

# Facility Energy Options: Making Smart Choices for Sustainability

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## Introduction

Sustainability – this is a concept we’re hearing about as a goal, a solution, and sometimes as a panacea for the problems we face as engineers involved with the built environment. What does it mean? How should it be applied to the problems we solve? What benefits will be gained as a result? These are questions being actively addressed by researchers and practitioners alike in a quest to create facilities that better meet the needs of their owners and occupants while minimizing the demands we place on natural ecosystems and resource bases, and mitigating the impacts we pass on to future building stakeholders.

With respect to energy, the challenge faced by engineers is particularly acute. We live in a time of increased dependency upon energy as a driver of our economy and culture, where technology is advancing at a pace that may eventually outstrip Moore’s Law, the classic postulate that computing processor power is limited in growth to double no more than every 18 months (see *To learn more – Moore’s Law and Technology development*). At the same time, our facilities are responsible for 65% of all U.S. electricity consumption, with an average annual increase in the rate of land development of 2% per year (see *To learn more - the effects of the built environment and strategies for facility sustainability*). What does this mean in terms of future demands on our power supply infrastructure, or our reliance on international sources of fuel? What can we as engineers do to make better choices for our facilities that will enable them to continue to provide necessary functionality without overstepping the capacities of the resource bases upon which they depend?

Making smart choices is defined for many building owners as maximizing return on investment. How can engineers responsible for making facility design choices most effectively meet this objective? This article explores an approach being adopted by sustainable designers to maximize return on investment in facility energy technologies while enhancing the performance of their facilities to better meet occupant requirements. The approach revolves around one simple principle, described in greater detail in the must-read book *Natural Capitalism* (see *To learn more – Sustainable Design and doing things in the right order*): Do the right things, at the right time, and in the right order.

What are the right things, right time, and right order for optimizing facility energy investments? In the following sections, we’ll explore the spectrum of energy optimization strategies as they fall into four basic categories: reducing demand, optimizing efficiency, balancing loads, and using alternative energy sources. These categories represent the “right order” for facility energy investments, and set forth an overall strategy for increasing facility sustainability in terms of energy demands and consumption.

## Reduce Demand

The first set of strategies to consider in making facility energy investments is centered around finding opportunities to reduce or eliminate the demand for energy in the first place. The classic approach to reducing demand for energy was pioneered back in the 1970's: set back your thermostat and wear a sweater (or remove clothes during the cooling season). While building occupants may cringe at these kinds of behavioral changes, not all demand reduction strategies involve compromising personal comfort or functionality. For example, simple timers or occupancy sensors can help to reduce demand by reducing operating hours for equipment like water heaters that are not needed during hours when a facility is not occupied, or by switching off lights or reducing ventilation in spaces that are not in use.

Other strategies may contribute to demand reduction with no changes required in occupant behavior. Passive heating, cooling, and daylighting all represent ways to provide required performance to building occupants while reducing or eliminating the use of electrical power to provide these services. One technology that is extremely promising in the Southeast is the desiccant wheel – the use of water-absorbing media to remove moisture from the air prior to its exchange with building air. These wheels greatly reduce the amount of energy required for dehumidification using classic refrigeration techniques. Another simple yet underutilized technology is the high-albedo roof – reflective roof coatings or materials that reduce heat gain through roof surfaces and thereby reduce the cooling loads experienced by a facility. In many cases, the albedo (or reflectivity) of a roof can be increased at no cost simply by choosing a lighter color for roof finishes during design. Still other approaches that have long been used in more severe climates include facility envelope improvements such as increased insulation, infiltration reduction via crack sealing and air/vapor barriers, and high efficiency windows – all of these envelope enhancements can reduce the demands on facility space conditioning equipment and increase occupant comfort during all seasons of facility operation.

## Optimize Efficiency

After options have been explored for reducing or eliminating demand for energy by building systems, the next set of strategies focuses on optimizing the efficiency with which remaining energy needs are met. Strategies in this category include paying attention to proper sizing of building equipment. Proper sizing can greatly enhance the efficiency with which mechanical systems use electrical power to meet occupant needs. As engineers, we're trained to think that excess capacity is a good design feature, and in many cases, this is true. With mechanical systems, however, oversizing equipment can mean that those systems operate at peak efficiency only a few days of the year. If a high degree of reliability is required for facility heating or cooling, it's far better to design parallel systems where *both* systems are used to meet peak demands, while during typical loading only one system operates at capacity to optimize efficiency. The investment in additional capital equipment is offset by operational savings in energy.

An often overlooked requirement for optimizing efficiency is proper operations and maintenance. No matter how well it may be designed, equipment will function only as well as it is operated and maintained. Processes such as continuous commissioning can be used for existing buildings to identify non-capital opportunities to improve efficiency with existing equipment, and typically pay for themselves in less than two years (see *To*

*Learn More – Continuous Commissioning*). In parallel, operator training is also essential to ensure that the capital equipment that is installed is used most effectively. Even simple maintenance practices such as cleaning the transmissive surfaces of lighting fixtures can greatly increase the light output of those fixtures, reducing the need for supplemental lighting in workspaces.

## **Balance Loads**

The third set of strategies to be considered after minimizing demand and optimizing efficiency relates to load balancing and peak shaving. Load balancing came about in response to incentives from public power utilities to try to balance the loads placed on centralized power distribution systems so that they could be more reasonably sized and so that the need for new power plants could be reduced.

Peak shaving means shaving demand from peak times during the day, and shifting that demand to off-peak times. Utilities often charge lower rates during off-peak times, thus providing an incentive for users to shift their demands in time to these periods. Certain kinds of thermal storage systems can exploit this opportunity very effectively: energy is used at night to super-cool a thermal storage medium, which then absorbs heat to provide cooling during the day. Other systems, such as building energy management systems, use electronic controls to balance loads during peak times by reducing the amount of power sent to equipment that is tolerant of voltage variability (like some air conditioners, pumps, fans, and motors) while maintaining a steady stream of power to equipment that can't tolerate this variability (like plug loads from computers). Depending on the local or regional climate for power production, margins for peak power consumption can be extremely significant, and in many areas, investments in equipment and controls to balance loads can pay back rapidly. Often, utility companies will finance or invest in these systems for built facilities, and may also provide technical assistance to support their implementation.

## **Use Alternative Energy Sources**

After reducing demand, optimizing efficiency, and balancing loads, the last set of strategies deals with finding alternative sources of energy. There are two primary ways to obtain alternative energy: through contracting with a Green Power Provider, and generating one's own power on site. The first approach, contracting with a Green Power Provider, is dependent upon the existence of such a power provider in your location, and the state of deregulation in your area. In some areas of Georgia, Green Power is soon to become available for those who wish to purchase it. Green Power Providers generate electricity from renewable energy sources such as wind power and solar power, while avoiding nonrenewable power sources such as fossil fuels.

The other option for alternative energy is to explore the possibility of incorporating small-scale decentralized power generation capabilities on your site, such as photovoltaics, wind turbines, gas-fired microturbines, or fuel cells. Having explored all the options for reducing, optimizing, and balancing your energy demands means that you can minimize the size of this investment considerably, and this is why alternative energy sources should be last in your list of things to consider. Given the difficulty of effective storage of electrical energy, the most effective way to use on-site alternative power

generation is in combination with a grid inter-tie. This means that you can sell excess power generated back to the electrical utility when you generate more power than you can use, as well as buying power from the grid when your on-site system does not meet your power demands. It also means that you can avoid the need for costly and high-maintenance battery storage systems as part of your power generation system. With photovoltaic systems in particular, the peak generation cycle falls at the same time of day as the peak demand (during the day), sometimes meaning that you can command a premium for excess power generated during this time. Utility systems, particularly those in regions without much excess capacity, often provide financing and/or technical assistance to support small-scale power generation systems for interested customers.

## Conclusions

With demand for energy only likely to grow in the future, engineers need to be aware of the needs and opportunities to reduce consumption of electrical power in built facilities. Not only can energy investments save money over the life cycle of a facility, they can also increase the robustness of the facility in terms of its vulnerability to variation in power availability from centralized sources. As America's need for and dependence on power grows, the vulnerability of our power generation capabilities will increase as well (see *To learn more – Localized Power Generation and Distributed Vulnerability*). Facilities with well-managed, minimal energy requirements that include non-energy-driven systems to meet occupant needs (like passive HVAC and daylighting) and on-site power generation capabilities will be the least vulnerable to fluctuations in power (and prices) from utility suppliers. We all need to focus on the dependence of our facilities on centralized supplies, to ensure that our facilities can continue to function productively and cost-effectively under all future scenarios.

## To learn more...

**About the effects of the built environment and strategies for facility sustainability** – see <http://www.buildinggreen.com>, home of Environmental Building News, from which the energy statistics in this article were obtained.

**About sustainable design and doing things in the right order** – see <http://www.naturalcapitalism.com>, the online version of the book *Natural Capitalism*.

**About Moore's Law and technology development** – see <http://www.wired.com/wired/archive/10.01/gilder.html>

**About Continuous Commissioning** – see <http://www.beslab.org>, the web site of the Brooks Energy and Sustainability Laboratory, a provider of energy efficiency and sustainable facility strategies and services.

**About localized power generation for distributed vulnerability** – see <http://www.wired.com/wired/archive/9.12/defense.html>

**About sustainable facilities and infrastructure and the strategies described in this article** – see <http://maven.gtri.gatech.edu/sfi>, the web site of Georgia Tech's Sustainable Facilities & Infrastructure Branch.

## **About the Author**

Dr. Annie Pearce is the Director of the Sustainable Facilities and Infrastructure Branch at Georgia Tech Research Institute and the author of a new graduate course at Georgia Tech on Sustainable Civil Infrastructure Systems. She has been involved with sustainable design as a teacher and researcher for over ten years, and has worked as a trainer and researcher across the United States and abroad. Georgia Tech's Sustainable Facilities and Infrastructure Branch provides applied research solutions, training, technical assistance, and information for all facets of sustainable facilities and infrastructure. For more information about the ideas in this article or to contact Dr. Pearce, see <http://maven.gtri.gatech.edu/sfi>.