Introduction

The green building movement in America is a strong advocate for the sustainable design and use of our built environment. Because of it, architects, engineers, developers, and owners are working harder to make buildings better for the long-term health of our planet.

In Pennsylvania and much of the northeastern United States, bioenergy continues to be one of the most promising yet under-utilized opportunities for green buildings today, and it should be given serious consideration as a practical, renewable, and affordable energy source for green buildings. Furthermore, bioenergy fuel and equipment are produced locally, providing economic benefit to the community in addition to regional ecological value.

What Is a Green Building?

Simply stated, a green building is one that has been designed to be ecologically responsible and resource efficient. Sometimes it is referred to as “sustainable building,” which is certainly a much more descriptive name. Architects, engineers, and contractors involved in sustainable building design strive to create projects that have the following characteristics:

- **Building site**: select and design the site in such a way that it enhances the local ecosystem, including, when possible, provisions for rainwater management, wildlife habitat, and plant life.
- **Building materials**: choose materials (as much as possible) that are nontoxic, made from renewable materials, and are recyclable.
- **Building systems**: design heating, cooling, plumbing, and electrical systems that minimize the wasteful use of energy and water through use of high-efficiency devices, proper insulation of the building envelope, and enhanced use of passive renewables (e.g., daylighting, passive solar, natural ventilation) and active renewables (e.g., rainwater harvest, solar photovoltaics).
- **Occupant health**: design the building so that occupants and users are exposed to a healthy atmosphere (primarily in terms of indoor air quality) that helps them live full and productive lives.

One aspect of sustainable buildings often forgotten is that while they must be designed and built properly, they must also be operated properly. If the energy-saving devices in a building are not compatible with the building’s use, people will probably not bother to use them, resulting in buildings that are much less sustainable than originally intended.

While it is difficult to precisely say what constitutes a “green” or sustainable building, many people and groups have worked toward a way of rating a building’s sustainability level. The most common method of measuring this in the United States is the LEED (Leadership in Energy and Environmental Design) rating. Developed by the U.S. Green Building Council, the LEED rating is widely regarded as the standard against which sustainable building design is to be measured. In the LEED system, points are allocated to a building according to its design and range from 40 points out of 110 for the minimum “certified” rating up to a “platinum” rating for buildings receiving 80 or more points.

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What Is Bioenergy?

Bioenergy is the useful energy (heat or power) derived from plant or animal material. There are many different types of bioenergy fuel, including but not limited to biomass, biogas, biodiesel, and bioethanol. There are also many ways to use bioenergy fuel, including for electricity production and the manufacture of automobile fuel and aviation gas. However, when we talk about sustainable buildings, the most common and practical form of bioenergy is the use of solid fuel (wood or field crops). In Pennsylvania, the most common fuel is wood, usually delivered as either chips or pellets. However, a small but increasing number of farmers are growing sustainable crops such as switchgrass to be sold as fuel as well.

One very reasonable concern people raise about bioenergy is the worry that using bioenergy might deplete our forests and/or compromise our food supply, resulting in economic and ecological pandemonium. While these are serious concerns, the current situation is actually quite the opposite—we are suffering from an oversupply of bioenergy resources in the Northeast.

Surprisingly enough, the region contains significant tracts of abandoned and poorly managed land, coupled with rural communities that face dwindling opportunities for the future. A growing bioenergy industry, if carried out in a sustainable manner, can be an important ingredient for economic, ecological, and societal improvement in the region. How can this be true? Consider the following two scenarios in Pennsylvania.

Repairing the Land with Bioenergy

The Keystone State includes roughly three million acres of abandoned mine land and other marginal sites that are characterized for the most part by poor soils, low plant growth rates, and marginal habitat for wildlife. Researchers are working on ways to reclaim these lands with perennial grasses that provide soil and water benefits, enhanced wildlife habitat, and a marketable energy crop. Including a marketable crop is a key aspect here because it provides an economic means for covering the cost of land improvement and management.

Better Forests with Bioenergy

Pennsylvania’s 16.6 million acres of forests cover 58 percent of the state and have been growing in size over the past several decades. However, the quality of these forests has not been as admirable. Typically, the only management that people could afford was to harvest tall, straight trees that could be cut into lumber. The remaining forest is generally less than ideal for lumber, wildlife, or biodiversity. Bioenergy harvests will allow forestland owners to manage their land more carefully, providing an enhanced species mix that improves the forest for the trees, wildlife, and people.

These scenarios are more realistic than some people think, and green buildings can be a key part of making them a reality by using bioenergy and by not only ensuring a customer for the fuel but also requiring that the fuel be certified by an independent forester as being from sustainably managed land.

How Bioenergy Can Work in Green Buildings

The most common scenario for bioenergy in a green building involves using solid biomass as a combustion fuel for space heat via circulated hot water. The building will need to include space for the biomass boiler plus fuel delivery and storage and ash removal. Automated systems and controls are commonly used to minimize day-to-day maintenance.

Large facilities may benefit from installing combined heat and power (CHP) systems that meet both thermal and electrical needs for the building. It is also possible to add thermally activated cooling, although the economics are often marginal and packaged design solutions are not yet readily available.

Winning Reasons for Using Bioenergy in Green Buildings

Don’t Just Reduce Fossil Fuel Use—Remove It

Bioenergy is arguably the most practical means for eliminating fossil fuel use in a building. Biomass is readily available in quantities that can meet the energy requirements of even large projects. In the case of combined heat and power systems, it may be possible to provide all the building’s energy needs from renewable biomass.

Match Your Load to Your Needs, Not Vice Versa

The Achilles heel of solar and wind power is that they only work when the sun is shining and wind is blowing (respectively). Bioenergy does not have this problem since bioenergy is stored energy that can be used when needed. As a result, the use of bioenergy can be matched to the load profile of a building without resorting to net metering on a fossil-fuel-dominated grid to provide adequate provision of service.

Integrate Your Building’s Energy Needs with the Ecosystem

Here’s an intriguing possibility that most sustainable energy codes often don’t recognize: bioenergy can be grown onsite (provided that the site is large enough) in a sustainable ecosystem that provides wildlife habitat, water quality, and soil quality enhancements. This is something unique that bioenergy offers to green buildings—complete ecosystem enhancement integrated with sustainable energy provision.
Proven, Reliable, and Cost Effective

Bioenergy has been used successfully in Pennsylvania for decades, providing reliable and effective renewable heat with an added bonus—biomass heating fuel usually costs less than traditional fossil fuels or alternative energy sources, even without the use of large tax subsidies.

In order to compare the relative cost of fuels, you must analyze them on a “per unit of energy” basis—namely, the cost per gigajoule (about a million btu) of energy available from the fuel. Historically, commercial chipped wood (the most common bioenergy fuel source for buildings) has been very inexpensive relative to other fuels.

While the economics of new construction are sometimes difficult to assess, biomass energy retrofit projects in the United States have generally shown good economic return, with paybacks in the seven- to ten-year range. This is higher than some investors would prefer, but when coupled with its renewable characteristics, the long-term cost savings make bioenergy a compelling option for green buildings.

Why Not?

In spite of the many positive attributes of bioenergy for green buildings, relatively few LEED-rated buildings utilize bioenergy. A recent analysis of LEED-rated buildings showcased in the Green Building Alliance’s database of case studies revealed that of thirty-four case studies of buildings in the northeastern United States, only three of the buildings used bioenergy. Furthermore, if we look at the size of the buildings involved, we find that only 1.4 percent of the buildings’ square footage utilized bioenergy. Given the benefits of wood energy for green buildings, this seems like a significant underuse.

Probably the most significant functional drawbacks of biomass heat in buildings are the needs to allow for regular fuel delivery and provide for minor maintenance over the course of the year. However, the largest obstacle to biomass energy use in green buildings is most likely the lack of familiarity within the professional design community. A recent study investigated this issue and found that building designers are often not familiar with biomass systems or their potential for use in commercial buildings. Typical quotes from building design professionals who were asked about bioenergy included, “Why have we not heard this before?” and, “This technology can help us” (Karakash and Richter, 2010).

Examples of Bioenergy in Pennsylvania

While commercial-scale biomass energy may be a new concept to many people, it has been successfully used for many years in the Keystone State. Mountain View High School in Kingsley has been in constant operation since 1989 and is an example of reliable, cost-effective biomass heat. Recently, the turn of the millennium has seen a steady increase in bioenergy use in buildings. Here are a few more examples of facilities that are reaping the benefits of renewable, sustainable bioenergy.

Multi-Unit Residential

The Spring Valley Bruderhof is a residential community of about 400 people in southwestern Pennsylvania that was retrofitted in 2008 with a biomass district heating system. The facility uses wood waste from its furniture and cabinet manufacturing shop and locally produced wood chips to provide hot water to homes and community buildings.

Institutional

Elk Regional Health Center in St. Mary’s, Pennsylvania, is one of several hospitals that have turned to biomass heat for its facility. Built in 2007, the system consists of a new mechanical room that houses both a fuel storage bin and the boiler. Low-pressure
steam is provided both to the hospital and the adjacent nursing home via insulated piping. This retrofit project saves an estimated $156,000 per year in energy costs and replaced the hospital’s use of fuel oil and natural gas. The facility uses wood chips provided by local logging companies on a contract basis as its fuel.

**Industrial**

Evergreen Community Power in Reading, Pennsylvania, is a new Combined Heat and Power Plant built to supply the process heat and electrical needs of United Corrstack, a local manufacturer of corrugated cardboard. The facility uses clean construction debris to feed the furnace, which provides low-cost fuel while simultaneously reducing the amount of waste to local landfills. Extensive emissions treatment equipment at the facility includes cyclonic separators, a bag house, and an electrostatic separator located adjacent to a residential neighborhood, resulting in an extremely clean operation.

**For More Information**

The Pennsylvania Fuels for Schools and Beyond program provides assistance and advice on biomass energy for schools, commercial buildings, hospitals, and industrial facilities. Visit the group’s website at [www.pafuelsforschools.psu.edu](http://www.pafuelsforschools.psu.edu).

Penn State Extension provides educational materials and programs aimed at better utilizing the state’s renewable forest resources. For more information, visit [extension.psu.edu/energy/woody-products](http://extension.psu.edu/energy/woody-products).

**References**


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