Prepared for:
Sonoma County, CA

March 2009

Sustainable Energy Practices

Guidebook for Public Agencies

BROWN AND
CALD ELL

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About this guidebook

We created this Sustainable Energy Practices Guidebook to help public agencies benchmark their greenhouse gas emissions and devise workable, achievable plans for reducing them. During the course of this project, we talked with staff in our county and technical experts across the country to uncover case studies and proven best practices that are relevant to the needs of government agencies and applicable to utility-based programs. The result is a structured set of sustainable practices and suggested policies, quantitative and financial analysis tools, and step-by-step "how-to" guidance for establishing and implementing an effective greenhouse gas reduction program.

This guidebook was funded by the Bay Area Air Quality Management District, whose staff validated our vision of leveraging the county's progress by sharing our sustainability story and the best practices we've learned from many innovative organizations. Our sincere thanks to our Brown and Caldwell team of consultants—Don Trueblood, Jim Schettler, Sally Mills, Jason Grant, Kenny Klittich and Soumya Srinivasan—who embraced our concept and helped make it a reality. And to County of Sonoma employees Tamra Pinoris (General Services), Gene Clark (Purchasing) and David Worthington (Fleet Management), we are grateful for your help in ensuring the guide's accuracy and relevance to its users across our county, state and beyond.

Historian Lewis Mumford once said: "Nothing is unthinkable, nothing impossible to the balanced person, provided it arises out of the needs of life and is dedicated to life's further developments." Similarly, it is our goal that this guide engenders discussion among its users about the efficacy of our approach and leads jurisdictions to develop plans, establish baselines, set ambitious targets and achieve them all, despite the challenges. Above all, this book can't simply sit on a shelf or in a hard drive. It should be a living document, amended and improved as appropriate, and used to engage us all in the ever-changing and evolving global conversation on sustainability.

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Sustainable Energy Practices Guidebook for Public Agencies

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Framework
for developing and implementing best practices

This introduction discusses the framework for selecting and developing best practices. The same practices will not apply to every situation, and a consistent method of making this evaluation is needed. When developing such an evaluation method, it is important to consider as many applicable variables as possible to arrive at a good decision. By creating an evaluation framework and organizing a sustainability initiative, a longer-term sustainable program can be created and maintained.

Once a commitment to sustainability is established, the agency needs to implement its strategy through appropriate organizational structures, systems, performance measures, rewards, culture and people. This strategy of organizing and managing the system is essential for agencies to coordinate activities and motivate employees (Epstein, 2008).

Implementation

A best practices framework defines a method by which potential projects are evaluated to determine whether they constitute best practices or whether other, more sustainable, practices would be better. Each framework for evaluating energy and water conservation best practices has several elements that include baseline identification, evaluation techniques and a method for measuring important considerations and verifying the evaluation after implementation.

As shown in Figure 1, the elements in the best practices framework being described here sometimes form a continuous loop that enable agencies to evaluate implementation performance and assess potential impacts due to a change in one or more elements. This section will help agencies develop a best practices framework for their

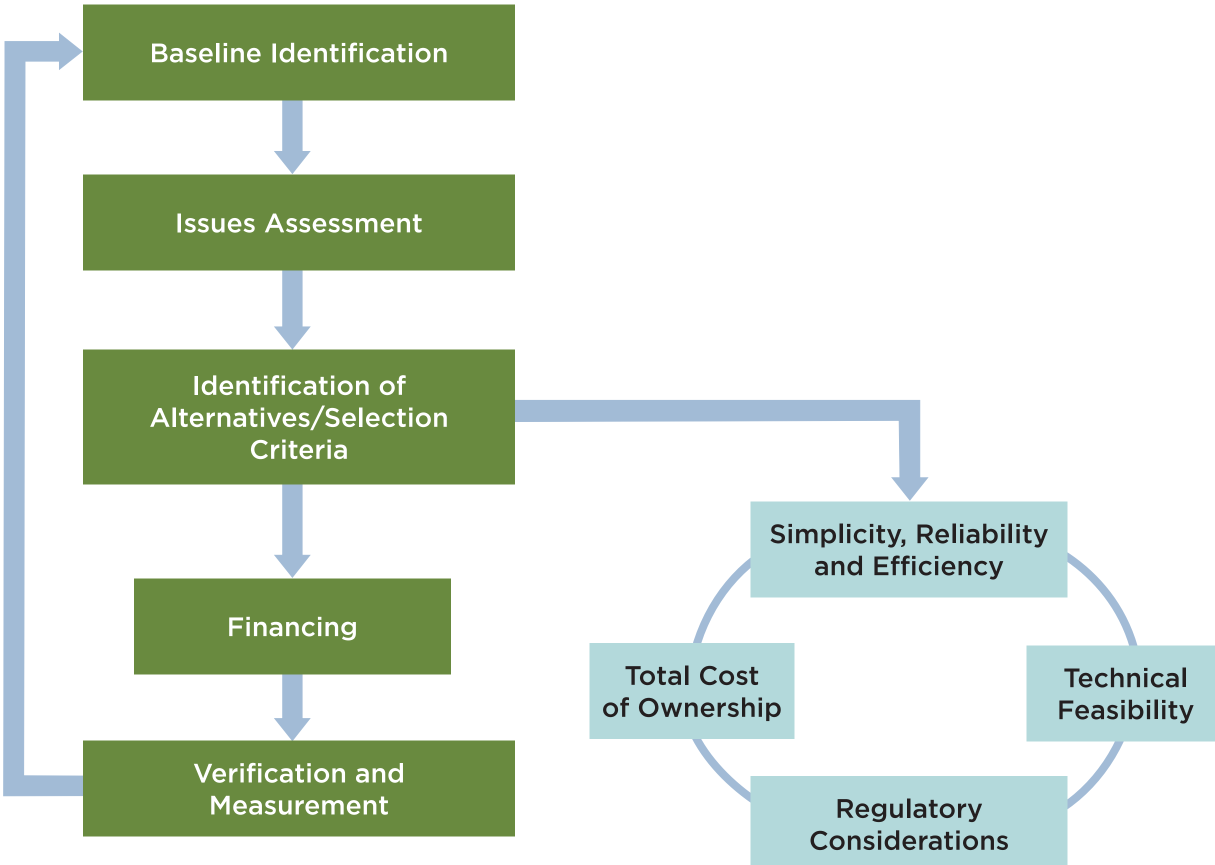


Figure 1. Key elements often used in the Best Practices Framework

specific needs, and provide metrics to evaluate the best practices after they are implemented. The framework discussed here may be reduced, expanded or modified to fit each specific application.

Baseline Identification

Baseline identification is usually, but not always, the first step toward developing the best practices evaluation. It is important because the purpose of any best practice is to improve upon the status quo. Without clearly identifying components of the status quo, it is impossible to determine whether or not a change, and the magnitude of that change, should be expected from implementing a new practice. The method used to define the baseline will depend on the conditions being considered. For instance, defining a greenhouse gas baseline would use very different methods than defining an energy use baseline. In some instances, the methods are inherently obvious and easy to implement. In others, some research or technical assistance may be needed.

The California Environmental Quality Act (CEQA) provides a model for evaluating the projected changes from proposed projects. It requires agencies to define existing conditions, identify potential changes that may occur due to a proposed action, and determine whether the potential changes are desirable, acceptable or unacceptable. The goal of developing a best practices framework is similar. Sometimes value judgments are necessary when comparing desirable changes to undesirable changes, both of which may occur.

Issues Assessment

After a baseline has been identified, an agency must determine improvement opportunities in the realm of sustainability. The goal of issues assessment is to enable an agency to compare its current operations with its potential future performance. This helps provide the agency an insight into areas that could be improved or best practices that could be implemented to be more sustainable.

Identification of Alternatives/ Selection Criteria

Sometimes there are multiple practices that would achieve a desirable outcome, and it is necessary to choose among them. For this, there is no universal set of selection criteria that is equally applicable to all cases; however a small set of well-chosen criteria tend to be the most effective approach for developing a best practices framework (see Figure 1). The following briefly describes the selection criteria that can be used:

- Technical feasibility/logistics. The goal of evaluating technical feasibility and logistics is determining whether implementing best practices would allow the agency to attain a desired level of outcome within the proposed timeframe.
- Regulatory Considerations. See Regulatory Framework section below for a detailed discussion on reglatory considerations for selecting alternatives.
- Total Cost of Ownership/Life-cycle Costing. Life-cycle assessment (LCA) is a technique used to minimize the environmental impacts of products, technologies, materials, processes, industrial systems, activities or services. Life-cycle Costing (LCC) is an extension of the basic LCA and attempts to identify all costs – internal and external – associated with a product, process or activity throughout all stages of its life.

Financing

One of the most common constraints on implementing best practices is initial investment. Even though a project may accrue financial benefits, it may not be implemented because of the initial costs that must be absorbed before financial benefits would occur.

Many financing mechanisms may be available for these projects; however, due to the political and social focus on sustainability projects, unique financing opportunities currently exist. The reader must note that many of these opportunities exist for a finite time and may or may not be available for a particular project timeline. Some examples of financing opportunities, also discussed in detail in Section 6, include:

- Public/private ventures (PPVs)
- Research and development in academia
- Federal funding

Verification and Measurement

To evaluate the success of any project, baselines and expectations need to be established. Following implementation, verification and measurement procedures for the same indicators outlined in the baseline will provide an indication on the framework's reliability. Modifications can then be made to improve the technique for the future.

Keys to Success and Overcoming Barriers

Implementing best management practices requires allocating sufficient resources into the process. Convincing top management officials, financiers and stakeholders of the benefits of these practices is also needed. Some important points to cover when implementing sustainable practices include:

- Reduced operating costs – energy cost savings
- Improved environmental benefits – better quality of life in the community
- Leadership opportunity to address issues related to climate change
- Pollution prevention and energy efficiency incentives
- Readiness for future environmental compliance requirements
- Better public, community and government relations

Management commitment is usually essential for implementing new and innovative best practices. Management should provide both visible support and the resources needed to implement and control the best practices framework. The needed resources may include staff resources, specialized skills, technology and financial resources.

Finally, improved management performance rests on an organization's ability to promote ownership and accountability for operations to its employees. Agencies should focus on evaluating choices for best practice implementation through stakeholder participation. Obtaining stakeholder "buy-in" for an agency's priorities and goals for sustainable development will improve overall performance.

Regulatory Framework

One set of standards, for which conformance is required, are those defined by federal, state and local law; regulations; ordinances; and permits. These regulatory requirements are boundaries around the planning and implementation of sustainability projects.

Climate Change

Climate change is a direct outcome of historical practices related to air emissions and energy use. If neglected, climate change may have serious implications on the quality of human and other life on the planet.

In 2006, the Governor and the state legislature of California passed landmark legislation, Assembly Bill-32 (AB-32). The bill, approved September 27, 2006, mandates significant reductions in greenhouse gas emissions from stationary sources such as power plants and petroleum refineries. AB-32 regulations are in a very early stage of implementation. As regulations develop, public utilities, especially those that are considered major source contributors of greenhouse gas emissions, may become regulated.

Water issues are also discussed here, primarily due to the inherent link between energy use and water supply, distribution and conservation practices, known as the energy-water nexus (refer to Section 1). For example, the California Energy Commission (CEC) issued a report on the water/energy relationship and incorporated recommendations into its Integrated Energy Policy Report (IEPR) submitted to the California State legislature in December 2005. Investing in water conservation can achieve 95 percent of the energy and demand-reduction goals planned by the state's investor-owned energy utilities for the 2006–2008 program periods at 58 percent of the cost of traditional energy efficiency measures. As a consequence, it has been suggested that agencies should carefully consider an integrated regional water management approach as a climate change response (Nelson et al., 2007).

In December 2008, the United States Environmental Protection Agency (USEPA) announced an intra-agency agreement between the Office of Air and Radiation and Office of Water to promote energy efficiency and reduce greenhouse gas emissions at publicly owned wastewater treatment plants and public drinking water systems (USEPA, 2008). The agreement cited several current and planned efforts to improve energy efficiency and offset power consumption at water treatment plants and distribution systems and at wastewater treatment plants. In addition, USEPA has been charged with developing a greenhouse gas regulatory program. As of this writing, details concerning what they may do and when were not available.

Energy

As of August 2008, California is one of the 32 states, along with the District of Columbia, with a Renewable Portfolio Standard, the California RPS, which was enacted in 2002 and amended in 2003 and 2006. The California RPS requires an increasing use of renewable energy from both investor-owned utilities and from municipal utilities. This RPS requires renewable energy sources such as solar, biomass, geothermal, ocean and wind power to produce 20 percent of the state's energy requirement by 2010, and 33 percent by 2020 (http://www.energy.ca.gov/renewables/index.html).

Water Supply and Distribution

A motivation to conserve water comes from the Urban Water Management Planning Act enacted by the California Legislature in 1983 (Water Code Sections 10610 - 10656). The Act states that every urban water supplier that provides water to 3,000 or more customers, or that provides more than 3,000 acre-feet of water annually, should make every effort to ensure the appropriate level of reliability in its water service sufficient to meet the needs of its various categories of customers during normal, dry and multiple dry years. The Act describes the contents of the Urban Water Management Plans as well as how urban water suppliers should adopt and implement the plans. The Department of Water Resources (http://www.owue.water.ca.gov/urbanplan/index.cfm) provides urban water management planning services to local and regional urban water suppliers. The Department of Water Resources staff reviews all urban water management plans that are submitted in accordance with the Act and provides recommendations to local and regional water suppliers through a review letter.

Water conservation is California's state policy (Water Code Sections 100 & 101) and is implemented through a partnership between local water districts and the Department of Water Resources. Specifically, the state codes require:

- All local jurisdictions to adopt a landscape water conservation ordinance, AB 325, Statutes of 1990, California Code of Regulations, Title 23, Ch 2.7, 490-495. Attractive, water-efficient, low-maintenance landscapes can increase home values between 7 and 14 percent. In addition, using trees and shrubs to provide shade in the summer and sunlight in the winter can reduce cooling and heating costs by half (EPA, April 1993).
- All fixtures must be ASME-certified (California Water Recycling Regulations and Statutes, California Health and Safety Code, Division 13, Part 1.5, Chapter 2, Section 17921.3 and California Code of Regulations, Title 20, Division 2, Chapter 4, Article 4, Section 1604 and California Code of Regulations Titles 22 and 17.)

Waste

The California Integrated Waste Management Board, in partnership with local jurisdictions, is responsible for implementing the state's waste diversion and recycled-content procurement mandates. Specifically, these mandates require:

- All local and state public agencies to purchase recycled products instead of non-recycled products whenever available and wherever fitness and quality are equal. AB 4, Eastin, 1989, Public Contract Code 2210.
- All local public agencies shall require the bidder to specify the minimum, if not exact, percentage of recycled products offered, both the post-consumer and secondary waste content, regardless of whether the product meets the percentage of recycled product required pursuant to subdivision (a) of Section 12200. Public Contract Code 12210.
- Local agencies to adopt an ordinance relating to adequate areas for collecting and loading recyclable materials in development projects. AB 1327, Farr, Statutes of 1991, Ch. 842, Public Resources Code 42910-11.

Compendium:
Topics for innovative best practices

The following seven sections provide a series of discussions, examples and ideas for best practices in a number of different areas. They describe the primary drivers of sustainability, both from a regulatory and implementation perspective, and provide specific examples for developing individual best practices on areas related to the following topics:

1. Climate change
2. Greenhouse gas emissions
3. Energy management
4. Water supply and distribution
5. Waste stream management
6. Financing considerations
7. Additional considerations

Each section provides best practice ideas to foster sustainability within the agency and describes what the best practice will accomplish, how it works, how it can be implemented, and any limitations. Advantages and disadvantages are discussed where appropriate. Some best practices apply nearly anywhere. These have been identified and recommended. Others, particularly those of high capital intensity, should be evaluated to determine whether or not they actually constitute a best practice in that specific situation. This concept and method are key when considering alternatives to a particular project.

Section 1
Climate change
as a best-practice driver

One of the greatest factors driving the sustainability initiatives for agencies, businesses and society is global climate change and its associated impacts. In California, reducing the impacts on climate change has also become the greatest regulatory implementation effort in recent history. A conceptual regulatory approach to mitigating global climate change has been structured in the California Global Warming Solutions Act (AB-32), which contains associated legislative actions, executive orders, and agency regulations. This framework will continue to develop for a decade or more before it is reasonably complete, but initial components are currently being implemented. The goal

of this regulatory structure is to reduce the quantity of greenhouse gases emitted within the boundaries of the State of California. The framework is quite simple in concept, but very difficult to implement. The AB 32 process begins by establishing a state-wide baseline and inventory of greenhouse gas emissions. This continues with verification and registration of sources, and next sets the following goals:

- Reducing GHG to 2000 levels by 2010, to 1990 levels by 2020, and to 80 percent below 1990 levels by 2050;
- Limiting emissions from new power production projects to 1,100 pounds of greenhouse gases per megawatt-hour of electricity; and
- Requiring that 20 percent of electricity generated in California come from renewable resources by 2010.

The framework also develops and implements tools to reduce greenhouse gases and monitor the results. It is important for agencies to understand the AB 32 process, as similar steps should be taken within an agency to develop a sustainable outcome.

Most, but not all, greenhouse gas emissions are associated with combustion of fuel, particularly petroleum-based fuel. The largest single contributor to greenhouse gas emissions in California is mobile sources (cars and trucks), followed closely by energy production. As a consequence, the greatest opportunities for reducing greenhouse gases are those that reduce energy consumption or change the source of energy, which in turn provides opportunities for best practices with multiple benefits.

Public Agencies' Role in Climate Change Management

Public agencies should take a lead role in managing climate change by implementing sustainable programs, plans, initiatives and activities to provide the public with adequate, reliable and reasonably priced resources, techniques and alternatives that are cost-effective and environmentally sound.

Public utilities have the opportunity to significantly impact climate change mitigation. Most public utilities are regulated by the California Public Utilities Commission (CPUC). The CPUC regulates privately owned electric, natural gas, telecommunications, water, railroad, rail transit, and passenger transportation companies. The CPUC has taken an active role in creating measures to help mitigate climate change by taking the lead on a number of clean-energy-related initiatives and policies designed to benefit consumers, the environment and the economy. Though the CPUC may not directly regulate most public agencies, many of their incentives and programs can be useful resources to agencies that want to implement best practices.

The Renewable Portfolio Standard (RPI) enforces all electric corporations to increase procurement from eligible renewable energy resources by at least 1 percent of their retail sales annually, until they reach 20 percent by 2010. The Energy Action Plan was implemented with the goal of ensuring that "adequate, reliable and reasonably priced electrical power and natural gas supplies, including prudent reserves, are achieved and provided through policies, strategies and actions that are cost-effective and environmentally sound for California's consumers and taxpayers" (http://www.cpuc.ca.gov). The CPUC has also helped implement other policies, such as the Energy Efficiency and Conservation Program, Greenhouse Gas Efficiency Performance Standard, California Emerging Technology Plan, Combined Heat/Power Initiative, Electricity Sector Carbon Policy, and several programs to help low-income households meet their energy needs in sustainable ways. Agencies should reference these policies and programs to obtain up-to-date best practice ideas and a knowledge base on climate change and related issues.

Another resource for agencies to manage climate change within their business is the "Flex Your Power" service (See Section 6 for more details). The web site (http://www.flexyourpower.org/) provides Best Practice Guides, energy saving ideas, and a tool to find rebates, efficient appliances, lighting, heating and cooling, energy audits and more by industry type and location.

The Energy-Water Nexus

The energy-water nexus refers to the intimate link between water and energy. Water is consumed to generate energy, and energy is consumed to provide clean water to the public. At its core, the energy-water nexus stems from the fact that there is a limited supply and a high demand for both. Figure 2 shows the approximate usage of water that demonstrates the strong influence energy production has on the water supply.

Climate change has spurred a race to find alternative energy sources that produce less greenhouse gas emissions. Some of the latest inventions include:

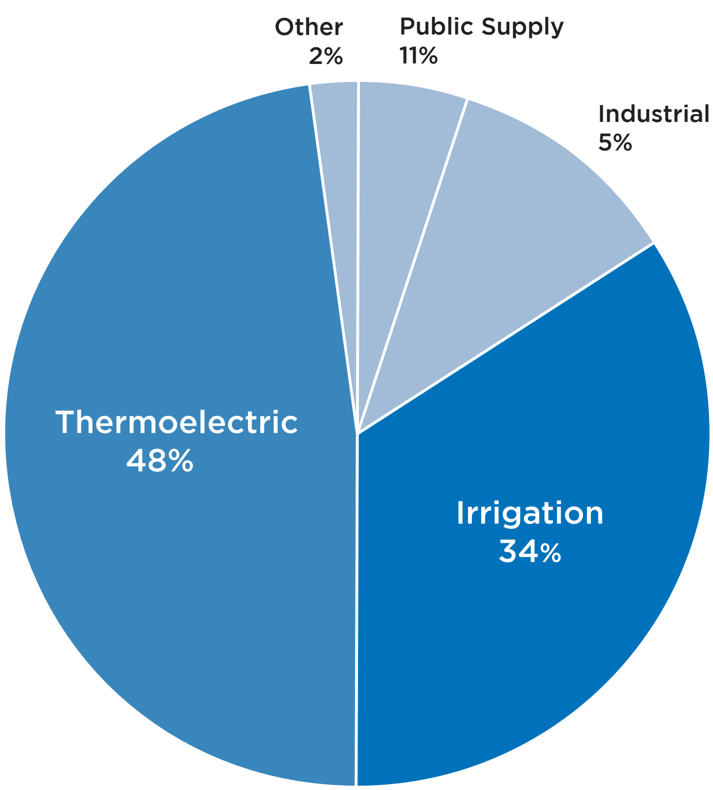
- Biofuels (ethanol/methanol And biodiesel)
- Electrical Generation (wind, water and solar power)
- Hydrogen Power
- Historically wasted energy (digester gas and landfill gas)

Some of these options, however, use a significant amount of water to produce that power. According to Michael Webber of the Center for International Energy and Environmental Policy at the University of Texas-Austin, at least 40 gallons of water is required to generate the fuel required to travel one mile on an ethanol-powered vehicle. Also, Webber's research has shown that replacing all gasoline-powered vehicles with electric vehicles would require 17 times more water, nearly 11 gallons per mile, compared with the 0.6 gallons of water per mile it takes to power today's vehicles with low fuel mileage rates. These factors create a complicated relationship between energy and water because most alternative energy options require an increase in use of water for production.

Several industries use water in one form or another to transfer energy, especially power plants. The other side to the energy-water nexus is the energy cost associated with collecting, pumping, treating and distributing water to meet consumer demands. This energy cost is substantial, as all the water is treated to a high level of purity and sanitation regardless of its intended use, be it drinking, landscaping industrial cooling, or even water for bathrooms and toilets.

Climate change has forced the energy-water nexus into the forefront. The US government has recently taken steps to accelerate problem solving for this issue. In late 2006, the Department of Energy delivered a report to Congress on the interdependence of energy and water. This was complemented by the Energy-Water Roadmap, a series of workshops that solicited opinions from more than 300 water managers and regulators on where gaps lie in efforts to sustain future supplies of these precious resources (Hoyle, 2008).

Agencies should consider options for dealing with the energy-water nexus in their specific situation. Actions taken now would save energy costs, conserve water and help create a sustainable world in the future, all while providing the resources needed to continue agency operations. Agencies can develop best practices, as listed in Section 3 on energy management and in Section 4 on water supply and distribution, to help mitigate issues relating to the energy-water nexus. It is also important to create awareness by making information available to the public and by stressing the connection between energy and water.



As much water is used for producing electricity as for irrigation. The total quantity of water withdrawn for thermoelectric power in 2000 was an estimated 195,000 million gallons/day.

Figure 2. Water Use in the United States

Source: U.S. Geological Survey, 2000

Section 2
Greenhouse gas emissions

Most greenhouse gas emissions are related to energy use in some manner, such as the purchase of electricity from the local utility, burning natural gas in building HVAC systems, burning gasoline in automobiles, etc. Some significant exceptions occur, but mostly in industry, not agencies. The two categories that comprise the greatest emissions in the inventories for the United States and for California are electrical generation and mobile sources, respectively. The link between greenhouse gas emissions is so close that most greenhouse gas estimating techniques begin with pulling records of energy use.

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Whenever greenhouse gases are of interest, the first action should be to establish a baseline emission inventory. Baseline inventories are imperative to take full advantage of future actions that will reduce greenhouse gas emissions. This is because the inventories that will define the amount of reduction in greenhouse gases for the purpose of assigning carbon credits must be audited by a third party, for both the baseline and post-project inventory.

It is not the purpose of this manual to provide step-by-step direction for conducting a greenhouse gas emission inventory. For that purpose, the reader is referred to the most current version of The Climate Registry General Reporting Protocol (http://www.theclimateregistry.org/downloads/GRP.pdf)

Sources of greenhouse gas emissions are typically categorized as indirect or direct emission sources. Indirect emissions occur as a result of an agency purchasing processed energy from another entity, typically a public utility. For example, electricity purchased from PG&E by a water utility to run pumps will result in a portion of the greenhouse gas emissions from PG&E being counted on the water utility's inventory. Best practices for reducing indirect emissions all reduce energy purchases from third parties. They may include replacing purchased energy by self production or reducing purchased energy by conservation. They may be as simple as replacing light bulbs with more energy-efficient bulbs or as complicated as installing a fuel cell. This topic is discussed in more detail in Section 3.

Direct emissions are from sources that are owned or operated by the public agency itself, such as mobile combustion sources (e.g., automobiles, trucks), stationary combustion sources (e.g., building heaters, boilers), process emissions (e.g., refrigerant change-outs), and fugitive sources (e.g., methane from wastewater systems). Public agencies can help reduce greenhouse gas emissions from direct sources by using some of the best practices below:

- Changing equipment/processes to operate more efficiently
- Implementing predictive operations and maintenance
- Choosing alternative fuels for mobile and stationary sources
- Reworking crew scheduling and routing to optimize travel and productivity
- Conserving energy within agency buildings (refer to Section 3)
- Generating on-site power, such as the use of solar panels to reduce electricity usage (refer to Section 3)
- Supporting electric companies to move toward alternative energy options
- Selecting green alternatives within the supply chain

Mobile Sources

Typically, fleet vehicles are the primary mobile source of emissions for an agency. As with any internal combustion powered automobile, gasoline and diesel fuels used in these vehicles result in greenhouse gas emissions. Every gallon of gasoline or diesel fuel consumed creates approximately 20 pounds of greenhouse gas emissions; therefore, it is crucial for public agencies to reduce emissions with a combination of cleaner burning fuels, fuel-efficient vehicles, and more efficient operational practices. Best practice approaches for lowering mobile air emission sources may include:

- Using alternative fuels
- Operating fuel-efficient vehicles
- Altering crew scheduling and routing

Laws, Regulations and Programs for Mobile Sources

Several laws, plans, programs, studies and such exist for alternative fuel and vehicle use that agencies should consider to reduce spending and to slow global warming. State laws, regulations and other programs that relate to alternative fuel usage include:

- Emission Reduction Requirements (Reference California Code of Regulations Title 13, Division 3, Chapter 1, Article 1, Section 1956.1)
- Alternative Fuels Plan (Reference Assembly Bill 1007, 2005, Assembly Bill 1012 and 2264, 2006, and California Health and Safety Code Section 43865)
- Alternative Fuel Vehicle (AFV) Acquisition Requirements (Reference Assembly Bill 1660, 2005, Assembly Bill 236, 2007,California Health and Safety Code Section 43810, and California Public Resources Code Section 25725)
- Biofuels Use (Reference Senate Bill 975, 2005, and California Health and Safety Code 43860)
- Zero Emission Vehicle (ZEV) Production Requirements (Reference California Code of Regulations Title 13, Division 3, Chapter 1, Article 1, Section 1962)
- Biofuels Specifications (Reference California Code of Regulations Title 4, Division 9, Chapter 6, Article 5, Sections 4145, 4146, 4147, and 4148)
- Biofuels Production Mandate and Alternative Fuel Use Study (Reference Executive Order S-06-06, 2006)
- Alternative Fuel Vehicle (AFV) License (Reference California Revenue and Taxation Code Section 10759.5)
- Alternative Fuel Tax (Reference California Revenue and Taxation Code Section 8651 to 8651.8)
- Truck Idle Reduction Requirement (Reference California Code of Regulations Title 13, Division 3, Chapter 10, Article 1, Section 2485 and Assembly Bill 233, 2007)

- School Bus Idle Reduction Requirement (Reference California Code of Regulations Title 13, Division 3, Chapter 10, Section 2480)

Agencies should also be aware of proposed legislations that could affect day-to-day fleet fuel usage. The BioFuels Security Act is a proposed legislative Act of Congress intended to phase out current single-fueled vehicles in favor of flexible-fuel vehicles. Also the E85 and Biodiesel Access Act could be included in any energy legislation that may be approved during this session of Congress. Finally, the President and several members of the United States Congress have recently called for mandatory production of flexible fuel vehicles.

In the United States, all vehicle conversions (except pure battery electric vehicles) must meet current applicable USEPA standards. USEPA instituted these standards to assure unimpaired emission control of motor vehicles throughout their useful life. Vehicles operating in California must follow conversion rules issued by the California Air Resources Board (CARB). In addition, vehicle conversions that require the addition of heavy battery systems or additional fuel tanks that may alter a vehicle's center of gravity, payload capacity, or handling characteristics may also need to be safety crash tested and certified to comply with Federal Motor Vehicle Safety Standards (FMVSS) and/or other National Highway Traffic Safety Administration (NHTSA) regulations (http://www.afdc.energy.gov/afdc/vehicles/index.html).

Agencies' vehicle conversions must be certified according to Mobile Source Enforcement Memorandum 1A (Memo 1A) issued with the Revision to the Addendum to Memo 1A, issued in 1998. The vehicle converter holds the Certificate of Conformity, issued by EPA, for each type of converted vehicle. An individual or entity wishing to convert a vehicle to operate on an alternative fuel must go through a company or organization associated with a certificate holder, and the work must be performed by a licensed technician associated with that company. It is the certificate holder's responsibility to ensure the equipment is properly installed and that it is safe, durable and meets the emission standards of the original model year of the vehicle. The Alternative Fuels Data Center of the U.S. Department of Energy can provide additional information to agencies.

Alternative Fuels

Fuels that are defined as alternative fuels by the Energy Policy Act of 1992 and are currently commercially available for vehicles include biodiesel, electricity, ethanol, hydrogen, methanol, natural gas and propane. Of these, the three most commonly used alternative fuels that should be considered for best practices are biodiesel, electricity and ethanol. Figure 3 below gives

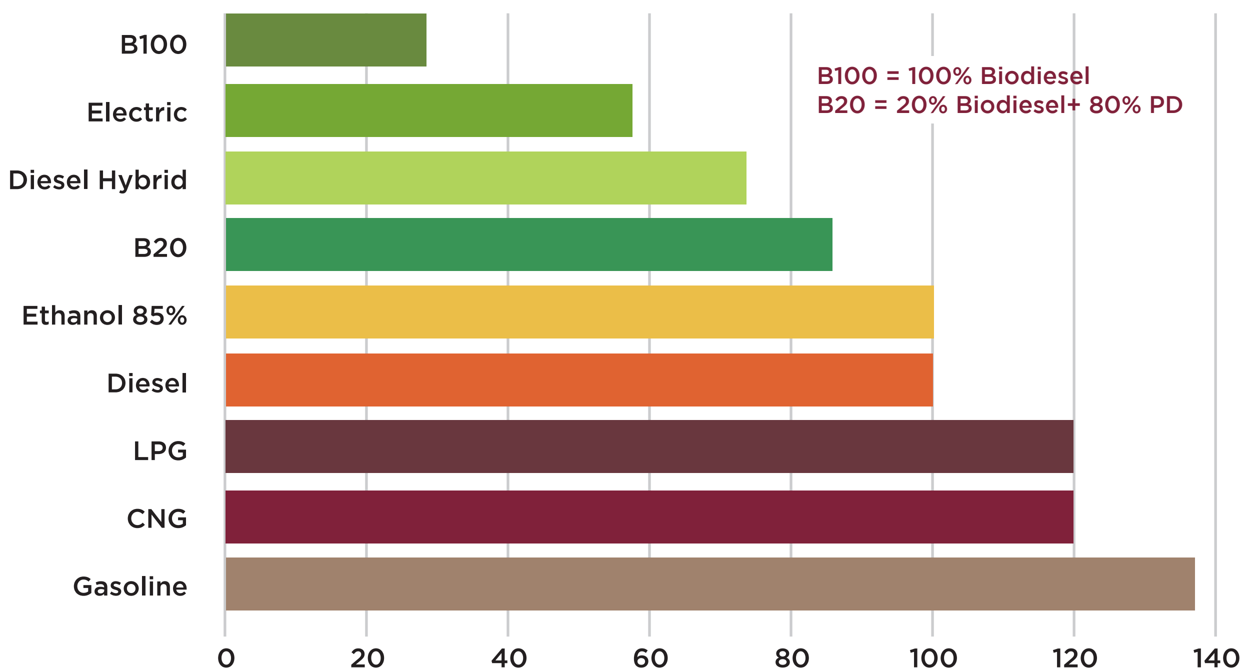

Figure 3. Relative Percentages of Global Greenhouse Gas Emissions

Source: www.shivaoutdoors.com/biotechx/index.php?id=24 a basic summary of percent of greenhouse gas emissions relative to diesel for several other fuel types.

Biodiesel is generated from non-petroleum oil (vegetable or animal) and is manufactured from carbon sources that are already part of the earth's balanced carbon cycle. Biodiesel in blends of either B2 (2 percent biodiesel, 98 percent diesel), B5 (5 percent biodiesel), and even B20 can be used in any vehicle equipped to use diesel fuel with little or no modification.

Several operability issues exist with biodiesel. Some include cold fuel flow, fuel foaming, water separation, and fuel oxidative stability. These issues can lead to reduced drivability, higher emissions than baseline, and increased maintenance costs. Older diesel vehicles (usually before 1992) would need to be upgraded or converted to prevent damage to rubber fuel lines and internal engine seals before biodiesel can be used. Also, biodiesel tends to release residue existing in fuel lines and cause clogging of filters when first used. In colder climates where the biodiesel could congeal, heating systems may need to be installed. Some manufacturers limit the percentage of bio-fuels used to maintain engine warrantees. Vehicle manufacturers may even void the vehicle's warranty if the engine is run on any particular fuel or combination for which it was not originally engineered. Operability issues can be averted somewhat by using additives such as anti-oxidants, cold flow additives, biocides, and NOx reduction additives.

Also, the CARB recently established rules that may be incompatible with some bio-fuel systems. Currently, biodiesel has not been approved to be sold in California in blends higher than 20% biodiesel.

As agencies consider possible actions to reduce air emissions, they should be cognizant of other impacts, both positive and negative that may occur as a result of their decision. For instance, Figure 4 shows that biodiesel, in certain percentages, can result in an expected decrease in greenhouse gas emissions while also resulting in an increase in other air pollutants, such as nitrous oxide (NOx). According to recent testing by the California Air Resources Board however, new engines may not produce an increase in NOx emissions. Research is currently underway in the governmental, public, and private sectors on these issues.

Another issue is availability and cost. The Energy Information Administration has found that production of biodiesel from "yellow grease", made from animal fats and oils, is more cost effective than production of biodiesel from soybean oil. However, yellow grease's supply is limited and has other production sectors it can feed into. Therefore, only small quantities would be available for biodiesel, lending it to be better suited for biodiesel blends. Currently according to the Department of Energy Alternative Fuels and Advanced Vehicles Data Center, the closest gas stations providing biodiesel in the immediate Sonoma County area are in Petaluma and Santa Rosa areas.

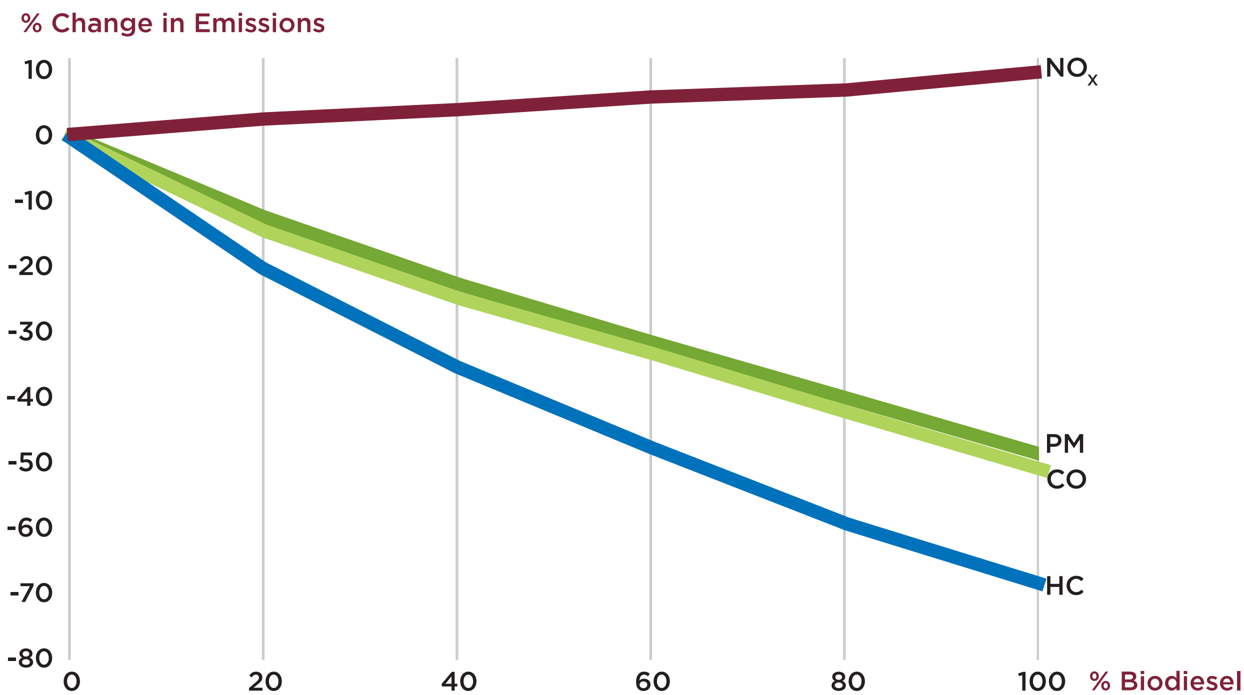

Figure 4. Average Emission Impacts of Differing Biodiesel Blends

Source: USEPA 2002

Electricity used to power fleet vehicles is an option that completely eliminates direct emissions, but increases indirect emissions, unless alternative energy is used as described in Section 3.

Hybrid vehicles are an established alternative vehicle that is equipped to use both gasoline and electricity as a power source. Toyota, GM, Ford, Lexus and Honda are some examples of automotive companies with available Hybrid vehicles on the market. Fleet vehicles could also be replaced with low-speed electric vehicles (LEVs) for use in confined environments such as warehouses, in-town commuting, meter readers, or anything that requires limited travel distances or parking convenience. Either vehicle will significantly cut an agency's direct mobile emissions, though will increase indirect emissions. As energy companies move more and more toward renewable energy sources, this option will be more and more sustainable. Plug-in stations currently are available in the Napa, Petaluma and Santa Rosa regions.

Battery recycling for hybrid and electric vehicles may cause concern in the future if these vehicles were to be produced in significant quantities. The energy consumed in recycling the batteries and the solid waste created may prove to throw off a GHG life-cycle analysis more so than any other alternative fuel source.

Ethanol fuel is another option produced from mixing fuel made from a renewable source (grain) and unleaded gasoline. The result is decreased direct cost to the agency, increased octane rating, and decreased greenhouse gas emissions. Ethanol is available in two blends—10 percent ethanol for all vehicles, and 85 percent ethanol for Flex Fuel Vehicles (FFVs). Figure 5 summarizes different types of ethanol and the related percent reductions in greenhouse gases compared to gasoline use in vehicles depending on the method used to process each fuel.

The US Department of Energy also provides a Flexible Fuel Vehicle Cost Calculator for agencies considering the use of E85 in FFVs. Currently, public agencies can purchase alternative fuel vehicles, have existing cars retrofitted by an authorized shop, or have the car factory converted, if those options exist. FFV manufactures include Chevrolet, Fiat, Ford, Peugeot, Renault, Honda, Mitsubishi, Toyota and Citroën. Chrysler, General Motors and Ford have each pledged to manufacture 50 percent of their entire vehicle line as flexible fuel by model year 2012, if enough fueling infrastructure develops.

Alternative fuel technologies are combining as well. The new plug-in hybrid vehicle Chevrolet Volt by General Motors, expected to be launched in the North American market in 2010, will take advantage of the E-Flex technology used today in GM's E-85 flex cars as one of the options that will be developed to recharge the batteries.

Currently, drawbacks to FFVs include a CARB rule that makes quantities of ethanol greater than 10 percent illegal in fuel used in standard gasoline-powered vehicles. Others include unknown cost and questionable availability. Though FFVs are becoming more readily available, ethanol fuels are not necessarily showing the same presence at gas stations in the Sonoma County region.

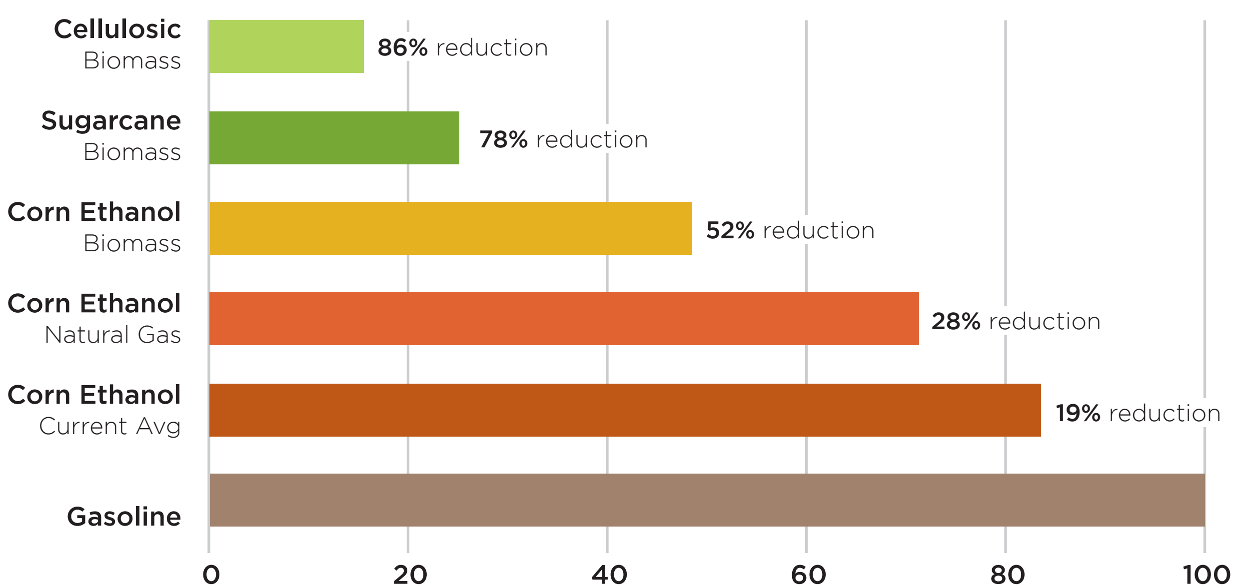

Figure 5. Greenhouse Gas Emissions from Transportation Fuels Classified by Energy Source

Source: Wang, 2007

The "food vs. fuel" debate is another factor to incorporate into the alternative fuel and sustainability scheme. The debate focuses on the dilemma regarding the risk of diverting farmland or crops for bio-fuels production. This is a detriment to the food supply on a global scale. Not only will prices for corn and soybeans rise, but these products will become scarce for the average consumer.

Compressed Natural Gas (CNG) is an additional option as an alternative energy source. Although its combustion does produce CO2, it is an environmentally cleaner alternative compared to gasoline, as shown in Figure 3. CNG is made by compressing natural gas (which is mainly composed of methane), to more than 3000 PSI so that it occupies less than 1 percent of its volume at standard atmospheric pressure. CNG is used in traditional gasoline internal combustion engine cars that have been converted into bi-fuel vehicles (gasoline/CNG). CNG can be used in gasoline and modified diesel cycle engines, but it is recommended to upgrade new vehicles only, rather than older vehicles. Agencies should also keep in mind that improperly installed CNG systems in vehicles may increase greenhouse gas emissions.

Depending on the relative cost of CNG and gasoline, CNG may be a cheaper option in terms of dollars per unit energy. Refer to Figure 6 for this comparison. Also note that this energy equivalence comparison does not take into account the infrastructure needed for a CNG refueling station, which adds to the initial capital cost. Refer to the US Department of Energy's Alternative Fuels and Advanced Vehicles Data Center (AFDC) Cost Calculator for detailed information on CNG's cost in the Honda Civic GX.

Hydrogen fuel cells for vehicles could be considered in the future; however, currently there is an inconsistency with the production and use. The first issue lies in the production of hydrogen energy itself. Whether it is by petroleum or natural gas, it takes energy to produce hydrogen power. To complicate the issue, creating hydrogen power, depending on the process used, will emit greenhouse gases.

Automobile companies that are working on concept hydrogen fuel cell powered vehicles include Audi, Mazda, BMW, Daimler, Fiat, Chrysler, Honda, Toyota, Ford, General Motors, Morgan, Renault, VW, Nissan and Hyundai/Kia.

Other emerging sources of fuel to watch for include Biobutanol, Biogas, Biomass to Liquids (BTL), Coal to Liquids (CTL), Fischer-Tropsch Diesel, Gas to Liquids (GTL), Hydrogenation-Derived Renewable Diesel (HDRD), and P-Series Ultra-Low Sulfur Diesel (http://www.afdc.energy.gov/afdc/fuels/index.html). Some of these are sustainable; some may not be sustainable energy sources. Cars running on vegetable oil are also being considered as viable options to cut air emissions and fuel costs, although accessibility is an issue. It is important for the success of a fuel switching project to select the most appropriate fuel for the circumstances and that considers factors such as cost, availability and reliability of supply.

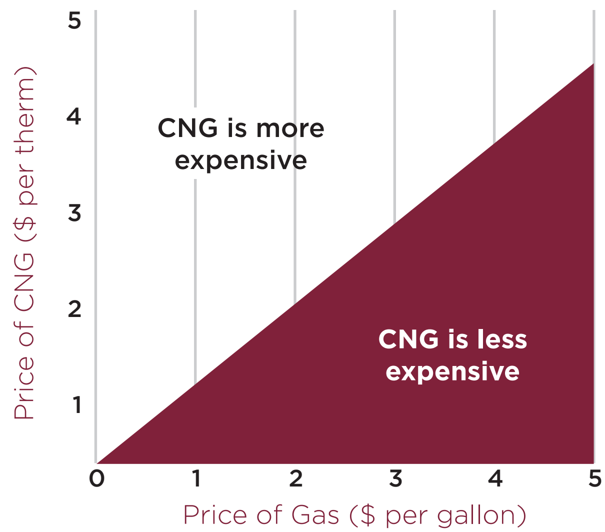

Figure 6. Gasoline and CNG Energy Equivalence and Cost Comparison

Automotive companies are constantly improving on and showcasing new alternative vehicle models. Agencies should consider this when looking into alternative fuels as a best practice.

Crew Scheduling and Routing

Apart from developing best practices in the areas of alternative fuels, agencies can consider ways of operating vehicles less and in more efficient ways to reduce air emissions. This can be done by smart crew scheduling and routing. Best practices include:

- Consider allowing staff to reduce commute by dispatching from home to job site
- Keeping all job sites for each crew member in close proximity to each other for that day
- Arranging order of crew site visits in a manner that reduces mileage
- Scheduling site visits during non-peak commute hours

Other transportation-related measures that could help agencies cut down on air emissions from vehicles are:

- Engine idling reduction measurements
- Incorporating systems to power accessories with vehicle engine off
- Driver education and outreach programs

For heavy-duty trucks, reduction equipment can include auxiliary power units, automatic engine stop-start controls, cylinder deactivation, cab and block heaters, air conditioners, and truck stop plug-in stations. Three types of idle reduction technologies available for light- and medium-duty vehicles are coolant heaters, air heaters, and energy recovery systems.

In addition, there are certain things that every driver can do to reduce idling:

- Turn off engine when parked or stopped (except in traffic) for more than a minute
- Avoid using a remote vehicle starter, which encourages unnecessary idling
- Avoid the drive-through; walk inside instead

Further, as a general rule, buses should be moving whenever the engine is on, and the engine should be turned off as soon as possible after arriving at loading or unloading areas. The bus should not be restarted until it is ready to depart, and idling time should be limited during early morning warm-ups to what the manufacturer recommends (generally no more than five minutes).

Employee Commute

Apart from creating routing schedules for crew members, carpooling and alternative transportation methods should be encouraged for all members of an agency. Trip reduction management best practices should be to:

- Encourage car-pooling or van-pooling by employees
- Encourage telecommuting by employees where appropriate
- Encourage use of mass-transit or human-powered units by agency employees (Sonoma GHG Action Plan)

These processes could be implemented by any agency, though additional planning and time would be required. The benefits of "smart" or sustainable crew scheduling and routing are important as these steps would help reduce air emissions from vehicles, increase an agency's efficiency, and decrease costs.

Stationary Sources

Most agencies have stationary combustion sources of emissions from items such as boilers, heaters, furnaces, kilns, ovens, flares, thermal oxidizers, dryers, and any other equipment or machinery that combusts carbon-bearing fuels or waste streams. Best practices should be developed for stationary combustion sources such as the use of alternative technologies and resources, and equipment and process changes.

Alternative Technologies and Resources

Biodiesel can also be used in stationary sources as a best practice as a heating fuel in domestic and commercial boilers. Older furnaces may contain rubber parts that would be affected by biodiesel's solvent properties but can otherwise burn biodiesel without any conversion required. Care must be taken at first; however, given that varnishes left behind by diesel will be released and can clog pipes, fuel filtering and prompt filter replacement is required. Another approach is to use biodiesel as a blend, and decrease the petroleum proportion over time to allow the varnishes to come off more gradually and be less likely to clog. Strong solvent properties, however, clean out the furnace and make it more efficient. Agencies should not use biodiesel in emergency generators; however, as when biodiesel is left unperturbed, it can separate or congeal.

Another best practice may be for furnaces to be completely replaced by geothermal heat pumps, which would greatly cut down on CO2 emissions. Refer to Section 3 for detailed information on heat pump technology.

Equipment and Process Changes

There are two situations when it makes sense for an agency to change out old equipment for new, more efficient equipment:

- When the equipment has reached the end of its useful life
- When replacing the equipment is financially beneficial

New combustion equipment will likely reduce production of air emissions, but not necessarily direct greenhouse gas emissions. In fact, one common air emissions control method is to convert carbon monoxide (a pollutant) into carbon dioxide (a greenhouse gas), as occurs in catalytic converters. One new and emerging technology for reducing direct carbon dioxide emissions from stationary equipment is carbon sequestration. This emissions control method aims to capture the carbon generated during the combustion process and somehow sequester or store it permanently. This technology is still in the development phase and is not currently recommended for use other than research studies for future technology options.

Most indirect emissions and greenhouse gasses are generated by equipment and processes that use electrical power. The simple method to reduce these emissions is to reduce power consumption. The Flex Your Power resource gives a broad array of energy saving options and services, including energy-efficient equipment, process equipment and systems, process change help, demand response programs, in-house renewable energy options, audits, education and training, equipment testing and repair, and diagnostic and measurement tools (refer to www.flexyourpower.org).

Refer to Section 3 for Energy Efficiency in Buildings and Alternative Energy options.

Predictive Operation and Maintenance

Predictive operation and maintenance (O&M) strives to predict the onset of equipment degradation or to address problems before they are identified. This comprehensive approach will save on energy costs and reduce greenhouse gas emissions for agencies. Predictive O&M bases the maintenance needed on the actual condition of the equipment, rather than on a set schedule.

Advantages of using the predictive O&M include:

- Increased component operational life and availability
- Preemptive corrective actions
- Decrease in equipment and/or process downtime
- Lower costs for parts and labor
- Better product quality
- Improved worker and environmental safety
- Improved worker morale
- Increased energy savings
- An estimated 8 percent to 12 percent cost savings over a preventative management approach

Disadvantages include increased investment in diagnostic equipment and staff training. Overall, equipment will be operated at an optimal level, which will save energy costs, decrease greenhouse gas emissions, and increase plant reliability.

To evaluate equipment condition, predictive maintenance uses nondestructive testing technologies such as infrared, thermography, acoustic (partial discharge and airborne ultrasonic), corona detection, vibration analysis, sound level measurements, oil analysis, and other specific online tests.

Refer to www.PlantServices.com for several resources for help choosing and implementing a predictive operations and management approach within an agency. The website offers news, articles, research papers and new products available to meet predictive O&M needs.

Section 3

Energy management:

The cornerstone of sustainability

Energy management is the cornerstone of sustainability because energy use is directly linked with greenhouse gas emissions. This, in turn, has a direct impact on global climate change; therefore, energy management, or using technologies to lower energy use, is an essential tool for running a sustainable agency. In the United States, power generation is the single largest contributor of carbon dioxide to the atmosphere, constituting about 33 percent of all carbon dioxide emissions (USEPA, 2008a). According to PG&E's California Public Utilities Commission-approved ClimateSmart program, PG&E generates an average of 0.524 pounds of CO2e/kW-hour from power generation; therefore, the best practices related to energy management include reducing energy use, improving energy efficiency, and using alternative energy sources.

The following best management practices are intended to provide tools and information to help agencies understand, plan and implement efforts to improve energy use.

Quantifying Energy Use

Before implementing an energy improvement project, it is important to understand the project's costs and the projected amount of energy the project will save. A project may produce electrical power directly, such as a solar panel, or it may consume less power than the system it is replacing, such as a lighting efficiency project. For projects that replace an existing system, the current power usage of that system must be determined (baseline) to quantify the new system's power savings. Understanding these characteristics is essential to developing a realistic estimate of simple payback.

A simple payback calculation shows the time, usually in years, that a project will take for its monetary benefit to outweigh its cost, i.e., to pay for itself. Simple payback calculation is explained in Section 6.

Energy Efficiency in Buildings

Best practices related to improving energy efficiency in buildings are recommended to be evaluated and addressed in the order presented below; however, this list is not meant to be exhaustive:

- Building upgrades
- Lighting systems
- IT equipment selection
- HVAC system

By approaching improvements in this order, it ensures that the improvements performed are effected by previous improvements and will result in the greatest overall energy savings. Categories at the bottom of the list are dependent on the preceding categories. For example, changing out heat-producing incandescent lights to low heat producing fluorescent lights will affect the needed distribution of cooling air and the baseline load on the HVAC system.

Figure 7 below from the Energy Star® website represents the energy use percentages for an average building, emphasizing the impact of implementing best practices in the areas listed above.

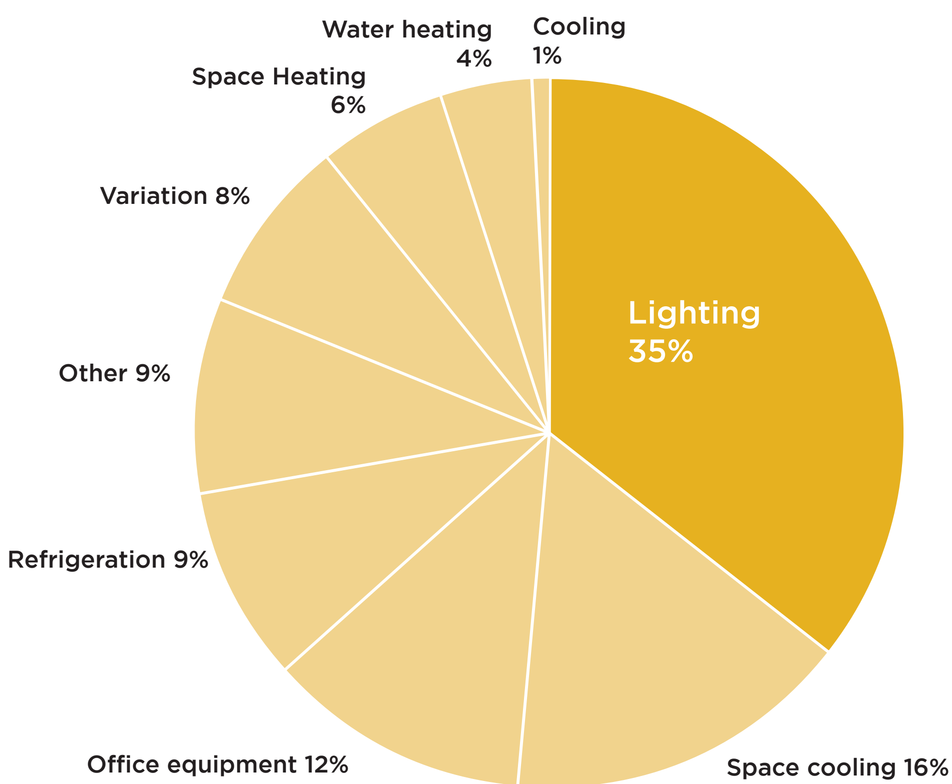

Figure 7. Average Estimated Energy Use Distribution by End Use for John Doe Building

Source: http://www.energystar.gov/index.cfm?c=business.EPA_BUM_CH6_Lighting

Building Upgrades

The Energy Star® Building Upgrade Manual (October 2007) denotes building upgrades as the first step to a successful energy efficiency plan. Initially, systems should be designed, installed, functionally tested, and capable of being operated and maintained according to the owner's operational needs. In a typical building setting, an upgrade would include evaluating existing systems such as lighting and HVAC to ensure they meet specified performance requirements and are installed and configured correctly.

Building upgrades are a good first step in implementing energy-saving projects. For example, if a problem exists in an HVAC system, such as a faulty timer, it can be addressed and corrected before embarking on more costly new projects that may yield less of an energy savings gain. In this example, correcting the timer issue for the HVAC system would most likely be a very cost-effective project, with a payback measured in weeks, if not days.

The building upgrade process has the potential to identify the 'low-hanging fruit' of energy conservation measures and will provide a solid backdrop as a basis of comparison for future improvements. Building upgrades are recommended as a best practice first step in an agency's energy efficiency program.

Lighting Systems

Lighting systems are a large segment of building energy use. Energy consumption for all lighting in the United States is estimated to be about 22 percent of the total electricity generated in the country. Converting electricity into useful light is one of the least efficient energy conversion processes in buildings today. Advanced lighting technologies can significantly improve the energy efficiency of lighting and reduce building energy consumption and costs. The following list highlights possible best practices for lighting technology improvements:

- Upgrade T12 fluorescent tube lamps (1.5-inch diameter) and magnetic ballasts with T8 lamps (1-inch diameter) and electronic ballasts. Replacing lamps and ballasts with more efficient light lamps and ballasts can produce an energy savings of up to 20 percent.
- Use motion sensors and photocells. Motion sensors allow lights to be used only during movement in a room or by timed durations, which minimizes lighting areas with no occupancy. Photocells can reduce lighting intensity when enough ambient natural light is available.
- Replace incandescent lights with compact fluorescents. Replacing incandescent lights with more efficient lighting provides a substantial energy savings, typically about a 75 percent reduction in energy consumption, for the same light output. It is also important to note that incandescent lights require appropriate disposal.
- Add vending misers to cold beverage machines. While not a lighting system, vending machines have similar usage pattern to lighting systems in that most are left on for prolonged periods of time. Vending misers consist of a motion sensor and timer that manages vending machine operation to reduce its energy consumption by extending the cooling cycle. A typical beverage vending machine uses 3,500 kWh over the course of a year. At $0.10/kWh, the cost to operate the beverage machine is $350 per year. Using such a device, energy consumption is typically reduced by about 46 percent. If the vending machines are owned by an outside company, an agency can request that an energy management device be installed on the machines you use.
- Use day-lighting when applicable. Day-lighting is allowing natural ambient light to enter a working space. If enough natural light is available, minimal electrical lighting may be used.
- Install multi-level switches. Multi-level switching allows the occupants of a room to adjust and control lighting illumination levels to meet their needs. Allowing occupants this level of control will enable them to use only what they need, which reducing lighting power consumption.
- Upgrade exit signs with light-emitting diode (LED) lamps. Exit signs with LEDs provide longer illumination life and use less energy. Such signs operate continuously, so the improved efficiency of these lights will be realized 24 hours a day.
- Delamp and add reflectors for lights to meet minimum level of Illuminating Engineering Society of North America (IESNA) levels. Delamping and adding reflectors requires removing typical fluorescent lighting systems, which essentially removes unnecessary lights.

A comparison of the various types of available lighting technologies is shown in Table 1.

Emerging Technology – LED Lighting. LED lighting is an emerging technology that has the potential to replace conventional lighting sources in both retrofit and new construction situations. The LED itself is highly efficient at producing light, but the system of LED's with their ballast and control circuitry determines the device's overall light efficacy. Currently, this technology is very new, and the cost-benefit for implementation is difficult to define. This technology should be reevaluated in the future as LED lights have the potential to surpass fluorescent bulbs in efficacy and to reduce lighting energy consumption.

IT Equipment Selection and Operation

Information Technology (IT) equipment, such as computers, monitors, printers and copiers, can consume 10 percent of the electrical power used by the building according to the 2003 Commercial Buildings Energy Consumption Survey (CBECS). This presents an opportunity to evaluate and improve on the energy

Table I. Lighting Comparison Chart

Lighting Type	Efficacy (lumens/watt)	Lifetime (hours)	Color Rendition Index (CRI)	Color Temperature (K)	Indoors/ Outdoors
Incandescent					
Standard "A" bulb	10–17	750–2500	98–100 (excellent)	2,700–2,800 (warm)	Indoors/Outdoors
Tungsten Halogen	12–22	2,000–4,000	98–100 (excellent)	2,900–3,200 (warm to neutral)	Indoors/Outdoors
Reflector	12–19	2,000–3,000	98–100 (excellent)	2,800 (warm)	Indoors/Outdoors
Fluorescent					
Straight Tube	30–110	7,000–24,000	50–90 (fair to good)	2,700–6,500 (warm to cold)	Indoors/Outdoors
Compact Fluorescent Lamp (CFL)	50–70	10,000	65–88 (good)	2,700–6,500 (warm to cold)	Indoors/Outdoors
Circline	40–50	12,000	–	–	Indoors
High-Intensity Discharge					
Mercury Vapor	25–60	16,000–24,000	50 (poor to fair)	3,200–7,000 (warm to cold)	Outdoors
Metal Halide	70–115	5,000–20,000	70 (fair)	3,700 (cold)	Indoors/Outdoors
High-Pressure Sodium	50–140	16,000–24,000	25 (poor)	2,100 (warm)	Outdoors
Low-Pressure Sodium	60–150	12,000–18,000	-44 (very poor)	–	Outdoors

Source: DOE EERE Website *http://apps1.eere.energy.gov/consumer/your_home/lighting_daylighting/index.cfm/mytopic=12030*

efficiency of IT equipment, especially when the equipment is scheduled for replacement.

Workstation computers and monitors make good candidates for energy management. Most modern computers and operating systems let a system administrator set power management features, such as turning off the screen or changing the computer to sleep, standby or suspend mode. A best practice approach should be to purchase Energy Star®-compliant IT equipment that supports a minimum level of energy management. These features, while not applicable to equipment that must always be on (e.g., servers or monitoring computers), can substantially reduce the amount of power consumed by IT devices.

For example, placing a typical desktop computer in standby mode can reduce its power consumption by 90 to 95 percent; placing a cathode ray tube (CRT) monitor in standby mode can reduce its power consumption reduced by 90 percent. A liquid crystal display (LCD) monitor in standby mode consumes almost no power.

Copy machines use more energy per unit than any other piece of common office equipment. Without energy management features, most of that power is consumed when the copier is not in use. Energy Star®-certified copiers use power saving features to lower the power consumed in standby and off modes. Also, the copier size should match office needs—a high-volume copier that gets minimal use is not as efficient as a low-volume copier in the same situation. Additionally, while reducing copies is also a direct power reduction, using less paper saves money and energy indirectly. For a typical copy machine, it takes 10 times the energy to produce a copy as the energy required to print on its face. Using auto-duplex features (automatically printing on both sides of the page) and establishing general printing policies will reduce paper consumption, save money and reduce direct and indirect energy consumption.

Power management features generally work by sensing user inactivity and changing the copier, computer or monitor power modes based on preset time limits. By ensuring these features are enabled and by establishing a universal IT power management policy, wasted energy consumption by IT devices can be greatly reduced.

Guidelines for replacing equipment – When replacing IT equipment, the most energy efficient equipment available should be selected. At a minimum, Energy Star®-certified equipment should be purchased. A newer standard, the Electronic Product Environmental Assessment Tool (EPEAT), is an environmental procurement tool designed to help institutional purchasers in the public and private sectors evaluate, compare and select desktop computers, notebook computers and monitors based on their environmental attributes. EPEAT rates products based on their energy performance and the environmental impact of manufacturing and disposing of the product, and even on general corporate programs, such as a Corporate Environmental Policy or Environmental Management System.

EPEAT has three rating levels—bronze, silver and gold. All of the ratings meet the mandatory requirements, while silver and gold include optional requirements. All EPEAT-rated product also meet Energy Star® certification. See the EPEAT website at www.epeat.net for more information.

Heating, Ventilation and Air Conditioning (HVAC) System

Heating, ventilation and air conditioning systems consume energy and are generally operated while a building is occupied. According to 2003 data from the Energy Information Administration, HVAC systems account for 39 percent of the electricity use and 44 percent of natural gas use in buildings in the Pacific Region.

Heating and cooling distribution systems bring heated or cooled air to occupied spaces inside buildings to control temperature and humidity, and to maintain them at a comfortable level. A distribution system generally consists of water or steam piping (for a water-based system) and air ducting, fans, louvers and registers. On average, the fans that move conditioned air through commercial office buildings account for about 7 percent of the total energy consumed by these buildings. So reducing fan electricalconsumption can result in significant energy savings. Details on implementing two best practices are described below.

Rightsizing air system fans. A USEPA study found that almost 60 percent of building fan systems were oversized by at least 10 percent, with an average oversizing factor of 60 percent. By using properly sized fans, an air distribution system will use only the energy it needs to blow air through it.

TAB analysis. Testing and Balancing (TAB) analysis for an air or water distribution system evaluates, identifies and corrects imbalances in the supply of heating and cooling air or water in a building HVAC system. The goal is to match the amount of air or water distributed to different portions of a building with the necessary load at those portions. For air systems, this is accomplished by measuring and adjusting dampers, fans, flow rates and air temperatures. For water systems, this is accomplished by adjusting and measuring water flow rates and temperatures, as well as pump speeds and pressures. The savings associated with TAB come from reducing the energy used by the heating and cooling system and can range up to 10 percent of heating and cooling costs.

While there are different types of heating and cooling systems, reducing the load on these systems will always reduce energy consumption. Here are a few general HVAC energy saving strategies:

- Calibrate indoor and outdoor sensors. Thermostats, humidistats, and pressure and temperature sensors can drift out of calibration and can send incorrect data to the HVAC control system. Calibrating these sensors would normally be part of a thorough building upgrade process.
- Routinely maintain all HVAC equipment. Maintaining HVAC equipment, which includes regular replacement of filters and cleaning vents/ductwork, will ensure the equipment can run as efficiently as possible.
- Adjust thermostats to regulate the temperature cooler in the winter and warmer in the summer. While this requires a balancing act of occupant comfort with energy savings, it will directly reduce the heating and cooling load on a building with almost no cost for the changes.
- Draw a portion of intake air for the system from the building. While this may cause a slight drop in indoor air quality, reusing some of the return air will reduce the amount of energy the HVAC system will need to either heat or cool it. This strategy is accepted practice under applicable regulation and industry standards.
- Use timers or HVAC system controllers to reduce or eliminate heating and cooling when the building is not in use. Even if an occupancy schedule is already in place, periodically reevaluating it to see if it still properly describes when the building is in use should be considered.
- If an occupancy schedule is not practical or the pattern is erratic, consider using occupancy sensors to trigger or disengage the heating and cooling systems.

The following describe some best practices for creating efficiency within specific HVAC systems. Agencies should consider replacing old systems and should take note of efficiency ratings before acquiring new equipment.

Central air conditioners. Air conditioning systems typically cool a refrigerant with a compression cycle and transfer heat from the incoming air to the refrigerant. This system is powered by an electrical motor and can consume large amounts of energy, especially in the heat of summer. Air conditioning systems have gradually increased in efficiency over time, and newer systems are generally more efficient than older systems. Air conditioning units carry a seasonal energy efficiency rating (SEER) and an energy efficiency rating (EER). Generally, the SEER rating is used for residential units and the EER for commercial units, which are standard for public agencies. For both ratings, a higher number indicates a higher efficiency.

Electrical (resistive) Heating. Electrically powered heating systems are less efficient than direct fuel heating due to the fact that fuel energy must be converted to electricity, sent over transmission lines, then finally converted to heat, as opposed to fuel that is converted directly to heat energy. These systems were eliminated from new construction 20 years ago in California as a result of Title 24.

Chillers. Central chiller plants are usually used for large buildings or groups of buildings and large cooling load applications. A chiller is a cooling device that uses heat and compression cycles to cool water for use in a cold water distribution system. Chillers can also be combined with Thermal Energy Storage (TES) systems to maximize energy use to make cold water when electrical prices are off peak. Chiller plants are very complex, and while the optimization of a chiller plant can provide significant energy savings, the myriad of configurations and possible improvements is beyond the scope of this handbook. Consulting a chiller specialist to reduce energy use and increase plant efficiency is recommended.

Boilers. Boilers use natural gas to heat or boil water for use in a hot water or steam distribution system. These are generally used in large buildings or groups of buildings and facilities. While the average commercial gas boiler has a combustion efficiency (100 percent minus flue losses) of 76 percent, new gas-fired commercial boilers have an average combustion efficiency of 80 percent, and high-efficiency boilers built with condensing heat exchangers have combustion efficiencies as high as 90 percent. For existing boilers, consider installing a combustion monitoring and control system. Such a system can monitor the exhaust gas and modify incoming air to maximize heat output while maintaining emissions limits. Insulating the pipes that transport hot water to minimize heat losses is also recommended.

Low-temperature geothermal heat pump. Heat pumps are mechanical refrigeration devices that provide heat energy, not electricity. Ground source heat pumps are a proven, well-established technology and an exceptionally efficient method of producing heat energy or cooling for building HVAC and domestic hot water. In addition, they supply heat or cooling with a much smaller carbon output than natural gas, the traditional lowest cost fuel for making heat from fuel. Heat pump performance is measured by its COP, or coefficient of performance. The larger the COP, the greater the efficiency of the heat pump. All Energy Star®-certified heat pumps must meet a COP of at least 3.3. These devices take advantage of the fact that ground temperature does not vary nearly as much as air temperature, and uses the ground as a heat sink in the summer and a heat source in the winter. This allows the system to transport heat energy to or from the ground, and while this takes power to perform the task, it does not consume as much energy as generating heat directly (as in a gas or electric heater) or by powering conventional air conditioning units (which transfer heat to the atmosphere). Geothermal heat pumps should be considered when building new construction or replacing aging HVAC equipment.

Energy Efficiency in Water and Wastewater Facilities

As described earlier in Section 1 and Section 2, there is an intricate link between water and energy. Water and wastewater treatment facilities provide some unique opportunities for energy management. Both of these industries consume large amounts of power; water treatment plants consume the most power pumping water, while wastewater facilities usually have aeration systems that are the biggest power consumer. The following summarizes some of the tools available to increase the efficiency and decrease the energy consumption of these facilities.

Variable Frequency Drives (VFDs) at Pump Stations. VFDs allow for pump speed adjustment. VFDs can be used to reduce pump output by reducing pump speed rather than throttling (increasing the frictional losses to slow the flow). Throttling flow is a direct waste of energy. VFDs are most effective when the application demands variable output flow control and when there are only a small number of pumps needed to meet the setpoint. This allows the pumps to be dialed down to the proper speed to meet the desired flow without increasing the flow resistance on the pump.

VFD speed adjustment can also shift the pump operating point to a more efficient region of the pump operating curve. A pump that is not well suited to flow conditions consequently will run at an inefficient point on its operating curve, and a VFD can correct this by moving the pump to its optimal efficiency point. Pumps that are over- or under-sized, or for which a large system change has been implemented, may benefit from adding a VFD.

Biogas recovery and usage. Wastewater treatment plants have an opportunity to harness a renewable energy resource from the methane gas released during wastewater treatment. While not all treatment plants use processes that create this gas, those that do either flare the gas, clean it and sell it to a power utility, or use it to produce onsite energy. A whole host of options exist to use this gas, the most common of which is to power a cogeneration plant designed to produce electrical power and heat. While this energy is produced using hydrocarbon fuel and releases CO2 gas, it is considered to be carbon neutral and sustainable (with proper pollution control measures) because the source of the carbon in the fuel is organic mater, not fossil fuel. This concept also applies to landfills that capture landfill gas. If this gas is flared rather than converted to power, a source of renewable energy is wasted.

Aeration system improvements. Improvements to aeration systems are intended to meet the process need of the system while consuming the least amount of power. The first step is to address the blowers used to move the large quantities of air on which an aeration system depends. Blowers that are not sized correctly, or are older, less efficient models, may be targets for replacement or VFD installation.

The second step is to identify and monitor the amount of aeration needed. Dissolved Oxygen (DO) probes can indicate which parts of the aeration process are getting more or less oxygen than they need. With this knowledge, air distribution can be optimized. The third step is to link the monitoring system to the blower system to control production of air by only producing what is needed, instead of running the blowers at a constant speed and using throttling valves to reduce the unneeded pressure. Improvements to this system have the potential to save energy in the largest energy-consuming process at wastewater treatment plants.

Replace older motors with premium efficiency models. Electric motor efficiency is often overlooked when evaluating pumps and other equipment. Older motors are less efficient than newer models. Replacing a typical T-frame motor with a new premium efficiency motor can reduce electricity consumption by several percent. The more the motor operates, the faster the payback. T-frame-style motors are operated continuously and approaching the end of their useful life are prime candidates. Table 2 below shows the yearly cost savings of switching from a T-frame motor to a premium-efficiency motor for various motor sizes and at 5000 and 7000 annual operating hours. This data, along with motor and installation cost, can be used in a simple payback calculation as explained in Section 6.

Alternative Energy Sources

This section defines and describes potential alternative energy sources. Each potential alternative energy source is described for type, size, cost, output and other considerations. There are several potential sources of renewable and alternative energy currently used in the US:

- Solar photovoltaic and passive solar
- Wind
- Hydropower
- Geothermal
- Fuel cells

Electric power generation is usually considered the most valuable, flexible and diverse form of energy. Of these six likely sources, solar power, wind power and small hydroelectric are most suitable for generating electric power from renewable sources. The following sections provide an evaluation of potential alternative energy sources applicable to this region, and their potential.

Solar

Solar photovoltaic (PV) cells, also known as solar cells, transform sunlight directly into electricity. Sunlight is a relatively abundant, clean renewable resource available for energy harnessing. Solar cells use semicon-

Table 2. Energy Cost Savings for Premium Efficiency Motor Replacement

Motor HP (460 VAC 3-phase)	Prem Eff Motor Full Load Efficiency, Percent	T-Frame TEFC Motor Full Load Efficiency, Percent	Energy Saving with Premium Efficiency Motor, kW	Yearly energy cost savings at $0.10 per kWhr	
				If operated 5000 hours per year	If operated 7000 hours per year
2	0.865	0.809	0.119	$60	$84
5	0.902	0.844	0.284	$142	$199
10	0.917	0.843	0.71	$357	$500
20	0.930	0.886	0.80	$398	$557
40	0.945	0.904	1.4	$716	$1,002
60	0.945	0.906	2.0	$1,019	$1,427
100	0.954	0.923	2.6	$1,313	$1,838
150	0.954	0.931	2.9	$1,448	$2,028
200	0.954	0.931	3.9	$1,931	$2,703

ductors to create the electrical power when exposed to solar radiation.

Solar PV systems are of various types and can be used in a variety of ways. Stand-alone or grid-isolated systems may be the best choice for applications where utility-generated electric power is unavailable, unreliable, undesirable or simply too costly to provide electrical services. Grid-connected solar PV systems can help supply some of the electrical power consumed during peak grid demand hours when power is most costly.

Grid-connected solar may also provide the benefit of net metering, which allows for overproducing electrical power generation to be applied to a utility bill for credit against use at non-peak periods where solar systems are not producing. California's Net-Metering law requires electric utilities to offer retail credit for a portion of the in-house electricity generated to all customers for solar and wind energy systems up to 1 MW. This law provides a system to allow for better compensation from PG&E for electricity generated by the customer using alternative energy sources. Net excess generation (NEG), or generated power in excess of a facility's internal use, is carried forward to a customer's next bill for up to 12 months. Any NEG remaining at the end of each 12-month period is granted to the customer's utility.

Passive solar is the technology of non-mechanical solar collection and use. Passive solar design integrates a combination of building features to reduce or even eliminate the need for mechanical cooling and heating and daytime artificial lighting. Building heating and natural lighting can all be accomplished with passive solar use. Passive solar technologies in the proper application can help lower energy consumption and energy cost. Passive solar is best suited for new construction, due to architectural/design requirements and difficulties associated with modifying existing structures for this technology.

Solar power is one of the most visible and well-known forms of renewable energy and is rapidly being applied to homes, businesses, industrial facilities and commercial office buildings. At least 25 water agencies and water treatments plants in California and Nevada have recently installed solar power projects. Some key characteristics of solar PV systems include:

- System types: Solar energy is converted to electricity by PV panels or by solar thermal power plants. PV projects are much more common, but passive systems are also being explored.
- Size: Most commercial and institutional PV systems have been in the 50 kW to 1,000 kW size. Water agencies and waste/wastewater treatment plants have an average PV size of about 500 to 550 kW.
- Cost: Solar PV systems have a typical installed cost of $7,000 to $9,000 per kW. Small-grid isolated sites with batteries or other special features can cost even more.
- Site considerations: Solar systems require a reasonably large piece of land or spatial area with direct exposure to sunlight so that the shading effect of one array does not affect an adjacent array.
- Capacity factor: The output of any electric power generation system can be measured and compared by a concept called the capacity factor. The capacity factor is the ratio of a system's output to its full output capacity over a period of time, indicating how much of the facility's energy generating capacity is in use over time. Typical solar power projects have a capacity factor of 0.14 to 0.21.
- Additional benefits: Solar power does not require the use of water, which gives agencies the opportunity to mitigate the energy-water nexus. In fact, solar power generation has no environmental dependence. Also, solar PV systems have an approximately 30-year panel life, and there are almost no ongoing operations and maintenance costs beyond possible semi-annual cleaning and periodically replacing inverters and other parts.

Wind

Wind power is captured using wind turbines. Wind power is considered a clean, renewable energy technology that is becoming ever more popular to public agencies. Wind energy is one of the fastest growing energy resources in the world, and the recent growth of wind power in the US was 45 percent in 2007 (http://www.windpoweringamerica.gov). Some important characteristics of wind power systems are described below:

- System types: Wind turbines are designed with both horizontal axis and vertical axis turbines. Horizontal axis turbines are clearly the most widely used, particularly in sizes above 250 kW.
- Size: Most commercial and institutional wind power turbines have been in the range of 50 kW to 2500 kW. Single turbine and multiple wind turbine sites are common.
- Cost: Wind power systems have an installed cost of $1,800 to $3,000 per kW. Smaller systems are on the higher end of the range. $1,500 per kW Self Generation Incentive Program (SGIP) incentives are available for projects over 30 kW (http://www.cpuc.ca.gov/PUC/energy/DistGen/sgip/).
- Site considerations: Wind power systems require a section of clear unobstructed land area to avoid disrupting the flow of wind through the turbine blades.
- Output: Typical wind power projects have a capacity factor of 0.28 to 0.40, though this can vary significantly by location.

Wind power applicability is extremely site specific and dependent on a reliable wind resource. Wind power is classified in one of seven classes per the National Renewable Energy Laboratory (NREL) system. Generally to be economically attractive, wind power projects should be located in NREL Wind Power Class

3 or higher (National Renewable Energy Laboratory, 2008a). A map showing Sonoma County wind data is presented in Figure 8; this map shows that while most of the county falls in the poor wind resource range, specific areas reach marginal, good and excellent wind resource ranges.

Hydropower

Hydroelectric power is a renewable energy source used to generate electricity by using a pressure differential in a water system. While traditional large hydroelectric power system are typically thought of as very large power plants powered by dams or rivers, a whole range of hydroelectric power system sizes exist.

Hydroelectric energy can be implemented on a small scale to take advantage of existing energy that is often lost in water system operation. Because of the familiar technology involved, small hydroelectric power projects are particularly well suited for water agencies. Some of the key characteristics of these sized facilities are as described below.

- System types. Small hydropower projects are built with Francis-type turbines, Pelton wheels, Kaplan turbine, or Archimedes screw-type turbines in very low head applications.
- Cost. Small hydroelectric power system costs vary extensively. They often have a typical installed cost of $3,000 to $10,000 per kW, and average unit cost is very site-specific.
- Site considerations. Small hydropower systems are extremely site-specific and require a continuous or near continuous source of water, along with excess head or water pressure, and a nearby connection to the electric power grid.
- Output. Typical small hydropower projects have a capacity factor of 0.30 to 0.80.

Hydrokinetic Wave and Tidal Power

Hydrokinetic energy is based on the technology of extracting usable energy, typically electric power, from the flow of water in rivers, streams and tidal estuaries. Hydrokinetic energy is still in its infancy; currently, only one application is known in the United States. Tidal power is also very limited and extremely site-dependant; however, wave energy has great potential as its sheer density can generate more energy than wind.

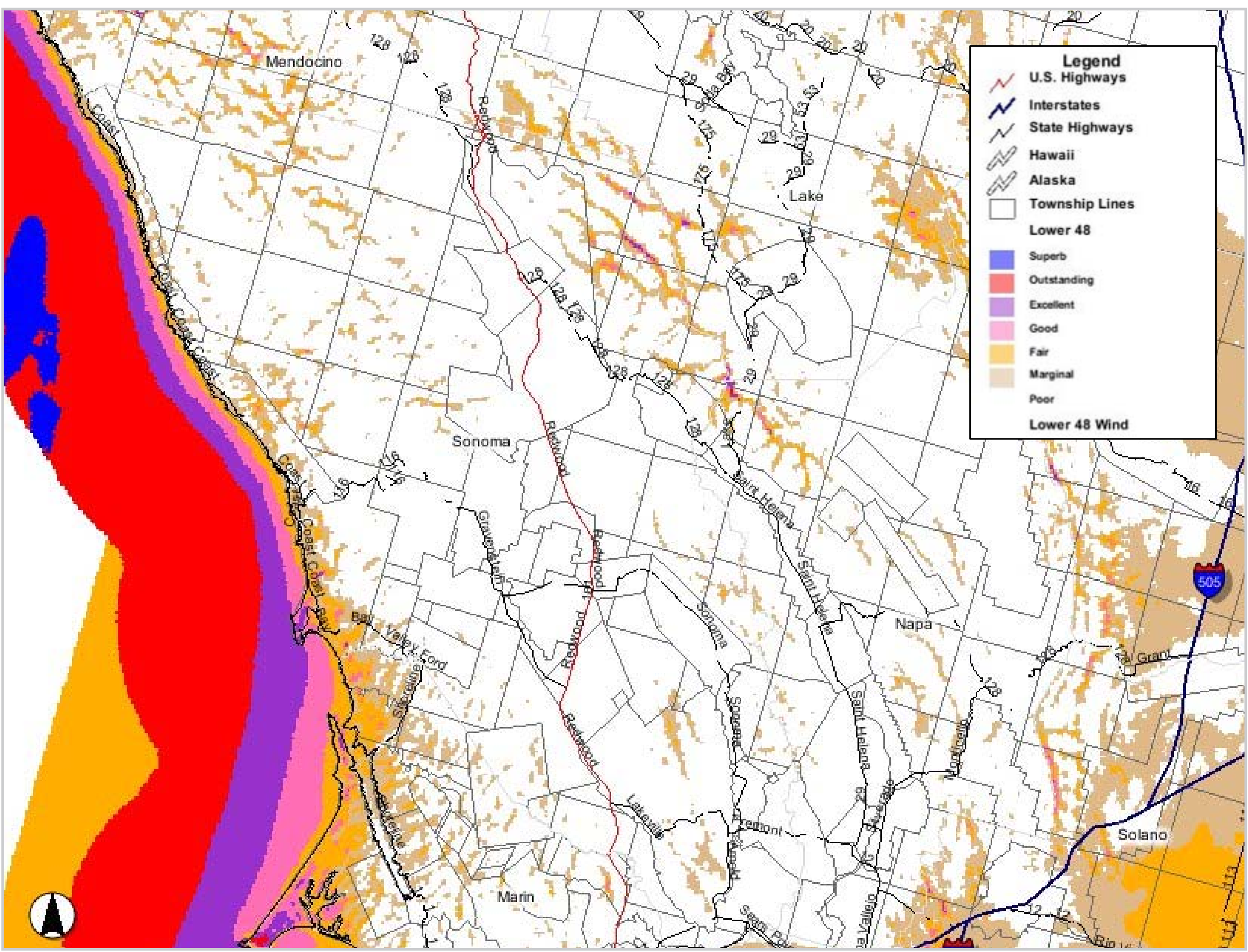

Figure 8. Wind Speed Data In Sonoma County

Source: http://mapserve2.nrel.gov/website/Resource_Atlas/viewer.htm

Wave power is also far more predictable than other alternative energies as it can be tracked due to gravitational tidal patterns offshore using computer programs to estimate energy output days in advance.

Geothermal Energy

Geothermal energy resources in California are producing clean renewable electricity, and geothermal power plants are some of the oldest, most reliable, and most successful forms of alternative energy in California. Traditional or high-temperature geothermal electric power is exceptionally site-specific and highly localized, and has had success in Sonoma County in the Geysers region. Although the success of geothermal energy at the Geysers is world renown, traditional high temperature (<180 °F) energy is very site-specific and not practical for most applications.

Fuel Cells

A fuel cell is an electrochemical device that combines hydrogen with oxygen to continuously produce electricity. The popularity of fuel cells is due to their high power generation efficiency, vibration-free operation, extremely clean exhaust emissions, and cutting-edge technology. Fuel cells are very quiet, with their accessories generating the little noise that they produce. Stationary fuel cells are available as fully modularized units in sizes of 200 kW and larger, and fuel cells are readily installed outdoors in weatherproof containers.

Much like photovoltaic cells and batteries, fuel cells offer a method of converting directly from a fuel source and oxygen to electricity. Most conventional power sources involve two steps of conversion to generate electricity. Fuel cells convert chemical energy to electricity by electrochemical means and, as such, can operate at a high efficiency. The chemical reaction in a fuel cell using hydrogen gas produces no criteria pollutant (NOx, CO, particulate, etc.) emissions or greenhouse gas directly. The integral reformer that produces the hydrogen for the fuel cell does produce carbon dioxide emissions; however, even the reformer produces essentially no criteria pollutants. Because the technology does not produce criteria pollutants, fuel cells are exempted from air permitting requirements. Additionally, while fuel cells are considered an ultra-clean technology by the California Air Resources Board, they are only technically a renewable power source if their gas supply is from a renewable (landfill gasses, bio-digesters) source.

As with all technologies, fuel cells are best used in some circumstances and not in others. Some pertinent factors regarding the use of fuel cells are listed below.

Site considerations for fuel cells. An ideal application for a fuel cell is one that:

- Has a continuous fuel source (natural gas, digester gas or landfill gas)
- Uses electrical power continuously (24/7) without large load changes
- Can use most or all of the waste heat generated by the fuel cell (cogeneration or combined heat and power)

Cost. Costs for fuel cell systems can vary based on type and size. A typical molten carbonate stationary fuel cell with a capacity of 300 kW has an equipment cost of about $4,500 per kW. This cost is per vendor quotations in early 2009. In addition, costs must be added for fuel supply piping, water piping, heat recovery equipment and installation of the connected electrical and mechanical equipment.

System types. Four very different types of stationary fuel cells are now in active commercial service or are undergoing development, including the following (see below for description).

- Phosphoric acid-type fuel cells
- Carbonate-type fuel cells
- Solid oxide-type fuel cells
- Proton exchange membrane fuel cells

Phosphoric acid type fuel cells. The first commercial fuel cells were the phosphoric acid type fuel cells, and the phosphoric acid system is the most mature technology. There are at least 10 municipal wastewater treatment plants that have installed 200-kW digester gas phosphoric acid fuel cells, including some installations with more than seven years of operational experience. Phosphoric acid fuel cells should thus be considered an established, proven technology, and not a developing or experimental technology.

Carbonate type fuel cells. Many of the newer fuel cell installations have used the carbonate type fuel cell, sometimes called the molten carbonate or the direct carbonate type fuel cells. Portions of the molten carbonate fuel cell, such as the reformer, and the inverter are extremely similar to those in phosphoric acid fuel cells. One important difference is the lithium and potassium carbonate electrolyte solution that allows the transfer of electrons within the unit.

Solid oxide and proton exchange membrane fuel cells are still being developed and are not considered to be viable for commercial power applications.

Section 4
Water supply
distribution and conservation

Water conservation is the most cost-effective and environmentally sound way to reduce the demand for water. Scientists believe that global warming will reduce the Sierra snowpack by mid-century, thus limiting the amount of potable water available for human use. Therefore, conserving water will extend fresh water supplies.

Water conservation also saves energy. About 6.5 percent of the energy used in the state of California is for pumping and treating water. Using less water would reduce energy used for pumping and using less hot water use will reduce additional energy used for water. Best management practices for reducing energy costs by efficient operations was discussed in the previous sections. This section describes best practices related to managing available water resources and saving energy by effective water conservation practices.

Developing a best practices framework from a water supply and distribution perspective should focus on:

- Water conservation efforts
- Energy management

The goal of water resources management and planning is to accrue major environmental, public health, and economic benefits by improving water quality, maintaining aquatic ecosystems, and protecting drinking water resources. Sound water resource management, which emphasizes efficient use of water, is essential to achieve these objectives.

In addition to saving energy, conserving available water supplies, and reducing operation cost, motivation to efficiently manage water resources also comes from regulatory sources. In December 2008, the USEPA announced an intra-agency agreement between the Office of Air and Radiation and Office of Water to promote energy efficiency and reduce greenhouse gas emissions at publicly owned wastewater treatment plants and public drinking water systems (USEPA, 2008b). The agreement cited several current and planned efforts to improve energy efficiency and offset power consumption at water treatment plants and distribution systems, and at wastewater treatment plants. Public water systems are encouraged to perform water audits and designated metering efforts to account for water. The systems also are expected to run a repair and replacement program.

The USEPA has developed a website dedicated to water management and planning and has provided links to the water management plan developed for 11 EPA facilities (http://www.epa.gov/oaintrnt/water/plans.htm). According to USEPA, a water management plan should include clear information about how a facility uses its water from the time it is pumped into the facility through disposal of the water. Knowledge of current water consumption and costs is essential for making the most appropriate water management decisions.

USEPA recommends dividing the water management plan into three components—water accounting, best management practices achieved, and water management opportunities. To create a proper facility water management plan, it is important to include the following elements at a minimum:

1. **Operation and Maintenance (O&M)**. Appropriate O&M recommendations should be included in facility operating plans or procedure manuals.
2. **Utility Information**. Appropriate utility information should include:
   - Contact information for all water and wastewater utilities.
   - Current rate schedules and alternative schedules appropriate for usage or facility type.
   - Copies of water/sewer bills for the past two years to identify inaccuracies and determine whether the appropriate rate structure is being used.
   - Information on financial or technical assistance available from the utilities to help with facility water planning and implementing water efficiency programs.
   - Contact information for the agency or office that pays the water/sewer bills.
   - Production information, if the facility produces its water and/or treats its own wastewater.
3. **Facility information**. At a minimum, a walk-through audit of the facility should be performed to identify all major water-using processes, location and accuracy of water measurement devices, main shut off valves, operating schedules, and building occupancy. Facilities should include a description of actions necessary to improve the accuracy of their water usage data. Activities can include a metering (or other measurement) plan for the facility.
4. **Emergency response information**. Water emergency and/or drought contingency plans should be developed that will describe how the facility will meet minimum water needs in an emergency, or reduce water consumption in a drought or other water shortage. This should be done in conjunction with the local water supplier.
5. **Comprehensive Planning.** Staff contractors and the public should be informed about the priority the agency or facility places on water and energy efficiency.

A focal point of water management plans is the use of best management practices. The best management practices plan for successful water management planning should be designed to consider all uses of water and maximize conservation. The following 10 areas of best practices are recommended by the Federal Energy Management Program:

- Public Information and Education Programs
- Distribution System Audits, Leak Detection & Repair
- Water Efficient Landscaping
- Toilets and Urinals
- Faucets and Showerheads
- Boiler/Steam Systems
- Single-Pass Cooling Systems
- Cooling Tower Systems
- Miscellaneous High Water-Using Processes (e.g., commercial kitchen equipment, commercial laundry equipment)
- Alternate water sources

The following sections provide a detailed discussion on each of the above 10 areas of best practices. Wherever applicable, the best practice management implementation options are divided into three categories—operation and maintenance, retrofit, and replacement options—to allow agencies to implement best practices based on site-specific needs (from Federal Energy Management Program website- http://www1.eere.energy.gov/femp/water/water_bmp.html).

Public Information and Education Programs

Public information and education programs are essential to increase awareness in the community about water conservation practices and also to educate communities about implementing these practices. In addition to installing a retrofit or water-saving technology, new operating procedures and replacements can be most effective when employees, contractors and the public know about the new technology or methods and how to use them properly.

Examples of public information programs include:

- Water conservation posters displayed in prominent locations throughout the facility
- Newsletters that describe current water use and future water conservation efforts and targets
- Campaigns in local newspapers and radio stations
- Websites, brochures and other materials
- Education programs such as training sessions or workshops for employees and community members, and programs in schools and colleges that can help public agencies incorporate conservation practices on a daily basis

Providing incentives to the public for implementing water conservation practices is another public outreach opportunity that not only motivates the public to conserve water, but also increases awareness.

Distribution System Audits, Leak Detection & Repair

A distribution system audit, leak detection and repair program can help facilities reduce water losses and make better use of limited water resources. Regular surveys of distribution systems should be conducted before obtaining additional water supplies and can have the following benefits:

- **Reduced Water Losses**. Reducing water losses will help stretch the existing supplies to meet increasing demand. This could help defer the construction of new water facilities such as wells, reservoirs or treatment plants.
- **Reduced Operating Costs**. Repairing leaks will save money by reducing power costs to deliver water, and reduce chemical costs to treat water.
- **Increased Knowledge of the Distribution System**. As personnel become more familiar with the system, including knowing the location of mains and valves, they are able to respond more quickly to emergencies such as main breaks.
- **Reduced Property Damage.** Repairing system leaks can prevent damage to property and safeguard public health and safety.
- **Improved Justification for Water Management.** By conducting routine water audits and verifying production and end-point meters, better accounting that helps validate the need to reduce water losses will result.

Systems audits are another best practice that agencies should employ. The first step in conducting a distribution system audit is pre-screening. The four major steps required to conduct a pre-screening distribution system audit, recommended every two years, include (from Kunkel et al., 2003):

- Determining authorized uses
- Determining total supply into the system
- Dividing authorized uses plus other verifiable uses by total supply into the system. If this quantity is less than 0.9, a full-scale system audit is needed.

A full-scale system audit can be conducted using an American Water Works Association Water Audit Software available online at http://www.awwa.org/Resources/Content.cfm?ItemNumber=590. If the full-scale audit finds leaks in the system, leaks must be repaired or pipes must be replaced. Depending on location, some local water utilities can also provide in-house audits.

Water-efficient Landscaping and Irrigation

In most locations, traditional landscapes require supplemental water to thrive. For example, Kentucky bluegrass is native to regions that receive precipitation in excess of 40 inches per year, but it is commonly planted in areas across the country that receive much less precipitation. To make up the difference between a plant's water requirement and the natural precipitation, additional water must usually be added in the form of irrigation. Depending on the climate, water applied outdoors may be a substantial portion of total water use. If the community includes any irrigated landscape, then exterior water use should be an important part of the overall water efficiency program. These principles apply to traditional landscapes, as well as cemeteries, golf courses, or other non-traditional landscapes.

There are two aspects of outdoor water use efficiency:

1. Designing a landscape that requires minimal supplemental water; and
2. Designing, installing and maintaining an irrigation system that applies appropriate amount of supplemental water in an efficient manner.

Water-efficient Landscaping

Water-efficient landscapes using native and other climate-appropriate landscape materials can reduce irrigation water use by more than 50 percent, stand up better to drought, reduce drought loss or damage, and require less time to maintain. Reduced turf and other irrigated areas can also significantly reduce time and money spent mowing, fertilizing, removing green wastes and maintaining landscapes. Best practice implementation options are described below.

Operation and Maintenance Options

- Periodically review all landscape service and maintenance agreements to incorporate a high priority for water and energy efficiency.
- Consider hiring landscape contractors that focus on water-efficient or climate-appropriate landscaping. Recommend that existing contractors attend courses or seminars to learn these techniques.
- Encourage landscape contractors to report and/or fix problems. This can help identify and report leaks or other inefficiencies in the landscape.
- Add mulch to plant beds. Mulch decreases water lost from the soil by evaporation and also helps reduce weed growth.
- Maintain a sufficient quantity of good topsoil of 4 to 6 inches to capture storm water as it falls and minimize run off. A soil with balanced particle sizes will also release the moisture back to the plant material over time, which may reduce irrigation requirements.
- Re-circulate water in decorative fountains, ponds and waterfalls, and shut off when possible to reduce evaporation losses. Check water recirculation systems annually for leaks and other damage. Consider using non-potable water in these systems (see Alternate Water Sources in this section).
- Alternate turf mowing height between low and high levels. This encourages roots to grow deeply and helps allow plants to go longer between watering sessions.
- Keep the landscape weed free so that valuable water is consumed only by decorative landscape.
- Stop using water to clean sidewalks, driveways, parking lots, tennis courts, pool decks, and other hardscapes.

Retrofit Options

- Select drought-tolerant or climate-appropriate turf, trees, shrubs and ground cover when replanting landscaped areas.
- Consider reducing the area of turf. Most turf requires substantially more water than planted beds, especially if the plants are climate-appropriate and covered with mulch.
- Eliminate “strip grass” to the greatest extent possible. Small strips of grass, common in parking islands and between sidewalks and the roadway, are hard to maintain and difficult to water efficiently. Use bushes, mulch or permeable hardscape instead.
- Implement low-impact development techniques such as making parking lot islands depressions instead of raised curb areas to capture and retain moisture.

Replacement Options

- Replace or install the entire landscape with climate-appropriate, water-efficient plant material.
- Design the landscape so that plants with similar water needs are grouped together (i.e., hydrozoning). This allows for more efficient irrigation.
- Check to ensure the soil does not need improvement before installing a landscape. Depending on the soil type, it may need to be amended to ensure water is delivered to the plant in an efficient manner.
- Use turf only where it is needed. Avoid long narrow areas that cannot be irrigated effectively.
- Plant trees at appropriate depths.
- When designing the new landscape, avoid the use of ornamental water features.

Water-efficient Irrigation

The U.S. Department of Energy estimates that more than 50 percent of commercial and residential irrigation water is wasted due to evaporation, wind, poor management, and/or improper system design, installation or maintenance. For optimal irrigation system performance, water efficiency should be considered from the inception of the system’s design through the installation, followed by consistent management and maintenance.

An important efficiency concept associated with irrigation systems is distribution uniformity, or how evenly water is applied over the landscape. Many times extra water is applied because the system is not distributing water in a uniform manner.

Once the irrigation system hardware is operating in an efficient manner, it is important to consider the irrigation schedule, which dictates the amount and timing of the water applied. Plants’ water needs change with the seasons; so should the irrigation schedule. Many landscapes are watered at the same level all year, adding unnecessary water for months at a time. Over-watering can cause more damage to plant materials than under-watering and can damage streets, curbs, other paving and building foundations.

Best practice management implementation options are described below.

Operation and Maintenance Options

- Recommend existing contractors become familiar with water-efficient irrigation practices through partnerships, classes, seminars and/or published guidance documents.
- Install an irrigation meter (also known as a “deduct meter”) to measure the amount of water applied to the landscape.
- Verify that the irrigation schedule is appropriate for climate, soil conditions, plant materials, grading and season.
- Always attach shut-off nozzles to handheld hoses.

Retrofit Options

- Replace existing irrigation system controller with a more advanced control system that waters plants only when they need it (see http://www.usbr.gov/waterconservation/docs/SmartController.pdf for more information).
- Consider retrofitting a portion of trees, shrubs or plant beds with low-flow, low-volume irrigation, also called micro-irrigation or drip irrigation.
- Increase the efficiency of the system's sprinkler heads.
- Install rain-sensing technology on the system to interrupt irrigation during periods of sufficient moisture.
- Install wind-sensing technology to interrupt irrigation cycles in the presence of significant wind.
- Install freeze-sensing technology to prevent irrigation during freeze conditions.

Replacement Options

- When installing a new system, hire an irrigation design company that has a background in designing water-efficient systems.
- After installing new irrigation systems, audit the irrigation system using a qualified irrigation auditor, such as EPA's WaterSense Program (http://www.epa.gov/watersense/), to determine if baseline efficiencies are compatible with design intent and to make certain minor adjustment recommendations as needed.
- Design the system for maximum water application uniformity.
- Use alternative sources of water where environmentally appropriate and local regulations allow. (see Alternate Water Sources in this section)

Toilets and Urinals

In the United States, about 4.8 billion gallons of water is used every day to flush waste. Since toilets and urinals account for nearly one-third of building water consumption, there is a huge potential for water conservation. Current federal law requires that residential toilets manufactured and sold in the U.S. after January 1, 1994, must use no more than 1.6 gallons per flush (gpf). Similarly, commercial toilets manufactured and sold after January 1, 1997, must use no more than 1.6 gpf and urinals must use no more than 1.0 gpf.

In 1999, the first High-Efficiency Toilet (HET) fixture was introduced. With superior hydraulic design, HETs flush at an effective flush volume of 1.28 gpf or less, or 20 percent below that required by the current national standard. Similarly, High-Efficiency Urinals (HEUs), which function at 0.5 gpf and less, are available from a range of manufacturers.

Best practice implementation options are described below.

Operation and Maintenance Options

- Check for leaks every six months.
- Periodically replace flush valves and fill valves in tank-type toilets.
- When performing maintenance, replace worn parts and adjust mechanisms to ensure that the water consumed per flush meets manufacturers' original equipment specifications.
- Correctly adjust and maintain automatic sensors to ensure proper operation.
- If waterless urinals are used, clean and replace the sealant cartridges or material in accordance with manufacturer recommendations.
- Encourage cleaning or custodial crews to report problems.

Retrofit Options

Consider using non-potable water for toilet and urinal flushing (see Alternate Water Sources in this section). Package gray water treatment systems can provide water filtered and treated sufficiently for these uses. If using non-potable water for toilet and urinal flushing, monitor flapper valves and seals to determine if there is an impact on their useful life.

Replacement Options

- Replace 3.5 to 5 gpf toilets with valves and bowls specifically designed to use 1.6 gpf or less.
- If replacing tank-type toilets (gravity or pressure assist), select toilets with the WaterSense label (http://www.epa.gov/watersense/pp/find_het.htm). These have an effective flush volume of 1.28 gallons or less (20 percent savings per flush over traditional 1.6 gpf toilets) and have been independently tested and certified for performance.
- Replace urinals with HEU models designed to use 0.5 gpf or less.

Faucets and Showerheads

Significant amount of water and energy are wasted using inefficient faucets and showerheads. Federal guidelines mandate that all lavatory and kitchen faucets and faucet aerators manufactured and sold in the U.S. after January 1, 1994, must use no more than 2.2 gallons per minute (gpm). In addition, metering faucets, those that, when activated, dispense water of a predetermined volume or for a predetermined period of time, must discharge no more than 0.25 gallons per cycle (gpc). Federal guidelines also mandate that all showerheads manufactured and sold in the U.S. after January 1, 1994, must use no more than 2.5 gpm.

In 2007, EPA's WaterSense Program released a specification for residential bathroom lavatory faucets and faucet accessories requiring a maximum flow rate of 1.5 gpm or less, a 32 percent decrease in flow rate over federal guidelines. If a facility still uses older faucets and showerheads, or uses faucets with flow rates greater than 0.5 gpm in public restrooms, there is a significant opportunity to save both water and energy costs.

Boiler/Steam Systems

Boilers and steam generators are commonly used in large heating systems, institutional kitchens, or in facilities where large amounts of process steam are used. The equipment consumes varying amounts of water depending on the size of the system, the amount of steam used, and the amount of condensate returned.

Best practice implementation options are described below.

Operation and Maintenance Options

- Develop and implement a routine inspection and maintenance program to check steam traps and steam lines for leaks. Repair leaks as soon as possible. Refer to CCR Title 8 for additional Boiler and Fired Pressure Vessel Safety Orders.
- Develop and implement a boiler tuning program to be completed a minimum of once per operating year.
- Provide proper insulation on piping and on the central storage tank.
- Manage blowdown process appropriately. Blowdown, which involves periodic or continuous removal of water from a boiler to remove accumulated dissolved solids and/or sludges, is a common mechanism to reduce contaminant build-up. Proper control of blowdown is critical to boiler operation. Insufficient blowdown may lead to deposits or carryover. Excessive blowdown wastes water, energy and chemicals. The American Society of Mechanical Engineers (ASME) has developed a consensus on operating practices for boiler feed water and blowdown that is related to operating pressure, which applies for both steam purity and deposition control, which should be followed (http://catalog.asme.org/ConferencePublications/PrintBook/2006_Consensus_Operating.cfm).
- Obtain the services of a water treatment specialist to prevent system scale and corrosion and to optimize cycles of concentration. Treatment programs should include periodic checks of boiler water chemistry.
- Develop and implement a routine inspection and maintenance program on condensate pumps.
- Regularly clean and inspect boiler water and fire tubes. Reducing scale buildup will improve heat transfer and the system's energy efficiency.
- Employ an expansion tank to temper boiler blowdown drainage rather than cold water mixing.
- Install meters on boiler system make-up lines.
- Install meters on make-up lines to recirculating closed water loop heating systems so that leaks can be easily detected.

Retrofit Options

- Install and maintain a condensate return system. By recycling condensate for reuse, water supply, chemical use, and operating costs for the equipment can be reduced by up to 70 percent. A condensate return system also helps lower energy costs as the condensate water is already hot and needs less heating to produce steam than water from other make-up sources.
- Install an automatic blowdown system based on boiler water quality to better manage the treatment of boiler make-up water.
- Add an automatic chemical feed system controlled by make-up water flow.
- To optimize cycles of concentration and reduce the frequency of blowdown, an inert ion such as silica or chloride can be measured in the boiler and the concentration compared to the amount in the boiler feed water.
- In large-scale boilers, blowdown heat exchangers are a useful technology that allows the heat contained in boiler blowdown to be transferred to boiler feed water. This also allows for the production of low-pressure steam that can be returned to the steam system or used in the deaeration of boiler feed water.

Replacement Options

- Consider performing an energy audit to reduce heating load and to ensure that the system is sized appropriately. Reducing the size of the boiler system can reduce water requirements.
- Always purchase the most life-cycle cost-effective boiler available for new installations or major renovations.
- Consider installing a small summer boiler, distributed system or heat-capture system for reheat or dehumidification requirements instead of running a large boiler at part load. Also consider alternative technologies such as heat pumps.

Single-pass Cooling Equipment

Existing single-pass or once-through cooling systems provide an opportunity for significant water savings. In these systems, water is circulated once through a piece of equipment and then is disposed of down the drain. Equipment that typically use single-pass cooling include CAT scanners, degreasers, hydraulic equipment, condensers, air compressors, welding machines, vacuum pumps, ice machines, x-ray equipment and air conditioners. To remove the same heat load, single-pass systems use 40 times more water than a cooling tower operated at five cycles of concentration. To maximize water savings, single-pass cooling equipment should be either modified to recirculate water or if possible, eliminated altogether.

Best practice management implementation options are described below.

Operation and Maintenance Options

- Provide proper insulation on piping, chiller or storage tank.
- Inventory cooling equipment and identify all single-pass cooling systems.
- Check entry and exit water temperatures and flow rates to ensure that they are within the manufacturer's recommendations. For maximum water savings, water flow rates should be near the minimum allowed by the manufacturer.
- Keep coil loops clean to maximize heat exchange with the refrigerated enclosure.
- Check operation of water control valve. Water control valves adjust the flow rate of water based on demand. Regular valve maintenance will ensure that water is used as efficiently as possible.

Retrofit Options

- To maximize water savings, eliminate single-pass cooling by modifying equipment to operate on a closed loop that recirculates the water instead of discharging it.
- If modification of equipment to a closed loop system is not feasible, add an automatic control to shut off the entire system during unoccupied night or weekend hours. This option should only be considered where shutdown would have no adverse impact on indoor air quality.
- Install a chiller or cooling tower. It's also an economical alternative, and excess cooling capacity may already exist within the building that can be used.

Replacement Options

- Replace water-cooled equipment with air-cooled equipment or best available energy/water-efficient technology.
- Replace the once-through or single-pass cooling systems with a multi-pass cooling tower or closed loop system.

Cooling Tower Management

Cooling towers regulate temperature by dissipating heat from recirculating water used to cool chillers, air-conditioning equipment, or other process equipment. Heat is rejected from the tower primarily through evaporation; therefore, by design, cooling towers consume significant amounts of water. The thermal efficiency and longevity of the cooling tower and equipment used to cool depend on the proper management of water recirculated through the tower.

Water leaves a cooling tower system in one of four ways:

Evaporation. This is the primary method by which the cooling tower transfers heat from the tower system to the environment. The quantity of evaporation is not a subject for water efficiency efforts, although improving the energy efficiency of the systems that are being cooled will reduce the evaporative load on the tower.

Drift. A small quantity of water may be carried from the tower as mist or small droplets. Drift loss is small compared to evaporation and blow-down, and is generally controlled with baffles and drift eliminators.

Blowdown or bleed-off. When water evaporates from the tower, dissolved solids (such as calcium, magnesium, chloride and silica) are left behind. As more water evaporates, the concentration of dissolved solids increases. If the concentration gets too high, the solids can come out of the solution and cause scale to form within the system, or the dissolved solids can lead to corrosion problems. The concentration of dissolved solids is controlled by blowdown of some water from the tower. Carefully monitoring and controlling the quantity of blowdown provides the most significant opportunity to conserve water in cooling tower operations.

Basin leaks or overflows. Properly operated towers should not have leaks or overflows.

The sum total of water that is lost from the tower must be replaced by make-up water:

$$\textit{Make-up} = \textit{Evaporation} + \textit{Blowdown} + \textit{Drift} + \textit{Leaks and/or overflows}$$

A key parameter used to evaluate cooling tower operation is "cycles of concentration" (sometimes referred to as cycles or concentration ratio). This is calculated as the ratio of the concentration of dissolved solids (or conductivity) in the blowdown water compared to the make-up water. Since dissolved solids enter the system in the make-up water and exit the system in the blowdown water, the cycles of concentration are also approximately equal to the ratio of volume of make-up to blowdown water.

From a water efficiency standpoint, the goal is to maximize cycles of concentration, which will minimize blowdown water quantity and reduce make-up water demand; however, this can only be done within the constraints of make-up water and cooling tower water chemistry. As cycles of concentration increase, dissolved solids increase, which can cause scale and corrosion problems unless they are carefully controlled.

In addition to carefully controlling blowdown, other water efficiency measures can be taken by using alternate sources of make-up water. Sometimes water from other equipment within a facility can be recycled and reused for cooling tower make-up with little or no pre-treatment and include:

- Air handler condensate (water that collects when warm, moist air passes over the cooling coils in air handler units). This reuse is particularly appropriate because the condensate has a low mineral content and is typically generated in the greatest quantities when cooling tower loads are the highest.
- Water used in a once-through cooling system.

- Pretreated effluent from other processes, provided that any chemicals used are compatible with the cooling tower system.
- High-quality municipal wastewater effluent or recycled water where available.

Commercial Kitchen Equipment

Commercial kitchen equipment represents a large set of water users in the non-residential sector. Commercial kitchen equipment water efficiency is especially important because the high-volume applications typically require the use of hot water; therefore, efficiently operating commercial kitchen equipment can result in significant savings in both water and indirect energy.

Types of water-using commercial kitchen equipment include pre-rinse spray valves, wash tanks and sinks, commercial dishwashers, food steamers, steam kettles, commercial ice makers, and combination ovens (combination oven/steamer).

Best practices implementation options are described below.

Operation and Maintenance Options

- Educate staff about the benefits of water efficiency and the importance of hand scraping before loading a dishwasher.
- Establish a user-friendly method to report leaks and fix them immediately. Encourage cleaning or custodial crews to report problems.
- Run dishwashers only if they are full. Fill each rack to maximum capacity.
- Check equipment's water temperatures and flow rates to ensure that they are within the manufacturer's recommendations. For maximum water savings, water flow rates should be near the minimum allowed by the manufacturer.
- Test system pressure in each piece of equipment, such as spray valves, wash tanks and sinks, dishwashers and steamers, to make sure they are between 20 and 80 psi. If the pressure is too low, then high-efficiency devices won't work properly. If it is too high, they will consume more than their rated amount of water. Actual pressure requirement would depend on the flow rate of the equipment's system. The following formula can be used to calculate reduction in flow rate, which would result in reduced pressure:

$$\text{New Flow Rate} = \text{Old Flow Rate} \times \left(\sqrt{\text{New Pressure}/\text{Old Pressure}}\right)$$

Based on the above formula, equipment with a flow rate of 2.5 gpm at 80 psi is equivalent to 2.2 gpm at 60 psi; therefore, reducing system pressure will result in additional water savings.

- For dishwashers, observe final rinse pressure to make sure it is at the manufacturer's recommended setting, typically 20 ± 5 psi. If the pressure is too low, then the dishes may not be rinsed and sanitized properly. If it is too high, they will consume more than their rated amount of water.
- Ensure all equipment is installed and operated according to the manufacturer's instructions.
- For steam cooking, use batch production as opposed to staged loading of food pans. If possible, fill the steamer to capacity as opposed to cooking one pan in a five-pan steamer.
- Garbage disposals can waste significant amounts of water. Eliminate or minimize the use of garbage disposals by using strainers or traps that employ a mesh screen to collect food waste.

Retrofit Options

- Install dishwashers with rack sensors to allow water flow only when dishes are present.
- Check to see if ice machines operate with single-pass cooling. To maximize water savings, eliminate single-pass cooling by modifying equipment (if possible) to operate on a closed loop that recirculates the water instead of discharging it; otherwise replace the ice-making head with an air-cooled unit.
- Install flow restrictors in existing pre-rinse spray valves to reduce the flow rate to 1.6 gpm or less.

Replacement Options

- For commercial dishwashers, check volume of service and size the dishwasher. Consider the energy tradeoffs associated with increased tank heat that may be required for larger machines.
- Purchase high-efficiency commercial dishwashers with the Energy Star® label (http://www.energystar.gov/).
- Replace water-cooled commercial ice makers with high-efficiency air-cooled commercial ice makers with the Energy Star® label.
- For low- to medium-volume steam cooking needs, purchase high-efficiency steam cookers. Look for steamers with improved insulation, standby mode and closed-system design to ensure that steamers are used most efficiently.
- Purchase high-efficiency pre-rinse spray valves. The Energy Policy Act of 2005 requires that pre-rinse spray valves manufactured after January 2006 have a maximum flow rate of 1.6 gpm. In 2007, the Federal Energy Management Program (FEMP) released a purchasing specification for pre-rinse spray valves that requires Federal Agencies to purchase pre-rinse spray valves that have flow rates of 1.25 gpm or less and that meet American Society for Testing and Materials (ASTM) F2323-03 requirements.

Commercial Laundry Equipment

Large amounts of water are regularly used in industrial laundries, making them highly suitable for a water efficiency program. Best management practice implementation options are described below.

Operation and Maintenance Options

- Meter or otherwise measure the amount of water used in commercial laundry equipment.
- Regularly inspect all equipment; locate and repair leaks in plumbing connections.
- Ensure that procedures are in place to turn off the water supply when the equipment is not in operation. Some equipment allows water to run constantly, even when the equipment is turned off. Replace this equipment when feasible.
- If applicable, check flow rates to ensure that they are within manufacturers' recommendations. For maximum water savings, the flow rate should be near the minimum allowed by the manufacturer. This can produce significant water savings.
- Wash only full loads. If this is impractical, and if the water level is able to be set by the user, encourage using only as much water as needed for that load. Also consider separating laundry by cycles needed.
- Large commercial laundry equipment should be programmable to use no more water than is required for the degree of soiling of the items being washed.

Retrofit and Replacement Options

- Replace old commercial clothes washers (vertical axis) with new high efficiency washers (horizontal axis) that use significantly less energy, water and detergent. Look for Energy Star®-labeled washers with a water factor of 8.5 gallons of water used per cubic foot or less. Most full-sized Energy Star®-qualified washers use 18 to 25 gallons of water per load, compared with the 40 gallons used by a standard machine. These efficient washers have the potential to reduce combined utility costs by as much as 50 percent.
- For large industrial or commercial-type laundries, consider replacing old washers with tunnel washers, or ozone laundering. Tunnel washers, also known as continuous batch washers, are heavy-duty, multi-tank systems for use in large industrial laundries. They are capable of handling up to 2,000 pounds of laundry per hour. Tunnel washers use counter-current wash methods to maximize water efficiency. These are costly to install, but are capable of saving up to 70 percent of the volume of water used with a washer-extractor, and require less operating and maintenance labor. Tunnel washers typically use about two gallons or less per pound of laundry.
- Install systems for ozone laundering. Ozone laundering is suited for lightly to moderately soiled laundry and uses no detergent, uses only cold water, and recycles water. Ozone-generating equipment is attached to the washer as a closed-loop system.

Alternate Water Sources

Many facilities have water uses that can be met with non-potable water from alternate water sources. Alternate on-site sources of water are most economic to capture if included in the original design. Common uses for these sources include landscape irrigation, ornamental pond and fountain filling, cooling tower makeup, and toilet and urinal flushing.

There are four major categories of alternate water sources potentially available to facilities—municipal-supplied reclaimed water, treated gray water from on-site sanitary or non-sanitary sources, rainwater harvesting, and storm water, which is not widely used.

Municipal-supplied reclaimed water can be treated and recycled for non-potable use. Sanitary gray water is water that is generated by bathroom sinks, showers and clothes washing machines, and can contain pathogens. Non-sanitary gray water is water generated by industrial processes or equipment such as reverse osmosis reject water and cooling tower condensate, and can contain chemicals, minerals and solids. This water is typically available at a significantly lower rate than potable water; however, use of reclaimed water is often restricted by local codes.

Rainwater harvesting captures, diverts and stores rainwater for later use. Captured rainwater is often used in landscaping because the water is free of salts and other harmful minerals, and it does not have to be treated. It is also useful in attracting and providing water for wildlife. Rainwater harvesting can also help prevent flooding and erosion as it will allow water to soak into the ground instead of saturating it and causing runoff. This, in turn, helps to reduce the contamination of surface water with sediments, fertilizers and pesticides in rainfall run-off.

Like rainwater, storm water can be harvested and reused. Storm water harvesting differs from rainwater harvesting in that the runoff is collected from drains or creeks, rather than roofs. The characteristics of storm water harvesting and reuse schemes vary considerably among projects, but most schemes include collection, storage, treatment and distribution. Captured water is typically treated to reduce pathogens and pollution levels through the use of constructed wetlands and sand filters. Disinfection techniques including chlorine, UV radiation and membrane filtration. The degree of treatment required depends on the proposed use. Potential limitations and disadvantages to storm water harvesting and reuse schemes include variable rainfall patterns, environmental impacts of storages, potential health risks, and high relative unit costs of treating storm water.

To develop an efficient and successful reclaimed water project, the utility must have a reliable source of wastewater of adequate quantity and quality to meet non-potable water needs. These projects are economically more viable when the cost of water is high, there is a lack of high-quality freshwater supply, reuse is the most cost-effective way to dispose of wastewater effluent, and there are local policies that encourage the use of reclaimed water or water efficiency.

Best practice options are described below.

Implementation Considerations

As described in other best practices, potential non-potable water use should be identified while reviewing current water use practices. The use of non-potable water is generally most cost-effective when included in the design of new facilities. Facilities using alternative on-site water sources must comply with all applicable backflow prevention requirements.

Municipal Supplied Reclaimed Water

- Municipal supplied reclaimed water pipes must be color coded with purple tags or tape according to standards set by the American Water Works Association to minimize cross-connection problems.
- Signs should be used liberally to indicate that reclaimed water is non-potable. Place them in public places such as in front of a fountain and on valves, meters and fixtures.
- The pressure of reclaimed water should be kept to 10 psi, lower than potable water mains, to prevent backflow and siphonage in case of accidental cross-connection.
- Reclaimed water mains should be run at least 12 inches lower in elevation than potable water mains, and horizontally at least five feet away.
- The quality of reclaimed water should be reviewed to ensure there will be no harmful effects, such as salt buildup, from long-term use.

Gray Water Recycling Systems

- The pathogenic organisms in sanitary gray water must not come into contact with either humans or animals. This can be accomplished by treating the water to eliminate pathogens or avoid their introduction into water by not mixing sanitary gray water with any potable water source. Human exposure can be prevented by not collecting or storing it in an open container, and by limiting use.
- Sanitary gray water used for irrigation should not be applied directly through a spraying device, but injected directly into the soil through drip irrigation. Drip irrigation achieves the benefits of using recycled water and at the same time avoids contaminating animals, humans and edible plants.
- A maintenance program for a gray water system must include the following steps, all of which must be performed regularly:
  1. Inspecting the system for leaks and blockages
  2. Cleaning and replacing the filter bimonthly
  3. Replacing the disinfectant
  4. Ensuring that controls operate properly
  5. Periodically flushing the entire system
- The use of on-site wastewater recycling systems should be considered when constructing new buildings. Even though many of these systems are costly to purchase, the payback period in savings from discharging less wastewater can be as little as 10 years or less.
- Gray water systems must be installed in accordance with local plumbing codes and by professional, licensed plumbing contractors. Installing a gray water system requires the retrofitting of existing plumbing, and all alterations to the plumbing system must be approved by local authorities.
- For buildings with slab foundations, recoverable gray water may be limited to washing machine discharge because most drain pipes, such as for sinks, are buried beneath the slab and thus not easily accessible without significant additional expense.
- For buildings with perimeter foundations, gray water may be recoverable from most sources due to accessibility to piping from crawl spaces.
- Depending on the gray water source, application, recycling scheme and economics, one gray water treatment method (e.g., media filtration, collection and settling, biological treatment units, reverse osmosis, sedimentation/filtration, physical/chemical treatment) may be more appropriate than the other.

Rainwater Harvesting

Rainwater collection and distribution systems can be incorporated into almost any existing site, although it is easier to incorporate them into new construction.

Section 5
Waste stream management

Waste stream management includes identifying various waste components, collecting and transporting these materials, and making decisions on end-of-life "disposal." This section provides guidance to agencies developing sustainable practices to effectively manage their respective waste stream(s). Agencies implementing sustainable waste stream management can lead by example and encourage businesses and individuals to follow.

Implementing sustainable waste stream management requires a transformation in the thinking about what constitutes "waste." Recently, the concept of "cradle-to-cradle" has emerged with the objective of shifting waste management from linear (or open-loop) systems where resources move through society and become waste to be disposed at a landfill, to circular (or closed-loop) systems in which the formerly disposed waste becomes a resource for a new

product or process. This concept has also been interpreted as "industrial ecology," or the sustainable combination of the environment, economy and technology. Industrial ecology ponders the idea that sustainable systems should be modeled after natural systems that do not produce any waste because resources are reused. The closed-loop system needs to be mapped out for all the components of a product (and its packaging) so that the components can either be reused, recycled or biodegraded. When adopting either cradle-to-cradle or industrial ecology into a sustainable waste management system, it is essential to perform a life-cycle evaluation to avoid shifting impacts from one system to another.

As an initial best practice approach, agencies should consider developing a sustainable integrated waste stream management plan that includes:

- A description of current waste management practices
- The volume and composition of the current waste streams generated
- Projection of future waste generation rates that considers changes in agency staffing and responsibilities
- An alternative analysis that focuses on implementing sustainable waste management strategies
- Details on the proposed changes to the waste management system (e.g., implementation schedule, compliance, enforcement, partnerships, outreach and education)
- Matrices to be used to track the effectiveness of the implemented sustainable waste management processes

California Senate Bill 14 (SB14) can provide a useful template for the sustainable waste stream management process. It includes an iterative process in which the matrices tracked are compared against established reduction goals so that every five years the waste stream management plan is assessed for deficiencies and further improvements.

The Waste Hierarchy

Waste hierarchy refers to a waste management strategy based on the desirability of the pending waste stream. Figure 9 has been widely used to represent structure of waste hierarchy and indicates in order of importance the most favored option from the least favored option.

Waste hierarchy is a process to be incorporated into sustainable waste management plans with the objective of reducing the total volume of waste being disposed in landfills. This strategy is known as waste minimization which, when implemented, has been traditionally referred to as the "3 Rs," or "reduce, reuse and recycle" (in order of importance). The term reduce is covered within the waste hierarchy pyramid under the "prevention" and "minimization" tiers.

Recently, a fourth "R" has been incorporated into the waste hierarchy, "re-think." The concept of re-think is analogous to the circular, closed-loop waste management systems being considered within the cradle-to-cradle and industrial ecology concepts. Implementing the fourth R into waste minimization requires a waste generator to review their entire waste-producing process and rethink systematical changes that ultimately reduce the overall volume of waste generated. A typical "re-think" example may include clothing manufacturers cutting extra material in the first round of manufacturing so that the left-over cuttings (i.e., the waste) can be more easily reused in smaller parts. Another example of the re-think philosophy is "pre-cycling", or pre-designing the integration of components into a product's manufacturing process that can be easily reused and/or recycled upon reaching the initial product's end-of-life.

The ultimate objective of the waste hierarchy is to produce a "zero-waste" system in which outputs from every resource or use are turned into the input for another resource or use. Zero-waste systems will require the residential, commercial and industrial sectors of society to maximize waste management strategies in alignment with the waste hierarchy, and to promote products and services that are environmentally friendly and designed so they have the potential to be repaired, reused or recycled.

Organizational objectives should include generating waste streams that fall into the upper tiers of the waste hierarchy, rather than the lower tiers. It will be important to include both technical and feasibility alternatives analysis in the decision for selecting each waste stream.

Reduction

The most desirable waste minimization strategy under the waste hierarchy is simply reducing the waste stream prior to disposal. Source reductions are the concepts of cradle-to-cradle and that industrial ecology systems can be incorporated into source reduction strategies.

Source reduction strategies implemented by local agencies is dependant on their waste streams. Implementation may require short-term capital investment, which can usually be recovered in the long-term by eliminating unnecessary and wasteful products. Some examples include:

- Eliminating disposable cups and plates used in office settings and replacing them with non-disposable dishware.
- Switching to electronic invoicing.
- Eliminating facsimiles and convert incoming faxes to emails.
- Converting all printers and copiers to duplex (i.e., double-sided) printing.

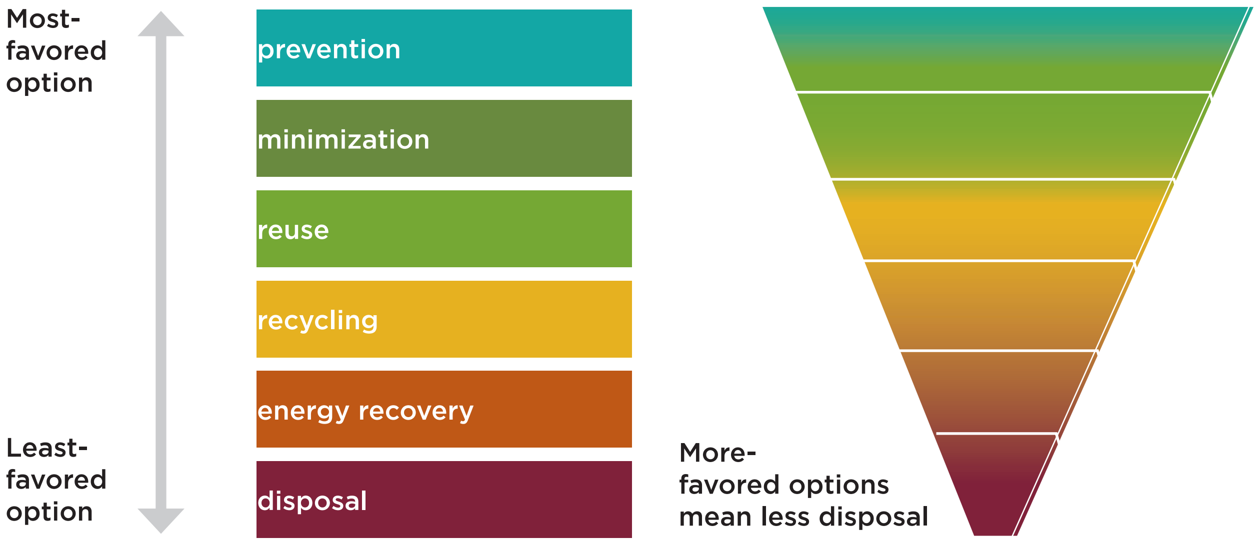

Figure 9. The Waste Hierarchy of Options

- Providing potable drinking tap water and eliminating the use of disposable water bottles.
- Establishing goals to reduce the volume of printed documents and encouraging electronic delivery of these materials.

Reuse

Reuse refers to using a product more than once. Implementing reuse strategies into waste management plans has potential advantages that include reducing energy and raw materials, establishing a new economy to implement the reuse measures, and realizing long-term cost savings; however, potential disadvantages to reuse are the energy requirements, transportation and product cleaning, and the additional labor time required to refurbish the used item. A life-cycle energy assessment should be performed prior to implementing reuse strategies to determine whether recycling would be a better sustainable solution than reuse.

Some reuse examples include:

- Providing employees with reusable water bottles to be used in offices and at job sites, rather than using disposal water bottles.
- Providing employees with reusable tote bags to discourage the use of disposable bags.
- Collecting and reusing paper products (e.g., newspaper, gift wrapping) as packaging material.
- Performing regularly scheduled delivery services, for both internal deliveries and with outside vendors (e.g., office products, food, uniform outfitters) using reusable transit packaging (e.g., totes, trays, baskets), rather than cardboard boxes.
- Establishing and/or encouraging the establishment of reuse networks or brokerages within the local department or agency. Items that could be incorporated into these reuse networks include office furniture, uniforms, electrical appliances, computers and cellular phones.

Recycling

Recycling is a key component of the waste hierarchy. Its objective is to reduce the adverse impacts of processing raw materials (i.e., extraction methods, air pollution, water pollution, energy usage) and promote a more sustainable system of resource consumption. Recycling reduces the volume of waste entering landfills.

In general, recycling programs in urban settings consist of curbside collection, while rural settings incorporate recycling drop centers into their regional waste management systems. These recycling programs can function in one of three differing collection methods depending on operational needs of the downstream waste facility.

1. **Mixed waste.** Recyclables are co-mingled with the general waste stream and then sorted and cleaned at the downstream waste facility. This method produces the least desirable outcome as the recyclable materials are initially soiled by the general waste stream, but is the most convenient to implement as no additional measures beyond the typical curbside waste collection need to occur for either the consumer or waste transporter.
2. **Co-mingled recyclables.** Recyclables are separated into a single waste stream, separate from the general waste stream, and then delivered to the downstream waste facility. The method requires additional pre-collection sorting measures and receptacles, but it produces a higher-grade end product. Advances in single-stream sorting technology have contributed increased purity of the end-product and ease of facility operation, which has resulted in increased recycling rates.

3. **Source separation.** Recyclables are separated at the source both from the general waste stream and from each other into individual receptacles (i.e., paper vs. plastic vs. glass vs. metals) and then transported to the downstream waste facility. This used to be the preferred collection method; however, as implementation and operation proved to be time-consuming and costly, and single-stream sorting of commingled recycles has advanced, waste management programs have begun switching to the latter method.

Some common recyclable materials include:

- Paper, plastic, glass
- Ferrous and non-ferrous metals
- Clothing and textiles
- Batteries
- Electronics
- Biodegradable waste
- Timber
- Tires

Agencies can promote recycling programs in their respective office settings and on agency projects. Some measures that could be incorporated to encourage recycling include:

- Installing clearly marked recycling receptacles at all locations where general waste is collected.
- Instituting budgetary "set-asides" and developing "price-preference" programs to provide funding for and promote the purchasing of recycling-friendly products.
- Exploring options to use recycled products in County projects (e.g., "glassphalt" for road surfaces, crushed recycled concrete as aggregate for new concrete).

Management of Biodegradable Waste

Biodegradable waste consists of waste originating from plant or animal sources that can be broken down by natural processes and organisms (i.e., "biodegraded"). Biodegradable waste that could be added into the agency's respective sustainable integrated waste management programs includes both green waste (e.g., yard clippings) and food waste (e.g., scraps, restaurant grease). Biodegradable waste can be aerobically composted to produce an extremely useful soil end-product (compost), or it can be anaerobically digested to produce biogas that can be converted to energy. In addition, biodegradable waste has been treated using incineration to generate electricity and heat ("waste-to-energy").

Managing the biodegradable waste stream is important for a sustainable future as treatment of this waste through the standard system of disposal at a landfill contributes to greenhouse gas generation. Biodegradable waste within a landfill decomposes under uncontrolled conditions, which generates methane, a more potent greenhouse gas than carbon dioxide, which is released to the atmosphere. Diverting biodegradable waste from landfill disposal to a controlled recycling system would reduce climate impacts and lead to a more sustainable waste management system.

Managing biodegradable waste can range from extremely passive methods in rural communities (i.e., piles of compostable materials) to engineered composting structures used in more densely populated urban settings. In addition, agency buildings with limited outdoor space can employ worm composting (vermicomposting), which uses sealed bins to produce both a rich compost and liquid soil amendment (worm tea).

Industrial composting is being explored as a waste management alternative to landfills. Industrial composting requires installing new waste management facilities and routinely collecting biodegradable waste. This process can yield great reductions in the emissions of greenhouse gases from landfills and also provide a new, sustainable energy source.

Biodegradable waste initiatives that can be incorporated into an agency's respective integrated waste management plan include:

- Incorporating biodegradable waste collection into office settings.
- Providing food waste collection receptacles for large gatherings (i.e., lunch meetings, seminars).

Management of E-Waste

E-waste is generated by the disposal of electrical or electronic devices (e.g., computers, cell phones, media/entertainment equipment). E-waste represents a small percentage of the total waste stream generated; however, due to its toxic and non-biodegradable components, e-waste disposal in landfills is a major environmental concern. Managing e-waste usually consists of community roundups or drop-off locations where the e-waste can then be sorted for reuse and recycling. Several of the components of e-waste can typically be separated and reused or repaired (e.g., aluminum, copper, plastic), which can then be resold as a commodity. Other components of e-waste are extremely toxic (e.g., cadmium, lead, mercury), and require special handling and recycling or proper disposal measures once separated from the reusable commodity components.

One policy for managing e-waste is known as extended producer responsibility (EPR), which requires manufacturers to be either financially or physically responsible for their product and its components through the end of their useful life. Financial responsibility incorporates third-party reuse/recycling into the market price, whereas physical responsibility involves manufactures developing "take-back" programs for their products. Some critics have contended that although EPR has merits, in some circumstances it is not being implemented in a sustainable manner. Some third-party auditing has demonstrated that e-waste is not being reused/recycled, but rather disposed of in developing countries where there are no environmental controls.

Agencies can incorporate e-waste into their respective sustainable integrated waste management plans by:

- Maintaining e-waste collection centers in offices.
- Purchasing electronic devices from manufacturers identified as having an auditable EPR incorporated into their products.

Management of Construction Waste

Waste generated from the construction industry, both from construction of new buildings and facilities and deconstruction of old ones, accounts for a major portion of the solid waste generated and disposed of in landfills; however, a significant portion of this waste stream can be diverted from landfill disposal and has the potential to be managed and sorted for reuse and recycling. Most components of the construction waste stream could be sustainably managed.

Agencies can incorporate construction waste into their respective sustainable integrated waste management plans by developing and requiring comprehensive construction waste management plans for all construction/deconstruction projects conducted by the respective agency or within their jurisdiction. Construction waste management plans should include:

- A list of the construction waste materials to be generated by the project and the estimated volume of each waste stream.
- Minimum requirements for percentage of reuse and recycling established for each waste stream.
- Specifics on the methodology to be implemented to manage the construction waste; i.e., on-site sorting measures; transportation to off-site recycling facility; on-site reuse into the construction project.

After completing each construction/deconstruction project, the results of implementing the respective waste management plan should be evaluated to determine if the reuse/recycling goals were met and if further sustainability measures could be implemented to increase construction waste reuse/recycling and decrease the volume of construction waste entering landfills.

Role of an Agency as a Waste Receiver

The generation of each waste stream is followed by its receipt for end-of-life "disposal." Agencies may also function as a waste receiver involved with collecting, transporting and disposal management of the various waste streams.

Waste Collection and Transportation

Waste collection involves handling, transporting and processing respective waste streams from the generators to the disposal facility (landfill or reuse/recycling center). Waste collection mitigates the adverse effects that result from unmanaged waste streams.

For agencies to implement their respective sustainable integrated waste management plan, and to also encourage community business and individuals to do the same, waste collectors and transporters need to provide services for managing respective waste streams. Examples of sustainable practices that waste collectors and transporters may institute include:

- Providing waste generators with appropriate receptacles that contain separate waste streams, including municipal waste, recyclables and biodegradable waste (both green and food). The receptacles should be covered, sturdy, clearly marked and easy to transport.
- Establishing and/or encouraging reuse networks for residential and business communities. Items that could be incorporated into these reuse networks include furniture, clothing, electrical appliances, computers and cellular phones, and other industry-specific materials or components deemed suitable for reuse.
- Providing community settings with recycling receptacles at all locations where general municipal waste is collected.
- Schedule routine community waste roundups "spring cleaning." These roundups can collect large municipal waste items (e.g., furniture) that may prove troublesome for curbside pick-up, and thereby help discourage illegal dumping of these materials.
- Develop biodegradable waste collection programs for large generators of green waste (e.g., community parks, landscaped office complexes) and food waste (e.g., schools, hospitals, restaurants).
- Work with farms and animal lots to manage, collect and process manure.
- Scheduling seasonally appropriate, large-scale green waste roundups (i.e., spring and autumn).
- Maintaining e-waste collection centers throughout the community.
- Scheduling routine (i.e., quarterly) community e-waste roundups. Note that the e-waste collected could then be sorted and sold to a recycler as a commodity, with the proceeds used for community fundraising.
- Ensuring waste haul routes from generator to transfer station and/or disposal facility are optimized in both distance traveled and volume of waste collected.

Waste Disposal

Although the goal of sustainable waste stream management is to reduce the volume of waste requiring disposal in landfills, until zero-waste systems are fully incorporated, landfill disposal of solid waste will be required. Agencies can be involved with managing landfill disposal facilities. Incorporating sustainable management practices into the operation and maintenance of these facilities can further reduce the adverse effect landfills can have on the surrounding community ecosystem.

Changes in landfill operations and maintenance will likely require substantial capital investment; therefore, life-cycle alternative analyses will be important in selecting appropriate modifications. Note that numerous sources of both public and private funding for such investments exist. Establishing a sustainable integrated waste management can likely aid local agencies in obtaining these funds. Some examples for sustainable landfill practices include:

- Designing and constructing composting cells into the landfill.
- Installing automated waste separators to mitigate recyclable waste streams from entering the landfill.

Regulation, Education and Outreach

Agencies can additionally function as "regulators" of waste streams generated within their jurisdiction. This role may include developing and promulgating ordinances that promote sustainable waste stream management practices, and the subsequent enforcement policies required to ensure compliance with the new regulations.

Example measures that agencies functioning as waste regulators may institute to promote sustainable waste stream management include:

- An "environmental tax" on items or services that reflect the environmental cost of manufacturing and disposing of the product, with the goal of encouraging reuse.
- Promoting "pay as you throw" disposal programs to encourage recycling and discourage waste generation by developing sliding pricing scales based on the total volume of each waste stream.
- Actively enforcing ordinances and regulations that ban the disposal of certain recyclable waste products (e.g., batteries, used oil, tires).
- Actively enforcing the ban of e-waste from entering municipal landfills.
- Establishing minimum requirements for percentage of reuse and recycling for each waste stream generated during construction projects.

To successfully implement a sustainable integrated waste management plan developed by each respective agency, educational and outreach programs will need to be developed. The objective of these programs will be to inform waste generators, both the respective agency/department and the general community served, how each waste stream is to be managed and what each one comprises. As part of this educational outreach, agencies could perform the following:

- Develop and distribute brochures that discuss the waste hierarchy and each individual's responsibility to manage waste per this hierarchy.
- Provide a listing of items/materials that can be incorporated into reuse networks/clearinghouses.
- Provide a listing of items/materials that are allowed and not allowed in the recycling program.
- Provide regular updates to the community regarding the success of the waste management plans (i.e., how much waste was diverted from the landfill by reuse/recycling, the reduction of greenhouse gas emissions achieved by diverting biodegradable waste from being disposed into landfills).

Note that following the implementation of these programs and grace period, enforcement actions can be considered that involve fining those continuing to dispose of waste streams in landfills that should otherwise be managed in a more sustainable manner.

Section 6
Financial considerations

There are several considerations when choosing the best ways to implement sustainable practices within an agency. Agencies should look at how sustainable changes can be considered as capital investments for the growth and benefit of the agency. Agencies must make financially intelligent decisions when purchasing or leasing the necessary equipment or improvements, or whether to use environmental service companies (ESCOs), or to use public/private ventures.

The following are environmental attributes to keep in mind when financing for sustainable management:

- Energy efficiency
- Enhanced indoor environmental quality
- Low embodied energy
- Recyclable or reusable components
- Recycled content
- Reduced environmental impact over the life-cycle
- Reduced or eliminated toxic substances
- Reduced waste
- Responsible storm water management
- Sustainable development, smart growth
- Bio-based content
- Uses renewable energy
- Water efficient
- Water reuse and recycling (http://www.epa.gov/opptintr/epp/pubs/products/construction.htm#b).

Purchasing

Buying equipment outright is the most common acquisition option. This process should start with a determination of what equipment and processes should be replaced. This can either be decided internally by the agency, or an outside entity can be hired such as a public utility (e.g., PG&E), to perform an audit that identifies inefficient equipment and processes.

A simple payback analysis is often used to determine whether an acquisition fits the agency's purchasing policy. A simple payback calculation shows the time, usually in years, that a project will take for its monetary benefit to outweigh its cost, or time to pay for itself. This evaluation is a useful way to differentiate among many different improvement projects on a financial basis. This technique is limited in that it only addresses monetary savings, not non-economic benefits. The simple payback is calculated with the following equation:

Simple Payback (years) = Capital Cost ($)/ Annual Savings ($/year)

As an example, if an energy improvement project has a capital cost of $1,000,000 and the project produces $100,000 a year in cost savings, the simple payback for the project is 10 years.

If the same project has an energy grant available of $400,000, the project cost is now the capital cost minus the grant, or $600,000. The cost savings per year remain $100,000, so the simple payback is now six years.

For a project that replaces outdated incandescent lighting technology with high-efficiency compact fluorescent lights (CFL), the cost savings are straightforward: A 100-watt light bulb replaced with a brightness-equivalent CFL that consumes 23 watts will reduce power consumption by 77 watts. Imagine there are 1,000 of these identical light bulb replacements in the project. The total energy savings for the project would be 77 kW. The estimated annual cost savings can be calculated using the following formula:

Annual Savings ($) = Annual Operating Hours(hours/year) x Energy Savings(kW) x Cost of Electricity($/kWh)

In this example, it was assumed that lights will be operating 10 hours a day, five days a week or 2,600 hours per year, and that the average cost of electricity (that will be displaced) is $0.10/kWh:

Annual Savings ($) = 2600 (hours/year) x 77 (kW) x 0.10 ($/kWh) = $20,020

Complications to annual savings can arise; however, when either relying on a Time-of-Use (TOU) power rate agreement or during an alternative energy project in which the power produced will not be used on site, but sold back to the utility.

A TOU agreement is an electric rate schedule in which the cost of electricity is dependent on the time of day and time of year the electricity is consumed. In the case of a TOU rate schedule, the effects of the on-peak, partial-peak and off-peak operating hours can be estimated by adjusting the cost of electricity to incorporate this factor or by estimating the operating hours for each rate period and applying the TOU rate for that period:

Annual Savings ($) = Energy Savings (kW) x [Annual On-Peak Hours (hours/year) x On-Peak Cost of Electricity ($/kWh) + Annual Partial-Peak Hours (hours/year) x Partial-Peak Cost of Electricity ($/kWh) + Annual Off-Peak Hours (hours/year) x Off-Peak Cost of Electricity ($/kWh)].

Excess energy can be sold back to the grid. For calculating the savings associated with an alternative energy project with power sold to the grid, the cost of displaced electricity becomes the sale price of electricity based on the power contract. This is generally lower than the cost of electricity for purchase from the electric utility.

Advantages of Purchasing

For an agency looking to buy equipment outright, advantages and disadvantages should be taken into account.

Some advantages of buying equipment outright include:

- Ownership of the asset that can't be repossessed unless it has been used as security for a loan
- No ties into long-term agreements, which may be difficult to terminate
- Lower overall costs than through a lease or hire purchase agreement, although money may need to be borrowed to make the purchase

Disadvantages of Purchasing

Some potential disadvantages of buying equipment outright for an agency include:

- Paying the full cost of the asset up front
- Adding to the purchase cost if a loan is used to fund the purchase
- Possibly buying equipment that may not be needed in the future
- Managing the disposal or selling of the outdated equipment
- Being entirely responsible for maintaining the asset
- The value of the asset may depreciate over time, leaving the agency with a value-less asset for disposal as opposed to leasing where the lessor maintains ownership
- Taking on all the risk if the equipment breaks down or gets replaced.

Resources for Purchasing Equipment

After considering the costs and benefits of purchasingf sustainable equipment, several resources are available to agencies for making the purchase.

A tool made available by the National Institute of Standards and Technology (NIST) Building and Fire Research Laboratory, BEES (Building for Environmental and Economic Sustainability) software, brings a powerful technique for selecting cost-effective, environmentally preferable building products. All stages in the life of a product are analyzed with the BEES software, including raw material acquisition, manufacture, transportation, installation, use, and recycling and waste management. Economic performance is measured using the ASTM standard life-cycle cost method, which covers the costs of initial investment, replacement, operation, maintenance and repair, and disposal. Environmental and economic performances are combined into an overall performance measure using the ASTM standard for Multi-Attribute Decision Analysis.

Another resource for agencies to use to find sustainable equipment to purchase is the Energy Star® site. The website provides online training, case studies, product lists, savings calculators, and other procurement materials.

Six easy steps to procure Energy Star® equipment, as listed on the website, are as follows:

- Review purchasing policies and identify product categories where savings exist.
- Visit http://www.energystar.gov for product listings. Use the Savings Calculators to determine savings opportunities and life-cycle costs.
- Coordinate with the appropriate offices within your organization to encourage the purchase of identified Energy Star®-qualified products.
- Modify procurement language and inform employees
- Access Quantity Quotes for bulk purchases of selected Energy Star®-qualified products
- Communicate success

Key benefits of using Energy Star®-marked products are:

- Reduced energy use of 10 to 75 percent without compromising quality or performance
- Fewer emissions of greenhouse gases that result from reduced use of fossil fuels
- Significant return on investment
- Extended product life (for specific products) and decreased maintenance
- Refer to http://www.energystar.gov/index.cfm?c=bulk_purchasing.bus_purchasing for details.

Currently, Flex Your Power is California's statewide energy efficiency marketing and outreach campaign. It is a partnership of California's utilities, residents, businesses, institutions, government agencies and nonprofit organizations working to save energy. Within their website they have an "Industrial Energy Efficient Product Guide". Each guide explains how energy efficiency can result in substantial long-term reductions in energy consumption and operating costs on service equipment/appliances, heating and cooling, manufacturing processing equipment, lighting, and water efficiency equipment options. The Flex Your Power Product Guides include benefits and potential savings of various products, and valuable tips on how to select the most energy-efficient models (http://flexyourpower.org/ind/tools/products.html).

Equipment Lease Concepts and Options

Leasing is another common acquisition option. Leasing often makes it more convenient to obtain needed equipment without over-extending resources in the process. A lease is essentially a loan in which the leaser retains legal title to the property being leased. Compared to most other forms of financing, leases are quick and easy to set up and administer. Equipment manufacturers or their affiliates will often set up the lease and arrange for equipment purchase and delivery.

Types of Leases

Several lease options exist, and it is up to the agency to engage in the lease that is best for the situation. Each agency should check with the equipment leasing company for the leasing options they offer. Energy Star® summarizes three different lease options—the operating lease, capital lease, and the municipal lease—all described below.

Operating Leases. Under an operating lease, the leaser owns the equipment and essentially rents it to the agency for a fixed monthly fee. At the end of the lease term, the agency may be able to purchase the equipment, extend the lease, negotiate a new lease, or return the equipment. Operating leases are simple, funded out of operating budgets, and may be ideal for short-term projects or projects where owning the equipment is not desirable. Payments are usually lower than for capital leases (see below). In the case of a capital lease, only the interest portion of the payment is deductible.

Capital Leases. Capital leases are essentially installment purchases of equipment, although legal title to the equipment remains with the leaser during the lease term. Title will often pass automatically to the agency at the end of the lease term, or for a small charge. Little or no initial capital outlay is required. Because the economics of a capital lease are so similar to those of a purchase, both financial accounting and tax rules treat these transactions as purchases.

Energy Star® also explains how capital leases can offer advantages over bank loans. Because leasing companies are not subject to the regulations that govern banks, they have much more flexibility in setting their terms. Capital leases typically require little or no down payment, have significantly less paperwork, and are approved faster. Capital leases may also finance soft costs. Credit-worthy organizations may obtain capital leases for as much as 140 percent of the value of the equipment purchased (hard costs). In such a case, a project requiring $500,000 in equipment may also fund another $200,000 of installation and other soft costs.

Municipal Leases. A tax-exempt municipal lease purchase agreement is simply a conditional sales or installment sales agreement. It is the market alternative to a cash purchase or tax-exempt municipal bond issue. The interest portion of the lease payment (income to the leaser) is exempt from federal taxation. This allows rates to be set lower than for bonds that generate taxable interest income, thereby providing the agency with significant cost savings.

A distinct advantage of municipal leases is that the agency's payment obligation usually terminates if the agency fails to appropriate funds to make lease payments. This allows the lease to be kept off the balance sheet. During the term of a municipal lease, the municipality holds title to the leased equipment while the leaser retains a security interest. With each payment the municipality establishes an equity interest in the equipment. At the end of the original lease term, the security interest is removed and the municipality has clear title to the equipment. (http://www.energystar.gov/ia/business/EPA_BUM_CH4_Financing.pdf).

Advantages of Leasing Equipment

Numerous advantages and benefits exist in connection to equipment leasing for an agency:

- More working capital: Compared to the 15 percent to 25 percent down payment typically required to purchase equipment, leasing requires no large cash outlay up front. This allows the agency to conserve working capital for use in more productive, higher-return areas.
- Minimize obsolescence: Leasing gets more mileage out of the money, simply because a monthly lease payment is a very small portion of the total cost of the equipment. So, rather than trying to "make do" with obsolete equipment due to heavy capital investment in its ownership, leasing gives the freedom to react quickly and cost-efficiently to changes in the marketplace (http://www.leaselo.com).
- Cost management: All costs associated with the new equipment can be included in the lease (installation, service contracts, etc.) so the agency can accurately forecast its cost on a monthly basis and tie the equipment's period of benefit to the period of payment. Also, since the lease represents fixed-rate financing, the agency can lock in the payments now.
- Flexibility: At the end of the lease term, the agency can opt to purchase the equipment or lease new equipment that may better suit their needs. With this flexibility, the agency can always access the latest technology. This can also reduce the risk of obsolescence (http://www.aseclease.com/whylease.html).

Energy Star® notes that municipal leases specifically offer a number of advantages:

- Fast, simple approval process: Compared to issuing a bond referendum, a municipal lease purchase is fast and flexible—the time required to close financing is typically weeks instead of months.
- Reduced transaction costs: Most costs associated with bond financing are eliminated. With a municipal lease, the municipality borrows only the cost of the assets. With bond financing, the municipality borrows both the cost of the assets and the fees associated with issuing the bonds.
- Lower interest rates: The interest income on a municipal lease is tax exempt to the leaser. The municipality benefits when the leaser passes these savings to the municipality in the form of a lower interest rate.
- Full financing: All of the project costs can be financed with a municipal lease. No down payments are required, and vendors are paid promptly upon funding the lease. Funding into an escrow account for projects requiring progress payments ensures that the municipality can take advantage of the deepest discounts afforded by the vendor.
- Practical terms: The lease term matches the useful life of the asset.
- No large capital outlay: Current taxpayers pay for project costs as they are incurred. This process also helps local governments and school districts manage their capital reserve fund balances.
- Ultimate ownership: Each lease payment builds equity in the future unencumbered ownership of the asset. At the end of the original lease term

there are no residual values, balloon payments, or purchase options to consider. Municipal leases do not involve return provisions, run-on rent, stipulated loss values, and asset management, thus hidden liability issues are avoided (http://www.energystar.gov/ia/business/EPA_BUM_CH4_Financing.pdf).

Disadvantages of Leasing Equipment

Disadvantages in leasing equipment are described below:

- Capital allowances cannot be claimed on the leased assets if the lease period is for less than five years (and in some cases less than seven years)
- It is more expensive than if the assets are bought outright
- Agencies can be locked into inflexible medium- or long-term agreements that may be difficult to terminate
- Leasing agreements can be more complex to manage than buying outright
- Agencies may have to be VAT-registered to take out a leasing agreement (http://www.businesslink.gov.uk/bdotg/action/detail?type=RESOURCES&itemId=1073791592).
- There is an obligation to continue making payments, which can pose a major financial problem
- There is no equity until the agency decides to purchase the equipment at the end of the lease term, at which point the equipment may have depreciated significantly
- Although the agency is not the owner, it is still responsible for maintaining the equipment as specified by the terms of the lease. Failure to do so can prove costly (http://www.allbusiness.com/business-finance/leasing/2540-1.html).

Grant and Incentive Programs

Sustainability efforts are now strongly encouraged by various federal and state agencies through a variety of incentives. These programs are continuously changing, and a full listing of the current programs is not practical and is not included (however, as an example, a general listing of many of the most significant programs for energy efficiency or alternative energy projects as shown in the following Tables 3 and 4). These programs may or may not be available in the future. Moreover, each program has its own standards for application, and one or all may not be available when desired. Choosing which grants and incentives are applicable and most appropriate for a given project can be a daunting task.

Tables 2-3 and 2-4 below summarize grants and loans for California for two types of projects—the first table for energy efficiency projects and the second for alternative and renewable energy projects. It must be noted that this table is current as of the last quarter of 2008. Programs change, and the reader should check for additional programs or to see if listed programs have expired.

Additional Incentives. The incentives listed were available at the time this guidebook was written.

The Database of State Incentives for Renewables and Efficiency (DSIRE) is a helpful directory that provides a comprehensive list of financial incentives available in each state for implementing alternative energy projects. As an example, the Self Generation Incentive Program (SGIP) provides an incentive of $1,500 per kilowatt (kW) of electric power generated from wind turbines of size ranging from a minimum of 30 kW up to 1 megawatt (MW).

The Million Solar Roofs Initiative and other incentive programs are bringing the cost of clean alternatives within reach of local governments, businesses and homeowners, making clean energy a financially attractive option (http://www.fypower.org/res/tools/rgl.html). Moreover, the continued growth of the clean energy sector encompassing renewable resources like hydro, solar, wind, wave and bio-based fuels, offer financial incentives from the State.

PG&E also has cash rebates and incentives available for energy efficient technologies. Refer to www.pge.com/mybusiness for details, ideas, eligibility and how-to's for lowing greenhouse gas emissions. Some examples of equipment qualifying for rebates include premium T-8 and T-5 lighting, occupancy sensors, daylighting controls, and efficient motors and pumps. Additionally, cash incentives and design assistance are available for new buildings. Other programs include energy analyzers and audits, Energy Star® Portfolio Manager, building upgrades, new efficiency options, economic development services, energy-saving tips, buyer's guide, demand response programs, self-generation incentives, along with several other energy saving and air quality improving tips and help.

The PG&E Customized Energy Efficiency Improvement Rebate Program offers incentives for retrofit improvements that are not covered under the standard energy efficiency rebate program. After a project proposal is reviewed and approved by PG&E, funding is appropriated for the project to be implemented. Some examples of measures that may be eligible for customized incentives include:

- Lighting
- Air compressors
- Variable Speed Drives (VSD) for heating ventilation and air conditioning
- Energy-efficient boilers, chillers, fans, premium efficiency electric motors, and pool heaters
- Continuously operating equipment
- Reflective window film
- Vending machine controllers

PG&E and other Independently Owned Utilities (IOU) also have a Local Government Partner (LGP) in many

Table 3. Highlights of a Few Energy Efficiency and Conservation Grants

Grant Program	Agency	Incentive Amount	Maximum Incentive	Time Window	Summary	Applicable Technology	Limitations
Energy Efficiency Rebates for Business	PG&E	Varies (i.e. $16 per occupancy sensor, and $2 to $9 per lamp		None listed (for 2008)	Rebates for lighting, and HVAC	Rebates for lighting, computers, time clocks, and HVAC. Size varies on an item by item basis	Only for the PG&E service areas
		Varies (i.e. $15 per PC)		None listed (for 2008)	Rebates for PC power management software		
Nonresidential Retrofit – Demand Response (NRR-DR) Program	PG&E	Varies	Up to 50 percent of project cost	None listed (for 2008)	Financial incentives for the installation of high-efficiency equipment or systems	HVAC, lighting, motors, refrigeration, control systems, VFDs	Only for the PG&E service areas, no other grants can be used
Energy Efficiency Grant Program	California Energy Commission State Loan Program	Up to 100 percent of the energy efficiency project cost Overall project was funded for $26 million	$3 million (no minimum)	None identified	Fixed 3.95 percent interest loan to be paid back within 15 years	No size limitations. Typical projects include lighting, motors and HVAC equipment energy efficiency upgrades	No limitations
Loan Guarantee Program	U.S. Department of Energy (DOE)	Loan Guarantee Program was issued with over $10 billion in loan guarantees	No size limit. Focus is on projects below $25 million.	Original July 2008 deadline was extended to Feb 28, 2009	U.S. DOE program was authorized Per Title XVII of the Energy Policy Act of 2005	Daylighting, along with several renewable technologies.	Projects must reduce greenhouse gas emissions
Qualified Energy Conservation Bonds	Federal Loan Program	$800 million in 0 percent interest bonds for qualified energy conservation bonds for local government agencies per the Clean Energy Improvement and Extension Act of 2008		Authorized October 3, 2008	Program similar to the Clean Renewable Energy Bonds (CREB) but for energy conservation	To be determined (projects may also receive this and CREB for renewable	To be determined

areas of their territory. An LGP exists to market energy conservation and demand reduction programs to local government agencies. The County of Sonoma is one such Partner. For organizations within a Partner's sphere of influence, a LGP can offer technical assistance, project assistance and rebates, and can be of great assistance to an agency planning energy efficiency project work of equipment purchases that will create energy savings. A best practice recommendation is to contact your IOU representative and ask if there is a Partner in your area.

For Non-Residential Retrofits, PG&E offers monetary incentive payments that are based on actual reduction in energy usage, measured by PG&E before and after the retrofit. Customers and/or their consultants may sponsor projects under this approach. PG&E should be contacted at the beginning of the process and before the project is started so that PG&E can help identify the appropriate application forms, confirm a project's eligibility, offer general advice on the technical aspects of the application, and walk the agency through the process.

Non-Residential New Construction (NRNC), also known statewide as Savings by Design, is a program for commercial, industrial, high-tech and agricultural customers that encourage energy-efficient building and process design and construction. This program, administered by PG&E under the auspices of the Cali-

Table 4. Highlights of a Few Renewable Energy Grants and Incentives

Grant Program	Agency	Incentive Amount	Maximum Incentive	Effective Time Period	Technology	Applicable System Size	Significant Limitations
Self Generation Incentive Program	PG&E (all 3 major California IOU's)	$1500 per kW	Up to 3 MW	Thru 2011	Wind power	<30 kW	Electric power must be consumed on site with no exporting
		$4500 per kW	Full funds to 1 MW, less above that	Thru 2011	Fuel cells	Up to 1000 kW	
Emerging Renewable Program	California State Rebate Program	$2500 per kW up to 7.5 kW. $1500 per kW for 7.5 to 30 kW	Up to 75 percent of the installed system cost	As of January 2007. No sunset date identified.	Wind power	Grants are only for sizes up to 30 kW	Must be grid connected. Must have 5 year warranty
Energy Efficiency Financing Program	California Energy Commis-sion State Loan Program	Up to 100 percent of the energy effi-ciency project cost Overall program is funded for $26 million	$3 million (no minimum) Fixed 3.95 percent interest loan to be paid back within 15 years	None identified	Typical projects include distributed generation and combined heat and power projects	None identified	No limitations Available to local governments.
California Solar Initiative	California Public Utilities Commis-sion	Varies. Typically up to $0.32 per kWhr. Program funded to $3 billion		Thru 2016	PV solar, and solar hot water	> 50 kW	Lower cap on solar heating systems
Clean Renewable Energy Bonds (CREB)	Federal Loan Program	$800 million in new CREB, generally for the public sector for financing renewable energy projects per the Clean Energy Improvement and Extension Act of 2008		October 3, 2008 thru December 31, 2009	PV solar, solar hot water wind power, geo-thermal energy and hydroki-netic power	To be determined	To be determined
Qualified Energy Conservation Bonds	Federal Loan Program	$800 million in 0 percent interest bonds for qualified energy conservation bonds for local government agencies per the Clean Energy Improvement and Extension Act of 2008		Authorized October 3, 2008	Solar hot water, PV, wind power, geothermal energy and hydrokinetic power	To be determined	To be determined

fornia Public Utilities Commission, offers owners and their design teams a variety of services and follows the protocol outlined in the NRNC/Savings by Design program material.

This program offers analysis and resources to aid owners and design teams with energy-efficient facility design, such as:

- Technical design assistance to analyze and design more energy-efficient buildings and process systems
- Owner incentives of up to $500,000 per project to help offset the investment in energy-efficient building and design
- Design team incentives of up to $50,000 per project to reward designers who meet ambitious energy-efficiency goals.
- Incentives offered in relation to alternative fuels vehicles include:
  - Alternative Fuel Vehicle (AFV) and Refueling Infrastructure Grants and Loans (Assembly Bill 2766)
  - High Occupancy Vehicle (HOV) Lane Exemp-tion (2005 Federal transportation bill Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU), Public Law 109-59) (Reference Assembly Bill 2600 and 1407, 2006, and California Vehicle Code Sections 5205.5 and 21655.9)

- – Lower-Emission School Bus Grants
- – Idle Reduction Incentives (Reference Assembly Bill 201, 2007, and Proposition 1B, 2006)
- – Alternative Fuel Vehicle (AFV) and Hybrid Electric Vehicle (AFV) Farmers Insurance Discount
- – Alternative Fuel Incentive Development (Reference Assembly Bill 1811, 2006)
- – Alternative Fuel Vehicle (AFV) Rebate Program

Private/Public Ventures

For an agency planning on implementing major fiscal and operational changes in their sustainable management, a public/private venture may be the best option. Public/private ventures (PPVs) are also know as Public-Private partnerships (PPPs), Joint Ventures or Collaborative Enterprises. PPVs are an arrangement whereby the resources, risks and rewards of both the public agency and private company are combined to provide greater efficiency, better access to capital, and improved compliance with a range of government regulations regarding the environment and workplace.

Advantages of Public/Private Ventures

Once the agency decides if the PPV route is feasible, it is important to assess the costs and benefits of such a financial strategy. Advantages and benefits of PPVs include:

- Maximizing the use of each sector's strength
- Reducing development risk
- Reducing public capital investment
- Mobilizing excess or under-utilized assets
- Improving efficiencies/speeding completion
- Better compliance with environmental regulations and laws
- Improved service to the community
- Improved cost effectiveness
- Shared resources
- Shared/allocated risks
- Mutual rewards (http://www.ncppp.org/resources/papers/norment_nc.pdf)

In a 1998 survey by the U.S. Council of State Governments, respondents were asked the reasons they used public-private partnerships over the past five years. The results were as follows:

- Cost savings, 40.9 percent
- Lack of in-house personnel and expertise, 32.5 percent
- Lack of State support of political leadership, 30.8 percent
- Flexibility and less red tape, 23.8 percent
- Speedy implementation, 21.4 percent
- Increased innovations, 20.4 percent
- High quality of service, 18.5 percent
- Other, 10.6 percent

Public agencies have found that they can use private resources and expertise to save precious funds through faster facility design and construction, as well as less expensive operations. The second-highest reason cited in the survey is the access to specialized expertise and proprietary technology.

Additionally, PPVs can help governments address sensitive political and labor issues. In the survey above, the third highest reason was to accomplish objectives when the agency couldn't directly take on the issue. With the flexibility and efficiency of private developers and operators, the agency can sometimes enlist the private sector to handle problems such as downsizing, coordination of political entities, regionalization, and implementation of difficult policies and cross border relationships (http://www.ncppp.org/resources/papers/seader_usexperience.pdf).

Disadvantages of Public/Private Ventures

Private/Public Ventures may not always be a worthwhile financial strategy for a public agency. The following disadvantages have been noted when creating a PPV:

- Tendering and negotiation: PPV contracts are typically much more complicated than conventional procurement contracts. This is principally because of the need to anticipate all possible contingencies that could arise in such long-term contractual relationships. In addition, there are typically significant legal costs in contract negotiation. It has been estimated that "total tendering costs equal around 3 percent of total project costs as opposed to around 1 percent for conventional procurement".
- Contract renegotiation: Given the length of the relationships created by PPVs and the difficulty in anticipating all contingencies, it is not unusual for aspects of the contracts to be renegotiated at some point. Given the length of time spanned by the contract, it is almost inevitable that circumstances will arise that cannot be foreseen; therefore, the cost of such changes is difficult to factor into the original project evaluation.
- Performance enforcement: One of the difficulties with performance specification in the area of service delivery is that performance sometimes has dimensions that are hard to formulate in a way that is suitable for an arms-length contract.

Examples and Opportunities

Examples shown below that are located in the US were taken from a report published by The Climate Group (2007) (http://www.theclimategroup.org/).

Partnership between Exelon Corporation and the City of Chicago (www.chicagosolarpartnership.com)

Goal: To reduce peak load electricity use and advance development of the solar energy industry in the Chicago metropolitan area.

Time Frame: Since 2000

The partnership's efforts have yielded close to 2 MW of solar installations in the Chicago metropolitan area, many of which are located on buildings, which helps to preserve open space. These efforts have helped Chicago reduce CO2 emissions by 1,361 tonnes per year, the equivalent of taking 275 cars off the road, as well as to reduce sulfur dioxide emissions between 10 and 20 tons per year.

Partnership between Verdant Power and the New York State Energy Research and Development Authority (www.verdantpower.com)

Goal: To produce 10 MW of commercialized clean energy from an underwater turbine field

Time Frame: Commercial operation estimated to commence in 2009

The efforts will displace the equivalent consumption of more than 18,000 tons of coal, 68,000 barrels of oil, or more than 12 million cubic meters of natural gas per year. It is also expected that the project will eliminate approximately 150 tons of SOx, 90 tons of NOx, and nearly 30,000 tons of carbon dioxide annually, which is roughly equivalent to taking 6,000 cars off the road.

Potential Partnership Opportunities

(Available at the time of this report's writing)

Johnson & Johnson, an American manufacturer of pharmaceuticals, medical devices and personal health-care products, has created a capital relief fund of up to $40 million annually for prioritizing and approving onsite renewable energy and energy efficiency projects. As of the end of 2007, Johnson & Johnson has reportedly approved 51 projects valued at US $99 million, 31 of which have been completed. Projects include boiler upgrades, HVAC enhancements, combined heat and power projects, solar installations, and chiller upgrades. To date, the completed projects have produced an average internal rate of return (IRR) of more than 16 percent.

United Nations Environment Program (UNEP) Sustainable Energy Finance Initiative (SEFI) (http://www.uneptie.org/energy/projects/SEFI/) is working to create a policy and economic framework where sustainable energy can increasingly meet the global energy challenge. Changing attitudes and helping mainstream financiers to consider sustainable energy investments are key components of the energy work within UNEP and the starting point for the UNEP SEFI.

Energy Services Companies (ESCOs)

To reduce their own capital costs, agencies can opt for a specific type of Public/Private Venture, the Energy Savings Performance Contract between the agency and an ESCO. An energy saving performance contract is an agreement to reduce energy costs via some technique or equipment in which the energy cost savings from the project funds pays for the cost of the project itself. An ESCO is a third-party professional business that provides designs and implements energy-saving projects that allow building owners to perform projects to upgrade their building assets to a more sustainable status. The ESCO performs an in-depth analysis of the property, designs an energy efficient solution, installs the required elements, and can maintain the system to ensure energy savings during the payback period. The savings in energy costs is often used to pay back the capital investment of the project over a five- to 20-year period, or reinvested into the building to allow for capital upgrades. The ESCO can finance a portion of the improvements, and then recoup its investment from a portion of the customer's energy savings in the years that follow.

Method of Conducting an Energy Savings Performance Contract

The project often begins with the development of ideas by the ESCO that would generate energy savings, and therefore cost savings. During the initial period of research and investigation, usually an energy auditor or audit team from the ESCO tours the site and reviews the project's systems and operation to determine areas where cost savings are feasible. A description of the potential project, and the proposed energy costs measured, is developed by the client and the ESCO's auditor, and then passed onto the ESCO's engineering development team. The engineers are responsible for creating cost-effective measures to obtain the highest potential of energy savings. These measures can range from highly efficient lighting and heating/air conditioning upgrades, to more productive motors with variable speed drives and centralized energy management systems and building upgrades.

Once the project has been developed and a performance contract signed between the agency and the ESCO, the construction or implementation phase begins. Following the completion of this phase, the monitoring and maintenance or measurement and verification (M & V) phase begins. This phase is the verification of the pre-construction calculations and is used to determine the actual cost savings. In fact, there are three options the owner must consider during the performance contract review:

- No warranty other than that provided on the equipment
- ESCO provided M & V to show the projected energy savings during the short term following completion
- ESCO provided M & V to show the projected energy savings during the entire payback period

According to the Energy Services Coalition, a qualified ESCO can help the agency can help put the pieces together by:

- Identifying and evaluating energy-saving opportunities

- Developing engineering designs and specifications
- Managing the project from design to installation to monitoring
- Arranging for financing
- Training staff and providing ongoing maintenance services
- Guaranteeing that savings will cover all project costs

Refer to the U.S. Department of Energy EERE's Federal Energy Management Program for lists of qualified ESCOs by region or technology and help with contract tools and guidance.

Advantages of Conducting an Energy Savings Performance Contract

Advantages in hiring an energy service company include equipment modernization, improved quality of lighting and space conditioning, enhanced worker productivity, environmental improvements, and probably at the top of most agencies' lists, financial benefits. Specifically, advantages include the following:

- Agency expends less capital. Some performance contracts require very little or no up front capital costs.
- Technical capacity and capability. Availability of technical and commercial expertise, manpower, and experience. Routine O&M can be dealt with quickly and efficiently. Quick, easy contact to the ESCO for complaints and maintenance. Energy service companies can provide efficient and relatively un-disruptive project management for any capital projects.
- Performance risk management. ESCOs have an incentive to reduce energy costs and have the resources. ESCOs will identify energy efficiency saving accurately and have the knowledge to do so, thus avoiding unexpected costs. Equipment upgrade must meet industry-wide standards. Guaranteed carbon emissions reduction.
- Flexibility. Onsite or local energy generation, opportunity for large integrated projects, the development of innovative energy business models, and the opportunities to bundle projects.
- Financing benefits. Finance experience and expertise. Provide the facility for capital investment. Reduced project and operational costs.

Figure 10 from the Energy Services Coalition gives a basic summary of the energy costs that would be saved after and ESCO improvement project.

In a new study, researchers at the Department of Energy's Lawrence Berkeley National Laboratory and Pacific Northwest National Laboratory concluded that "over $15 billion invested in energy efficiency projects installed by energy services companies at U.S. public and institutional facilities since 1990 has provided significant value to these customers". The researchers analyzed the performance of about 1,000 public/institutional projects representing about $2.5 billion in investment and estimated net economic benefits of more than $1.7 billion in reduced energy and operational cost savings. The researchers also found that median energy savings are about 15 to 20 percent of the utility bill baseline in all market segments (http://bleer.lbl.gov/?p=25). If the project does not provide returns on the investment, the ESCO is often responsible to pay the difference, keeping risk low for the agency.

Refer to the Energy Services Coalition's website to see information on how to get started with an ESCO, view

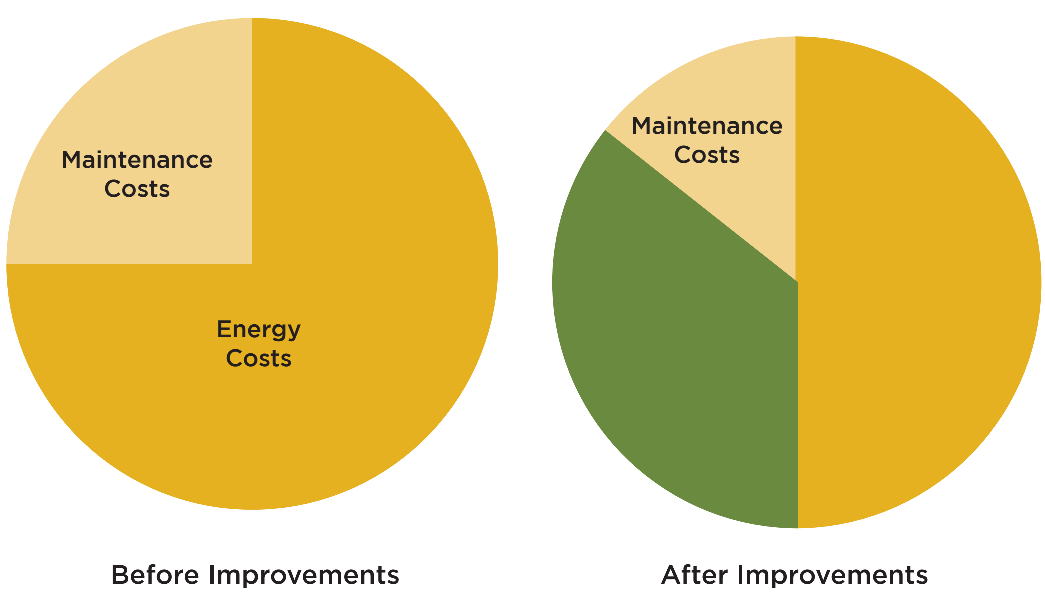

Figure 10. Summary of the Energy Costs Saved from an ECSO Improvement Project

Source: Energy Services Coalition

state and federal programs, get financing help, review pertinent legislation, documents, and other links.

Potential Disadvantages of Conducting an Energy Savings Performance Contract

Advantages and benefits of an agency going with an energy services company are widespread; however, depending on the public agency, ESCOs may not be the most feasible or affordable opportunity for creating a sustainable business. Disadvantages include the following:

- Energy service companies are businesses and thus naturally include a profit margin and their internal operational costs within the cost of their services; however, costs are proposed and approved by the agency before work commences.
- Energy service companies are relatively established in their ways and risk averse. This may limit the range of projects the ESCO wishes to undertake, possibly limiting the options of the agency under this form of project delivery. Of course, other project delivery options remain available to an agency. ESCOs typically prefer medium and large-scale projects, which can lead to the exclusion of smaller projects unable to finance energy efficiency measures.
- Whie energy service companies may arrange for third-party financing, the loan and credit worthiness generally applies to the owner rather than the ESCO. The credit rating and apparent prospects of the agency will not only influence the ability to raise finance but also the eagerness with which an ESCO pursues a long term contract.
- ESCOs can be complex and expensive to set up.
- Industrial ESCO business models may include high volume/low margin long-term operation and maintenance contracts. These often realize little benefit from energy savings and, therefore, provide less incentive to save energy than they do to provide a good Operation & Maintenance service. The agency may choose to eliminate this service from any contractual agreement and avoid the issue (http://www.micropower.co.uk/publications/esco.pdf).

Section 7
Additional considerations for sustainability

In addition to implementing best practices described in this guidebook, agencies should also take into consideration streamlining general operations and creating awareness regarding the supply chain and sourcing used for the company. Ideas to help agencies streamline operations are described in this section.

Streamlining Operations

Streamlining refers to the process wherein the agency modernizes and organizes operations to improve efficiency and cut costs. Useful steps in developing modernization and organization in an agency are described below:

- Measure everything: The daily effort of running the business can obscure the big picture of where time and money is spent.
- Simplify processes: Many processes become complicated over time. By simplifying these processes, an agency can make processes more repeatable. Also, simple processes are easier to automate, outsource, or pass on to less expensive employees.
- Automate processes: Human time is expensive. If something can be done by technology, it should be considered. A cost benefit analysis should always be done in deciding what to automate.
- Standardize: By standardizing, and agency can reduce the number of things that can go wrong.
- Think about the total cost: Cost over the entire useful life over time should be considered instead of just the original cost of purchases.

Once in-house operations are streamlined, an agency can look outside the company to ensure others that the agency may have business agreements with are also following a similar sustainable path.

Green Sourcing and Supply Chain

It is important to consider both short and long term issues when developing a sustainability strategy. The most important sustainability opportunities often come from outside the sector and its supply chain. It is important for an agency to be cognizant of where products and equipment come from and that these sources are green. Environmental responsibility is no longer just a regulatory burden, it has become an imperative. Soaring energy and commodities costs are pushing everyone to pursue options to reduce costs, where these goals can be met with sustainable management. A host of products and solutions are available to save energy, water and waste, and many more are on the way. At no time has there been more interest from stakeholders in operating in ways that protect the environment and respect human health and safety.

Green Sourcing

Supply chains in general and green sourcing in particular are quickly becoming the primary focal points for improving financial performance while building an agency's green credentials. Green sourcing (see Figure 11) can help agencies meet their cost reduction goals while also increasing revenues. It can also contribute to a better public image and reputation with the stakeholders.

Traditional Six Step Sourcing Methodology	Traditional Focus Areas	Green Focus Areas	Elements to Consider Sustainable Sourcing
Step I Assess Opportunity	Spend Analysis focuses primarily on materials and logistics costs	Spend Analysis encompasses direct and indirect environmental costs	Environmental Regulations
Step 2 Assess International Chain Supply	Specification focused, map current process, identify process opportunities	Spec Review considers industry's most environmentally sound products and services	Direct Energy Cost Reduction (Energy Efficiency of Sourcable Items)
Step 3 Assess Supply Market	Identify potential sources of supply, perform supplier assessments/ comparisons	Supply base includes vendors who specialize in more efficient, sustainable products	Indirect Energy Cost Reduction (Energy Efficiency to Reduce Transportation Costs)
Step 4 Develop Sourcing Strategy	Confirm scope, determine desired outcomes, brainstorm process enhancements	Sustainability considerations are specified in the RFP document	Substitutes of Commodity Items with Sustainable Equivalents
Step 5 Implement Strategy	Develop/ implement supplier solicitation, strategy, conduct supplier negotiation, award contract	Bid analysis's quantifies cost/benefits of sustainability attributes	Reduced Water Consumption
Step 6 Institutionalize Strategy	Transition to new process, develop supplier relationships, implement operation changes, monitor/report performance	Sustainability attributes closely tracked and audited	Sourcing Materials with Higher Recycled Content

Green Steps to Emphasize in Sustainable Sourcing

Figure 11. Six-Step Strategic Green Sourcing Process

Source: http://www.scmr.com/article/CA6611885.html

Deloitte, a consulting company, has developed a green strategic sourcing process for agencies to consider in their efforts to pursue green sourcing opportunities to achieve their margin improvement goals. Their six-step approach as shown in Figure 10 is a comprehensive process for enhancing sourcing savings by taking advantage of environmental factors.

A comprehensive green sourcing effort should assess how an agency fundamentally uses the items either internally, in its own operations, or in its products and services. Green sourcing is not just about finding new environmentally friendly technologies or increasing the use of recyclable materials. It can also help drive cost reductions in a variety of ways including product content substitution, waste reduction, and lower usage.

Throughout this six-step process, an agency should keep in mind these four essentials of green sourcing:

- Green sourcing requires modifications to the traditional sourcing process.
- Sustainability must be evaluated with a wider range of internal stakeholders.
- Visualizing and capturing green sourcing savings often involves greater complexity and longer payback periods than sourcing teams are used to.
- Green sourcing requires a variety of analysis techniques that emphasize data-driven modeling of the costs and benefits of energy use, waste reduction, and so forth (http://www.scmr.com/article/CA6611885.html).

A public agency should also keep in mind some critical success factors of green sourcing as listed below:

- Sponsorship
- Education
- Buy-in

Green Supply Chain Best Practices

For years, businesses have been concentrating on improving supply chain visibility, refining efficiency and minimizing cost. Despite the focus moving toward a green supply chain, the goals of visibility, efficiency and cost reduction do not have to be discarded. By examining the agencies that have already made strides toward a green supply chain, it is evident that best practices help to begin the transition. After an agency understands where green improvements can be made, a set of goals can be created and metrics can be formed to track progress.

First, the green supply chain goals must be aligned with the agency's goals. Creating a green supply chain that has little to do with the agency's goals will not help achieve objectives. An agency should look at its overall goals and identify how a transition to a green supply chain can help achieve those goals. For example, if an agency wants to reduce its energy costs, it should start by looking at consumption to see if a reduction can be made by using more energy efficient and greener equipment.

Next, agencies that want to transition to a green supply chain should take the opportunity to review all their processes to identify areas where adopting a greener outlook can actually improve the business. An agency should review each process along the supply chain to identify if a more environmentally sound approach will help cure the inefficiencies that occur.

When reviewing purchasing processes, the aim of any agency looking to transition to a green supply chain should be to find suppliers who have minimized their environmental impact without reducing the quality of their product or significantly raising costs. By purchasing products from green suppliers, agencies can begin their green supply chain before any material reaches their site.

Resources

Technical assistance

Many organizations offer technical assistance to agencies on current regulations, policies, incentives and information on new programs, including:

- EPA http://www.epa.gov/
- Department of Toxic Substances Control (DTSC) http://www.dtsc.ca.gov/
- California Air Resources Board (CARB) http://www.arb.ca.gov/homepage.htm
- Pacific Gas and Electric (PG&E) http://www.pge.com/index.html
- California Energy Commission http://www.energy.ca.gov/
- Bay Area Air Quality Management http://www.baaqmd.gov/
- California Public Utilities Commission (CPUC) www.cpuc.ca.gov/
- Flex Your Power www.flexyourpower.org
- US Department of Energy www.energy.gov
- USGS www.usgs.gov

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Online resources and tools

The BEES (Building for Environmental and Economic Sustainability) software for selecting cost-effective, environmentally-preferable building products: http://www.bfrl.nist.gov/oae/software/bees/

Link on the US Department of Energy page containing indoor energy saving tips: http://www1.eere.energy.gov/consumer/tips/

In Hot Water: Water Management Strategies to Weather the Effects of Global Warming, B. Nelson, M. Schmitt, R. Cohen, N. Ketabi, and R. Wilkenson, Natural Resources Defense Council, July 2007. http://www.nrdc.org/globalWarming/hotwater/hotwater.pdf

MAGICC and SCENGEN - user-friendly interactive software suites that allow users to investigate future climate change and its uncertainties at both the global-mean and regional levels: http://www.cgd.ucar.edu/cas/wigley/magicc/index.html

Life cycle cost accounting spreadsheet: http://ohp.parks.ca.gov/?page_id=25083

Database of State Incentives for Renewables and Efficiency: http://www.dsireusa.org/

Flex Your Power: http://flexyourpower.org/ind/tools/products.html

Pacific Gas and Electric: www.pge.com/mybusiness
U.S Department of Energy – Alternate Fuels: http://www.afdc.energy.gov/afdc/fuels/index.html

U.S Department of Energy – Alternate Vehicles: http://www.afdc.energy.gov/afdc/vehicles/index.html

Self-Generation Incentive Program (SGIP): http://www.cpuc.ca.gov/PUC/energy/DistGen/sgip/

ACEEE: Online Guide to Energy-Efficient Commercial Equipment http://www.aceee.org/ogeece/ch5_office.htm

U.S. Department of Energy - Energy Efficiency and Renewable Energy. Building Technologies Program: Lighting R&D http://www1.eere.energy.gov/buildings/printable_versions/lighting.html

U.S. Department of Energy - Energy Efficiency and Renewable Energy. A Consumer's Guide to Energy Efficiency and Renewable Energy. When to Turn off Personal Computers http://apps1.eere.energy.gov/consumer/your_home/appliances/index.cfm/

Benefits of ESCO for Government Projects: http://bleer.lbl.gov/?p=25

Public-Private Partnerships: http://www.ncppp.org/

Green Construction: http://www.epa.gov/opptintr/epp/pubs/products/construction.htm#b

Equipment purchase and lease concepts:
http://www.businesslink.gov.uk
http://www.aseclease.com/whylease.html
http://www.leaselo.com
http://www.allbusiness.com/business-finance/leasing/2540-1.html

Energy Star® Financing: http://www.energystar.gov/ia/business/EPA_BUM_CH4_Financing.pdf

Streamlining operations: http://www.productivity501.com/streamlining-your-business/71/

Green Sourcing/Supply Chain:
http://www.scmr.com/article/CA6611885.html
http://logistics.about.com/od/greensupplychain/a/GSC_Best_Prac.htm

California Solar Initiative:http://www.gosolarcalifornia.org/csi/index.html

California Energy efficiency financing: http://www.energy.ca.gov/efficiency/financing/

California Emerging Renewables Program: http://www.energy.ca.gov/renewables/emerging_renewables/index.html

Limitations

This document sets forth the results of Brown and Caldwell's research into sustainability practices that may be applicable to public agencies. It is comprised of Brown and Caldwell's compilation and interpretation of pre-existing information from third parties or the client, which information has not been independently verified by Brown and Caldwell unless explicitly stated herein. Brown and Caldwell makes no warranties, express or implied, with respect to this document, except for those, if any, contained in the agreement pursuant to which the document was prepared. All data, drawings, documents, or information contained in this report have been prepared exclusively for the person or entity to whom it was addressed and may not be relied upon by any other person or entity without the prior written consent of Brown and Caldwell unless otherwise provide by the Agreement pursuant to which these services were provided.