture levels drop below pre-programmed levels. Projects can also use a weather-driven programming system. Drip-type irrigation systems are considered the most efficient of the automated irrigation methods because they deliver water directly to the plants' roots. It is also important to revise your watering schedule as the seasons change. Over-watering is most common during the fall when summer irrigation schedules have not been adjusted to the cooler temperatures.

To further reduce your water consumption, consider using alternative sources of irrigation water, such as grey water, reclaimed water and collected rainwater. According to the AWWA Research Foundation, homes with access to alternative sources of irrigation reduce their water bills by as much as 25 percent. Greywater is untreated household wastewater from bathroom sinks, showers, bathtubs and clothes washing machines. Greywater systems pipe this used water to a storage tank for later outdoor watering use. State and local greywater laws and policies vary, so you should investigate what qualifies as greywater and if any limitations or restrictions apply. Reclaimed water is wastewater that has been treated to levels suitable for non-potable uses. Check with local water officials to determine if it is available in your area. Collected rainwater is rainwater collected in cisterns, barrels or storage tanks. Commercial rooftop collection systems are available, but simply diverting your downspout into a covered barrel is an easy, low-cost approach. When collecting rainwater, cover all collection vessels to prevent animals and children from entering and to prevent mosquito breeding. Some states might have laws that do not allow the collection of rainwater, so be sure to check with your state's water resource agency before implementing a rainwater collection system.

USE OF MULCH

Mulching aids in greater retention of water by minimizing evaporation, reducing weed growth, moderating soil temperatures and preventing erosion. Organic mulch also improves the condition of your soil as it decomposes. Mulch are typically composed of wood bark chips, wood grindings, pine straws, nut shells, small gravel or shredded landscape clippings. Avoid using rock mulch in sunny areas or around non-arid climate plants, as they radiate large amounts of heat and promote water loss that can lead to scorching. Too much mulch can restrict water flow to plant roots and should be avoided.

APPROPRIATE MAINTENANCE

Water and fertilize plants only as needed. Too much water promotes weak growth and increases pruning and mowing requirements. Like any landscape, a water-efficient yard will require regular pruning, weeding, fertilization, pest control and irrigation. As your water-efficient landscape matures, however, it will require less maintenance and less water. Cutting turf grass only when it reaches two to three inches promotes deeper root growth and a more drought-resistant lawn. As a rule of thumb, mow your turf grass before it requires more than one inch to be removed. The proper cutting height varies, however, with the type of grass, so you should contact your county extension service or local nursery to find out the ideal cutting height for your lawn. Avoid shearing plants or giving them high-nitrogen fertilizers during dry periods because these practices encourage water-demanding new growth.

Pumps and Motors

Pump systems consist of pumps, drivers, pipe installation and controls (such as ASDs or throttles) and are a part of the overall motor system. Below some of the energy efficiency opportunities for the pumping system are presented.

The American Society of Mechanical Engineers (ASME) has published a standard that covers the assessment of pumping systems, which are defined as one or more pumps and those interacting or interrelating elements that together accomplish the desired work of moving fluid.

In this standard, the procedure of conducting a 14-detailed energy assessment of the pumping system as well as the energy efficiency opportunities are described:

1. Maintenance
2. Monitoring
3. Controls
4. Reduction of demand
5. More efficient pumps
6. Proper pump sizing
7. Multiple pumps for varying loads
8. Impeller trimming (or shaving sheaves)
9. Adjustable speed drives (ASDs)
10. Avoiding throttling valves
11. Proper pipe sizing
12. Replacement of belt drives
13. Precision castings, surface coatings, or polishing
14. Improvement of sealing

MAINTENANCE

Inadequate maintenance lowers pump system efficiency causing pumps to wear out more quickly and increasing costs. Better maintenance will reduce these problems and most importantly, save energy.

Proper maintenance includes the following:

- Replacement of worn impellers, especially in caustic or semi-solid applications
- Bearing inspection and repair
- Bearing lubrication replacement, once annually or semi-annually
- Inspection and replacement of packing seals
- Inspection and replacement of mechanical seals
- Wear ring and impeller replacement
- Pump/motor alignment check
- The largest opportunity is usually to avoid throttling losses

Typical energy savings for operations and maintenance are estimated to be between 2% and 7% of pumping electricity use for the U.S. industry. The payback usually is less than one year.

MONITORING

Monitoring in conjunction with operations and maintenance can be used to detect problems and determine solutions to create a more efficient system. Monitoring can determine clearances that need to be adjusted, indicate a blockage, impeller damage, inadequate suction, operation outside preferences, clogged or gas-filled pumps or pipes or worn-out pumps.

Monitoring should include:

- Wear monitoring
- Vibration analyses
- Pressure and flow monitoring
- Current or power monitoring
- Differential head and temperature rise across the pump (also known as thermodynamic monitoring)
- Distribution system inspection for scaling or contaminant build-up

One of the best indicators to follow for monitoring is specific energy or power consumption as a function of the flow rate.

CONTROLS

The objective of any control strategy is to shut off unneeded pumps or to reduce the load of individual pumps. Remote controls enable pumping systems to be started and stopped relatively quickly and accurately and reduce the required labor concerning traditional control systems.

REDUCTION OF DEMAND

Holding tanks can be used to equalize the flow over the production cycle, enhancing energy efficiency and potentially reducing the need to add pump capacity. In addition, bypass loops and other unnecessary flows should be eliminated.

Energy savings may be as high as 5% to 10% for each of these steps.

Total head requirements can also be reduced by lowering process static pressure, minimizing elevation rise from the suction tank to the discharge tank, reducing static elevation change by use of siphons and lowering spray nozzle velocities.

MORE EFFICIENT PUMPS

Pump efficiency may degrade by 10% to 25% in its lifetime. Industry experts however point out that this degrading performance is not necessarily due to the age of the pump but can also be caused by changes in the process which may have caused a mismatch between the pump capacity and its operation.

Nevertheless, it can sometimes be more efficient to buy a needed pump, also because newer models are more efficient.

Several pumps are available for specific pressure head and flow rate capacity requirements. Choosing the right pump often saves both pumps. For a given duty, a pump that runs at the highest speed suitable for the application will generally be the most efficient option with the lowest initial cost.

Exceptions include slurry handling pumps, high specific speed pumps or applications where the pump needs a very low minimum net positive suction head at the pump inlet.

Replacing a pump with a new efficient one reduces energy use by 2% to 10%. Higher-efficiency motors have been shown to increase the efficiency of the pump system by 2% to 5%.

PROPER PUMP SIZING

A pump may be incorrectly sized for current needs if it operates under throttled conditions, has a high bypass flow rate or has a flow rate that varies more than 30% from its best efficiency point flow rate (U.S. DOE-OIT, 2005). Where peak loads can be reduced, pump size can also be reduced. A smaller motor will however not always result in energy savings, as these depend on the load of the motor.

Only if the larger motor operates at low efficiency, replacement may result in energy savings. Pump loads may be reduced with alternative pump configurations and improved operations and management practices.

When pumps are dramatically oversized, speed can be reduced with gear or belt drives or a slower-speed motor. This practice, however, is not common. Paybacks for implementing these solutions are less than one year. Oversized and throttled pumps that produce excess pressure are excellent candidates for impeller replacement or “trimming,” to save energy and reduce costs.

Correcting pump oversizing can save 15% to 25% of electricity consumption for pumping (on average for the U.S. industry).

MULTIPLE PUMPS OR VARYING LOADS

The use of multiple pumps is often the most cost-effective and energy-efficient solution for varying loads, particularly in a static head-dominated system. Alternatively, adjustable speed drives could be considered for dynamic systems. Parallel pumps offer redundancy and increased reliability.

The installation of parallel systems for highly variable loads on average would save 10% to 50% of the electricity consumption for pumping for the U.S. industry.

IMPELLER TRIMMING (OR SHAVING SHEAVES)

Trimming reduces the impeller's tip speed, which in turn reduces the amount of energy imparted to the pumped fluid, as a result, the pump's flow rate and pressure both decreases.

A smaller or trimmed impeller can thus be used efficiently in applications in which the current impeller is producing excessive heat. In the food processing, paper and petrochemical industries, trimming impellers or lowering gear ratios is estimated to save as much as 75% of the electricity consumption for specific pump applications.

ADJUSTABLE SPEED DRIVES (OR ASDs)

ASDs better match speed to load requirements for pumps. As for motors, the energy use of pumps is approximately proportional to the cube of the flow rate and relatively small reductions in flow may yield significant energy savings. New installations may result in short payback periods.

In addition, the installation of ASDs improves overall productivity, control and product quality, and reduces wear on equipment, thereby reducing future maintenance costs.

Being able to adjust the load in motor systems, including modulation features with pumps is estimated to save between 20% and 50% of pump energy consumption, at relatively short payback periods, depending on application, pump size, load and load variation.

As a rule of thumb, unless the pump curves are exceptionally flat, a 10% regulation in flow should produce pump savings of 20% and 20% regulation should produce savings of 40%.

AVOIDING THROTTLING VALVES

Variable speed drives or on-off regulated systems always save energy compared to throttling valves. The use of these valves should therefore be avoided. Extensive use of throttling valves or bypass loops may be an indication of an oversized pump.

PROPER PIPE SIZING

Energy may be saved by reducing losses due to friction through the optimization of pipe diameters. The frictional power required depends on flow, pipe size (diameter), overall pipe length, pipe characteristics (e.g., surface roughness, material, etc.), and properties of the fluid being pumped.

Correct sizing of pipes should be done at the system design stages where costs may not be restrictive.

REPLACEMENT OF BELT DRIVES

Most pumps are directly driven. However, some pumps use standard V-belts which tend to stretch, slip, bend, and compress, which leads to a loss of efficiency. Replacing standard V-belts with cog belts can save energy and money, even as a retrofit.

It is even better to replace the pump with a direct-drive system, resulting in increased savings of up to 8% of pumping systems' energy use with payback periods as short as six months.

PRECISION CASTINGS, SURFACE COATINGS OR POLISHING

The use of castings, coatings or polishing reduces surface roughness that in turn, increases energy efficiency. It may also help maintain efficiency over time. This measure is more effective on smaller pumps.

IMPROVEMENT OF SEALING

Seal failure accounts for up to 70% of pump failures in many applications. The sealing arrangements on pumps will contribute to the power absorbed. Often the use of gas barrier seals, balanced seals and no-contacting labyrinth seals can help to optimize pump efficiency, operating costs and initial costs.

Plug Loads

Plug loads are the energy used by equipment that is usually plugged into an outlet. Plug loads as a share of overall building energy use is higher in energy efficient buildings. In minimally code-compliant office buildings, plug loads may account for up to 25% of total energy consumption. But in high efficiency buildings, plug loads may account for more than 50% of the total energy consumption.

Out of the total plug load in a building, "Computers and monitors accounted for 66% of all [plug load] devices; office electronics (printers, faxes, multifunction devices, and computer speakers) accounted for 17% of all devices; miscellaneous devices (portable lighting, telephones, and coffee makers) accounted for the remaining 17% of all plug load devices." (Moorefield, L., et al. 2008). Other devices included in the research include battery chargers, vending machines, and refrigerators (Roberson, J. et al. 2004).

Plug loads are not related to general building lighting, heating, ventilation, cooling and water heating, and typically do not provide comfort to the occupants.

Modern electronic equipment usually incorporates a variety of power levels or "modes," and is usually "on" continuously at some power level. The various modes allow for power management of the equipment – correlating the power mode to the user's activity level. The most common modes are active, standby and off. Active mode powers equipment as it is being operated and is the most energy intensive. Standby mode leaves the equipment on but is powered down either automatically when the equipment has been idle for a specified time or manually placed on standby by the user. Electronic devices will return to active mode when a user engages in the equipment. Off mode either does not draw any power or draws very little power because it has been manually turned off or unplugged by the user. Many electronic devices never completely turn off to start quickly when the user activates the device. These are called "parasitic loads." For example, if a DVD player has been switched off using the remote, but it is still connected to a power socket, it will continue to draw a small quantity of power. Parasitic loads are also known as "phantom loads" or "vampire loads."

Plug loads can be surprisingly large, consuming approximately 30% of the electricity used in offices. For example, California's office plug loads consume more than 3,000-gigawatt hours annually, costing business owners more than $400 million each year. This is equivalent to the carbon dioxide emissions of 140,000 cars (700,000 metric tons) per year. Minimizing plug loads is a primary challenge in the design and operation of an energy-efficient building. According to NREL plug loads in commercial buildings account for almost 5% of U.S. primary energy consumption. On average, plug loads account for approximately 30% of electricity in offices (Moorefield, L., et al. (2008). In minimally code-compliant office buildings, plug loads may account for 25% or less of total energy consumption; in high-efficiency buildings, plug loads may account for more than 50% of the total energy consumption (Poll, S., and C. Teubert 2012).

Aggregated impacts of plug loads are significant. As an example, researchers estimated that California's office plug loads consume more than 3,000-gigawatt hours annually, costing business owners more than $400 million each year. The associated carbon dioxide emissions of these plug loads are more than 700,000 metric tons annually — equivalent to the carbon dioxide emissions of 140,000 cars for one year. The equipment inventory showed that offices contained on average 7 devices per employee and 30 plug-load devices per 1,000 square feet of office space.

Research reveals that power management does not operate in isolation, but rather is subject to the complexities of the workplace environment. For example, a problematic aspect of devices "waking up" is the delay in activating. This delay often frustrates users. Equipment is often left in active mode when not in use - especially networked equipment ENERGY STAR labelled products have factory-installed power management settings that require the device to enter a low power mode; however, users, administrators and software updates often disable these settings. Several reports studied trends in turn-off rates and concluded that turn-offs were reduced in the more recent studies.

The referenced research papers provide recommendations and strategies for reducing plug and process loads. Several identify a team approach. For instance, the U.S. General Services Administration's Plug Load Reduction Checklist recommends project design through an integrated team and the following strategy:

- Establish a plug load champion
- Develop a business case for addressing plug loads
- Benchmark your conventional equipment and operations
- Be willing to identify occupants' true needs
- Meet needs as efficiently as possible
- Turning it all off
- Institutionalize plug load measures through procurement decisions and policy programs
- Address unique miscellaneous plug loads
- Occupant awareness, education, and feedback
- Encourage the design team to identify applicable plug load strategies

Best practices can include no cost and low-cost options. Variables affecting project targets may include project budget and projected return on investment (ROI). But plug load reductions in the 50% range are achievable. As an example of a successful plug loads reduction effort, NREL's Research Support Facility had the goal of becoming a "net zero" office facility. To reach this goal, NREL would need to achieve a 50% reduction from estimated legacy plug loads energy use. Their plug and process load are estimated to be 18.5 kBTU/ft2/yr – reduced from the projected baseline of 35.1 kBTU/ft2/yr.

In addition to utilizing an integrated team approach, research highlights the following plug load interventions:

- By enabling power management in computers, energy use during non-business hours can be decreased by 60%. Reducing time delays can reduce it even further.

- For copiers, when power management is built-in and properly functioning, about 90% of the energy used during non-business hours can be saved.
- For laser printers, without power management, about 50% of energy is used during non-business hours, and 45% of energy is used during idling during business hours. Power management in laser printers based on these data could reduce the energy used by up to 95%
- Install schedule timer plug strips: (Moorefield, L., et al. 2008) (Acker, B., et al. 2012) (Metzger, I., et al. (2012)

Plug strips included in the research are schedule timer plug strips, occupancy and load-sensing plug strips. Timed plug strips outperform all other plug strip interventions. The payback period for a $100 device was best for the schedule timer controls, at an average of 3.425 years for all devices combined. The average payback period for the load-sensing controls and occupancy sensing was 30.5 years and 13.9 years for all devices combined.

Before implementing smart plug strips consider the cost of energy at the site and whether centralized solutions are in place to switch non-essential systems on and off.

Specify energy-efficient Energy Star equipment and pay special attention to parasitic loads to use efficient equipment in the most efficient manner.

REPLACE DESKTOPS WITH LAPTOPS WHEN APPROPRIATE

Laptops are 76% more energy efficient than desktop computers. Desktops are in the active mode about 30% of the time whereas laptops are in active mode only 10% of the time. On average, desktop computers are on standby or sleep 50% of the time and disconnected 7% of the time. Laptops are on standby or sleep 58% of the time and disconnected 26% of the time.

REPLACE CRT MONITORS WITH LCD MONITORS

CRT monitors used 14 to 49% more power than LCD monitors depending on the mode, though 79% of monitors inventoried were LCD monitors.

LASER PRINTERS, MULTI-FUNCTIONAL DEVICES AND INKJET PRINTERS

Inkjet printers and multifunction devices are 70% more energy efficient than laser printers. For laser printers without power management, about 50% of energy is used during non-business hours. For laser printers with power management, 45% of energy is used during idling in business hours. Among the sample of printers, 46% were laser and 34% were inkjet. The turn-off rate was twice as high (30%) for inkjet printers as for laser printers (15%); inkjet printers are more likely to be turned off than laser printers because they are much less likely to be networked.

NREL specified that Nonrated equipment must be researched to find the most efficient model, which should be turned off when not in use, if possible. Even if the equipment is energy efficient, the parasitic loads require special attention. Efficient ways can be explored to perform the operations and subsequently an energy efficiency.

NOTE: Plug load management teams should consider that the building occupants and equipment users typically know best about a facilities and workforce's needs. ROI of equipment upgrades, and occupant behaviour modifications must consider the trade-offs between environmental impacts and worker productivity. For instance, laser printers may be considered most productive because of high-speed printing, double side printing, collation, etc. Inkjet and multi-function devices may be more relevant in small offices and for specific office environments.

PROVIDE OCCUPANT TRAINING

Lack of occupant training can lead to disabling of controls. Many users are annoyed by delays of power management, and so disable it or set a long-time delay like 60 minutes. Technological innovation to shorten the inconvenience of wake-up from power management is necessary to achieve more energy savings by power management.

WORK WITH IT TO ALLOW OCCUPANTS TO POWER DOWN AT NIGHT

Though not technically part of automatic power management, the degree to which people turn off equipment by hand can be as important to energy use and savings as power management. Research shows power management can reduce energy demand by over 60%. The desktop turn off rate was 36% (laptops not included), CRT monitors was 32%, and LCD monitors was 18%.

ESTABLISH EFFECTIVE ENERGY POLICIES

From the energy perspective, changing energy-saver policies to transition to the lowest power mode (standby) was found to save more energy than schedule-based control where loads were completely de-energized during off-hours. This is especially effective on devices such as computers, monitors, copiers and printers. However, from a productivity perspective, a balance must be struck between energy savings and inconvenience to users due to wake-up times delays. For monitors, the wake time is typically insignificant; but for printers and copiers, the warm-up times can range from a few seconds to minutes.

Waste Management

Office buildings, schools, stores, hotels, restaurants and other commercial and institutional buildings generate significant amounts of materials and waste. Here are tools and resources to help facility managers, building owners, tenants and other stakeholders improve waste management in their buildings, reduce costs and enhance sustainability.

Many organizations are content simply to establish a system for removing trash. Increasingly, greater attention is being paid to waste management and proactive organizations are seeing the benefits of establishing a waste reduction program.

- **Save money:** Increasing recycling can cut your disposal costs and improve your bottom line.
- **Knowledge is power:** By understanding the amount and types of waste your organization produces, you're better positioned to find ways to reduce hauling costs and negotiate for waste and recycling services that fit your needs.
- **Streamline reporting and information sharing:** Tracking your waste management activities in one platform and using a standard set of metrics, makes it easier to share and report information with stakeholders.
- **Enhance sustainability:** Managing waste, water, and energy more efficiently are core components of sustainability. Improving your organization's sustainability can boost your corporate image, attract quality tenants to your properties and positively engage employees.
- **Reduce greenhouse gas emissions:** Waste prevention and recycling offer significant potential for reducing greenhouse gas emissions.
- **Conserve resources:** Reuse and recycling conserves natural resources including trees, metals and water.

ESTABLISH EFFECTIVE ENERGY POLICIES

Materials and wastes offer an often-overlooked opportunity to improve an organization's sustainability, prevent greenhouse gas emissions and reduce costs. The first step is tracking the amount of waste your organization generates, for, as the adage goes, "you can't manage what you don't measure." Tracking your waste and recycling provides the key foundation for a successful waste reduction program.

ENERGY STAR Portfolio Manager® is a free, easy to use, online tool for tracking waste, energy and water data over time. Use it to benchmark the performance of one building or a whole portfolio of buildings, all in a secure online environment. It offers a consistent set of metrics for assessing your waste management activities.

TEAM UP

- Leverage an existing team. Consider adding a focus on waste reduction to your organization's existing green team. This may mean bringing in additional team members with a focus on waste and recycling.
- Create a new team. If your organization doesn't have a green team, consider creating a group responsible for planning, designing and implementing waste reduction activities. Some tips for pulling together you team include:
    - Get support from management.
    - Recruit representatives from different areas of your organization. A broad-based team will offer a variety of perspectives, creative problems-solving techniques and likely identify more opportunities for improvement.
    - Relate the size of your team to the size of your organization and gather representatives from as many departments, tenants or functions as possible.

As the team comes together, it is important to identify its responsibilities, which may include:

- Working with your organization's management to set short and long-term waste reduction goals.
- Gathering and analysing information related to the design and implementation of your planned activities.
- Securing management participation in endorsing program goals and implementation, communicating the importance of reducing waste within the organization, guiding and sustaining the program and encouraging and rewarding employee commitment and participation in the effort.
- Promoting the program to other employees and educating them on ways to participate.
- Offering employee incentives to reduce wastes.
- Engaging employee to seek suggestions and create recognition and awards programs.
- Monitoring progress.
- Reporting the status of planned activities to management.
- Reporting the organization's waste reduction efforts to all employees.

SET GOALS

Having clear measurable goals gives teams a shared understanding of what they're working to accomplish and how they're progressing. Look at your tracking data to establish a benchmark and inform your goal setting. Setting goals helps you prioritize activities for preventing waste and expanding recycling programs. Then track progress towards the goals using your benchmark.

To identify specific activities that may most effectively lead you to reach your goals, conduct a waste assessment. The information collected will help you pinpoint the waste reduction areas on which to focus.

ASSESS THE PROGRAM

Tracking the waste assessment is critical to gain insights on how to improve the count of recyclables and wastes hauled from your building gives you an understanding of how your waste management program is performing – data on the amount of waste produced and recycling rate. However, to gain insights on how to improve, a waste assessment is critical. A waste assessment will provide you with important data to discover opportunities for waste reduction.

A waste assessment or audit is a systematic review of your building and its operations to identify the quantity and composition of materials in your waste stream. Knowing what's in waste enables you to effectively tailor your waste reduction program.

Additionally, consider contacting your city or county's recycling office or your waste hauler for assistance in conducting a waste assessment. Some local governments and waste haulers offer free waste audits to businesses.

USING THE WASTE ASSESSMENT RESULTS

Use your waste assessment results to inform your waste reduction activities. For example, you might find there is a high percentage of contamination in your recycling stream, indicating the need for improved communication and education about what should go in the recycling bin. Or the results could highlight that participants are throwing out a large percentage of recyclables in the trash.

After reviewing the results of the waste assessment, consider holding a team brainstorming session to identify potential waste reduction activities. List your most promising options and evaluate them in terms of feasibility and how they align with your goals. When analysing and selecting your activities:

- Focus first on waste prevention, which will help eliminate waste at the source, saving natural resources and energy and cutting costs.
- Evaluate recycling and composting options to manage waste that cannot be prevented.
- Implement waste reduction activities best suited for your organization. You may want to start off with one or two clear activities to get others engaged. Then roll out other initiatives as some of the early waste prevention and recycling behaviours become a habit.

IMPROVING OPERATION PRACTICES

Waste prevention and recycling programs can be significantly improved by actively engaging and educating employees and identifying markets for your recovered materials.

WASTE PREVENTION

The most effective way to reduce your organization's waste is to generate less in the first place. Waste prevention offers the greatest environmental benefits and cost savings.

- **Reduce:** Organizations can modify their current practices to reduce the amounts of waste generated by changing the design, manufacture, purchase or use of materials or products. For example, your organization could encourage employees to only print what they need and ensure that printer settings have defaulted to print double-sided to save paper.

- **Reuse:** Reuse of products and packaging prolongs the useful life of these materials, thus delaying final disposal or recycling. Reuse is the repair, refurbishing, washing or just simple recovery of worn or used products, appliances, furniture and building materials. For example, by encouraging occupants to use reusable coffee mugs rather than single-use, disposable cups, you don't have to manage the disposal of a bunch of coffee cups.

- **Donate:** Organizations can donate products or materials to others who need and can use the items. For example, restaurants, hotels and cafeterias promptly distribute perishable and prepared foods to hungry people in their communities. Many local food banks will pick up food donations free of charge, saving you storage and disposal costs.

RECYCLING

Recycling saves energy helps keep materials out of landfills and incinerators and provides raw materials to produce new products. When waste cannot be prevented, recycling is the next best option. Recycling is more than extending the life of landfills. It is about making the best use of the resources we have available and conserving those resources for future generations. It is about conserving water, energy, land and raw materials.

Composting is recycling for organics. It converts organic materials, like food waste and yard trimmings, into a valuable soil amendment that contributes to soil health and keeps organic wastes out of landfills.

When looking to increase recycling, there are two interrelated components to address, availability and engagement.

Any building's operational cost management strategy must include good waste management as a key element in addition to sustainability planning. When compared to managing energy and carbon, managing the environmental effects of operational generated is often given less priority.

Nevertheless, there are obvious, low-complexity opportunities in the design of on-site operational waste management regimes that can support a facility's commitment to lessening the environmental effects of operational waste and related disposal costs. Here are a few important strategies listed to improve on aspects of waste management.

- **Recycle**: Recycling conserves resources, energy and water while lowering greenhouse gas emissions.

- **Waste Audit**: A waste audit is a formal, structured process used to quantify the amount and types of waste being generated. Information from audits will help identify current waste practices and how they can be improved. It can also determine how to reduce waste, determine the effectiveness of the waste management strategies currently in place, and identify any need for implementing new strategies such as single-stream recycling, composting, and haul trip optimization. This aids in reducing the quantity of waste reaching landfill.

AVAILABILITY OF WASTE COLLECTION FACILITIES

This refers to the collection systems, markets and equipment available to you that influence and impacts your recycling options. Your location and the amount of materials or waste your organization generates shapes your opportunities to increase recycling. Availability has several layers:

- **Regional:** What material end markets and processing facilities can you access, particularly if you have large amounts of materials?
- **Local:** What materials are accepted by your municipal or county programs for recycling or composting? What services do haulers in your area offer? Are there other businesses or organizations that could use your waste material, like waste exchanges and donation outlets?
- **Within a Building:** What services does your hauler offer for your building? Are recycling and composting bins visible and convenient?

ENGAGEMENT

According to US EPA's Managing and Reducing Wastes: A Guide for Commercial Buildings, once the option to recycle or compost is available, then it's important to engage and educate. Recycling is an easy, visible way for people to engage in an organization's sustainability efforts. Best practices include:

- **Kick It Off:** Whether you're starting a new recycling program or reinvigorating an existing one, make an announcement and host a program kick-off. Have a senior leader in the organization announce the goals, why this effort is important, and how it will be implemented.
- **Keep It Fun:** Use challenges, zero waste lunches, recognition, and more to highlight people's role in helping the organization meet its waste reduction goals.
- **Pictures, Please***:* Clear signage on recycling, composting, and trash bin that includes pictures of what goes in which bin. For example, the sign-maker feature provides pictures that you can use to customize recycling, composting, and landfill signs.
- **Better Together:** When it comes to trash and recycling bins it's best to keep them next to each other, so people have both options in one place. It should be as easy to recycle as it is to throw something away. Ensure all waste and recycling bins are clearly marked to avoid misuse.
- **Be Consistent:** If your recycling bins are blue, composting is green, and trash is black, keep the colors consistent throughout your program and building.

- **Keep It Up:** Ongoing communication and promotion are key to program success. You can leverage special emphasis days like Earth Day (April 22nd) and America Recycles Day (November 15th) and celebrate program milestones to maintain momentum.

Renewable Energy Supplementation

Renewable energy is energy from sources that are naturally replenishing but flow-limited; renewable resources are virtually inexhaustible in duration but limited in the amount of energy that is available per unit of time.

The major types of renewable energy sources are:

- Biomass
    - Wood and waste
    - Municipal solid waste
    - Landfill gas
- Hydropower
- Geothermal
- Wind
- Solar

BIOMASS - RENEWABLE ENERGY FROM PLANTS AND ANIMALS

Biomass is renewable organic material that comes from plants and animals. Biomass was the largest source of total annual U.S. energy consumption until the mid-1800s. Biomass continues to be an important fuel in many countries, especially for cooking and heating in developing countries. The use of biomass fuels for transportation and for electricity generation is increasing in many developed countries as a means of avoiding carbon dioxide emissions from fossil fuel use. In 2021, biomass provided nearly 5 quadrillion British thermal units (Btu) and about 5% of total primary energy use in the United States.

Biomass contains stored chemical energy from the sun. Plants produce biomass through photosynthesis. Biomass can be burned directly for heat or converted to renewable liquid and gaseous fuels through various processes.

Biomass sources for energy include:

- Wood and wood processing wastes — firewood, wood pellets, and wood chips, lumber and furniture mill sawdust and waste and black liquor from pulp and paper mills
- Agricultural crops and waste materials — corn, soybeans, sugar cane, switchgrass, woody plants and algae, and crop and food processing residues, mostly to produce biofuels

- Biogenic materials in municipal solid waste — paper, cotton and wool products, and food, yard and wood wastes
- Animal manure and human sewage for producing biogas/renewable natural gas

HYDROPOWER IS ENERGY IN MOVING WATER

People have a long history of using the force of water flowing in streams and rivers to produce mechanical energy. Hydropower was one of the first sources of energy used for electricity generation, and until 2019, hydropower was the largest source of total annual U.S. renewable electricity generation.

In 2021, hydroelectricity accounted for about 6.3% of total U.S. utility-scale electricity generation and 31.5% of total utility-scale renewable electricity generation. Hydroelectricity's share of total U.S. electricity generation has decreased over time, mainly because of increases in electricity generation from other sources.

Hydropower: Water Cycle

Understanding the water cycle is important to understanding hydropower. The water cycle has three steps:

- Solar energy heats water on the surface of rivers, lakes, and oceans, which causes the water to evaporate.
- Water vapor condenses into clouds and falls as precipitation — rain and snow.
- Precipitation collects in streams and rivers, which empty into oceans and lakes, where it evaporates and begins the cycle again.

The amount of precipitation that drains into rivers and streams in a geographic area determines the amount of water available for producing hydropower. Seasonal variations in precipitation and long-term changes in precipitation patterns, such as droughts, can have large effects on the availability of hydropower production.

Hydroelectric Power is Produced with Moving Water

Because the source of hydroelectric power is water, hydroelectric power plants are usually located on or near a water source. The volume of the water flow and the change in elevation — or fall, and often referred to as *head* — from one point to another determine the amount of available energy in moving water. In general, the greater the water flow and the higher the head, the more electricity a hydropower plant can produce.

At hydropower plants, water flows through a pipe or *penstock* then pushes against and turns blades in a turbine to spin a generator to produce electricity.

Conventional hydroelectric facilities include:

- **Run-of-the-river systems,** where the force of the river's current applies pressure on a turbine. The facilities may have a weir in the watercourse to divert water flow to hydro turbines.
- **Storage systems,** where water accumulates in reservoirs created by dams on streams and rivers and is released through hydro turbines as needed to generate electricity. Most U.S. hydropower facilities have dams and storage reservoirs.

Pumped-storage hydropower facilities are a type of hydroelectric storage system where water is pumped from a water source up to a storage reservoir at a higher elevation and is released from the upper reservoir to power hydro turbines located below the upper reservoir. The electricity for pumping may be supplied by hydro turbines or by other types of power plants including fossil fuel or nuclear power plants. They usually pump water to storage when electricity demand and generation costs, and/or when wholesale electricity prices are relatively low and release the stored water to generate electricity during peak electricity demand periods when wholesale electricity prices are relatively high. Pumped-storage hydroelectric systems generally use more electricity to pump water to the upper water storage reservoirs than they produce with the stored water. Therefore, pumped-storage facilities have net negative electricity generation balances. The U.S. Energy Information Administration publishes electricity generation from pumped storage hydroelectric power plants as negative generation.

GEOTHERMAL ENERGY

Geothermal energy is heat within the earth. Geothermal energy is a renewable energy source because heat is continuously produced inside the earth. People use geothermal heat for bathing, for heating buildings, and for generating electricity.

WIND ENERGY

Wind is caused by uneven heating of the earth's surface by the sun. Because the earth's surface is made up of different types of land and water, the earth absorbs the sun's heat at different rates. One example of this uneven heating is the daily wind cycle.

WIND ENERGY FOR ELECTRICITY GENERATION

Today, wind energy is mainly used to generate electricity. Water-pumping windmills were once used throughout the United States, and some still operate on farms and ranches, mainly to supply water for livestock.

SOLAR THERMAL HEAT ENERGY

A solar oven (a box for collecting and absorbing sunlight) is an example of a simple solar energy collection device. In the 1830s, British astronomer John Herschel used a solar oven to cook food during an expedition to Africa. People now use many different technologies for collecting and converting solar radiation into useful heat energy for a variety of purposes.

We use solar thermal energy systems to heat:

- Water for homes, buildings, or swimming pools
- Air inside homes, greenhouses, and other buildings
- Fluids in solar thermal power plants

SOLAR PHOTOVOLTAIC SYSTEMS

Solar photovoltaic (PV) devices or solar cells, convert sunlight directly into electricity. Small PV cells can power calculators, watches and other small electronic devices. Larger solar cells are grouped in PV panels, and PV panels are connected in arrays that can produce electricity for an entire house. Some PV power plants have large arrays that cover many acres to produce electricity for thousands of homes.

Using solar energy has two main benefits:

- Solar energy systems do not produce air pollutants or carbon dioxide.
- Solar energy systems on buildings have minimal effects on the environment.

Solar energy also has some limitations:

- The availability and amount of sunlight that arrives at the earth's surface varies depending on time of day, location, season of the year and weather conditions.
- The amount of sunlight reaching a square foot of the earth's surface is relatively small, so a large surface area is necessary to absorb or collect enough energy to be useful.

ASSESSING RENEWABLE ENERGY OPTIONS

Agencies should assess renewable energy options for each specific project when integrating renewable energy in new building construction or major renovations. This section covers the preliminary screening, screening, feasibility study and sizing and designing systems phases. There are phases of the renewable energy assessment process that occurs in parallel with the normal development of a project. Links to deeper-level information are also provided to help agencies assess their renewable energy options. Almost any location can use renewable energy technologies. However, not every form of renewable energy may be practical at a particular site. Determining which technology or combination of technologies is best suited to a specific construction project is done during the assessment process. This section describes the entire assessment process and details how this process fits into the overall construction project timeline. In general, the practicality of most renewable energy technologies increases when considered early in the planning stages of site and building design.

Narrowing the choices of renewable energy options involves several steps:

- Preliminary screening
- Screening
- Renewable energy feasibility study
- Size and design systems

Renewable energy technologies can be considered and incorporated at every stage in the design process. However, significant factors that enable cost-effective and technologically feasible implementation of renewable technologies are often determined in the early design phases. It is prudent to consider and start analysing the potential for these technologies in the very early, conceptual stages of design.

PRELIMINARY SCREENING

The first step in assessing renewable energy options is to conduct a preliminary screening to distinguish between technologies that are worth reviewing and those that should be eliminated without further analysis. This step should occur early in the planning of a construction project. Preliminary screening involves resource maps and other basic tools to choose technologies to pursue further.

SCREENING

The next step in assessing renewable energy options is a full screening. The screening is usually performed by an outside party or an independent renewable energy expert. It is a review of the possible technology options that identifies dead-ends and further narrows the list to probable technologies for the project. This is a more detailed look at the available resources and a high-level analysis of expected costs and savings, utility considerations, and potential incentives. This screening can also assess each technology's ability to contribute to energy goals and requirements. The agency can analyse specific sites or screen across properties to decide which areas have the greatest renewable energy potential.

Screening should be completed during the programming phase of the project, as it is needed to inform early design decisions and project requirements. It is also very helpful in establishing early budget life-cycle cost estimates for renewable energy.

RENEWABLE ENERGY FEASABILITY STUDY

Once an agency has identified probable technologies, a detailed review of the feasibility and economic viability of each renewable energy technology, also called a renewable energy feasibility study, can determine which renewable energy technologies most effectively meet the agency's energy requirements and goals. The renewable energy feasibility study takes a deeper look into the remaining technologies to quantify how much energy each technology could produce or offset; reviews details of utility interconnection, tariffs and revenue; analyses access to financial incentives as well as project funding models; and reviews National Environmental Policy Act (NEPA) requirements, permitting requirements, and operational costs. This assessment can be accurately conducted only after a potential location has been chosen for the project and initial estimates for energy loads and usage exist. Ideally, the feasibility study is conducted before the schematic design phase.

SIZE AND DESIGN SYSTEMS

Following the renewable energy feasibility study, the technologies to be included in the new construction project will be defined and the design team will be ready to size and design the systems. At this point in the process, building energy loads and demands will largely be known. Utility requirements and all applicable codes and standards will also need to be considered and met at this stage. This is the last step in the process of assessing renewable energy options. Integrating renewable energy into a construction project must be in the hands of renewable energy experts and closely coordinated with the overall project design team.

ASSESSMENT FACTORS

Assessing technology options involves examining several factors:

- **Available renewable resources:** Renewable energy technologies rely on resources like sunlight, wind, biomass, or heat from the earth. Some technologies require a threshold level of a resource to be feasible or cost effective.

- **Available space:** Many technologies require additional space, either on a roof or on land, to function properly.

- **Technology costs:** The cost of any renewable energy technology system is calculated along with its potential energy output to estimate its economic feasibility.

- **Energy costs:** Estimating the economic feasibility of technologies includes calculating the expected costs of energy to the project that will be offset.

- **Ability to connect to the grid:** When incorporating an electric power technology system into a project, the system will typically need to be interconnected with the utility power grid. The rules vary by state and utility as to what size and type of technologies can be interconnected economically.

- **Agency goals:** Agency energy goals are important in assessing various technologies. Federal agencies can set goals or mandates, or they could be required by legislation, to incorporate renewable energy into their energy use portfolio.

- **Available incentives:** Any financial incentives, such as grants, favourable tariffs, or net metering, can affect the economic feasibility of various technologies.

- **Additional Factors**: Other considerations that can affect renewable energy decisions include energy security requirements, zoning, permitting, and environmental review requirements.

The depth at which each factor is considered varies depending on whether the analysis is for a preliminary screening, a full screening, or a feasibility study. Project location solidifies a few variables — including renewable resources, land availability, conventional energy cost, available incentives, local net metering and interconnection policies. In the early design phases, however, several factors are not yet defined and should be considered. These include orientation and siting of a building on a lot, design of a building to optimize access to the renewable resource, and sizing of a renewable energy system to offset an optimum amount of site energy load and to minimize usual energy purchases (while maximizing the applicability of financial incentives, if applicable).

Whole Building

Energy/ Emission reduction strategies listed under this topic of the whole building are focussing on the implementation of energy conservation measures that do not fall under other topics, however these best practices upon implementation could lead to energy/ emission reduction of the building in operation.

HEAT ISLAND REDUCTION

In urban areas or other constructed environments with little natural vegetation, using landscape on the site and the roof will reduce the amount of heat that gets absorbed into the building, especially during the day. Using a white/light-shaded paint colour reflects a large part of the sun's rays back into the atmosphere, thus reducing the heat absorbed by the building and helping keep the interiors cool. Reduction in the amount of heat absorbed into the building means lesser load on the air conditioning system. This will directly be reflected by the energy demand of the HVAC system.

ENERGY METERING AND SUB-METERING

Energy metering is a crucial prerequisite for monitoring and cost reduction. Specific building systems or spaces can be identified as using more energy thanks to sub-building level meters. These sub-meters interact with lease provisions in multi-tenant buildings to help understand the energy demand better.

ASHRAE LEVEL 2 ENERGY AUDITING

Detailed energy calculations and additional financial analyses of suggested energy measures form the basis of a Level 2 ASHRAE energy audit. This level of an audit makes use of utility data spanning a longer time frame to enable a deeper comprehension of the building's energy usage. Based on comprehensive data and analysis of the precise equipment and operational circumstances used in the building, it aids in quantifying possible energy savings.

BUILDING MANAGEMENT SYSTEM

BMS refers to retrofitting a management system in the building to track and verify shutdowns, holiday scheduling, peak load management, optimize equipment runtime, and support demand response will aid in reducing operational carbon emissions as well as reduce utility costs.

FUEL CELLS FOR POWER BACKUP AND TRANSPORTATION

Stationary fuel cell units can be used for backup power as well as for utility vehicles associated with the buildings and reduce the need for fossil-based fuels. Fuel cells operate at higher efficiencies and generate lower emissions when compared to combustion engines.

References & Additional Resources

- ANSI/ASHRAE/IES Standard 100-2018 – Energy Efficiency in Existing Buildings
- ASHRAE 62.1 – 2022 – Minimum ventilation rates and other measures intended to provide indoor air quality (IAQ)
- U.S. Department of Energy – Advanced Energy Retrofit Guides
- U.S. EPA – Insulation Materials
- U.S. EPA – Cool Roofs
- ENERGY STAR – Ways to Save
- U.S. Gov. – Public Building Water Auditing Best Practices
- ENERGY STAR – Lighting
- U.S. EPA – Managing and Reducing Wastes: A Guide for Commercial Buildings
- U.S. EPA and U.S. DOE – After-hours power status of office equipment and energy use of miscellaneous plug-load equipment
- National Renewable Energy Laboratory, U.S. DOE – Assessing and Reducing Plug and Process Loads in Office Buildings
- U.S. General Services Administration – Sustainable Facilities Tool Office Plug Load Field Monitoring Report
- American Council for an Energy Efficient – Office Building Plug Load Profiles
- Federal Energy Management Program – Guide to Integrating Renewable Energy in Federal Construction
- U.S. EIA – Renewable Energy
- U.S. EPA – Energy Efficient Landscaping
- U.S. EPA – Water Efficient Landscaping
- U.S. General Services Administration – Plug Load Reduction Checklist
- American Society of Mechanical Engineers – Energy efficiency improvement opportunities in pumping systems
- Steps to advanced water efficiency
- Whole Building Design Guide – Biogas
- Whole Building Design Guide – Biomass for Electricity Generation

- Whole Building Design Guide – Geothermal Energy Direct Use
- Whole Building Design Guide – Geothermal Electric
- Whole Building Design Guide – Geothermal Heat Pumps
- Whole Building Design Guide - Hydropower
- Whole Building Design Guide – Hydrogen and Fuel Cells
- Whole Building Design Guide – Ocean Energy
- Whole Building Design Guide – Daylighting
- Whole Building Design Guide – Passive Solar Heating
- Whole Building Design Guide - Photovoltaics
- Whole Building Design Guide – Solar Ventilation Air Preheating
- Whole Building Design Guide – Solar Water Heating
- Whole Building Design Guide – Wind