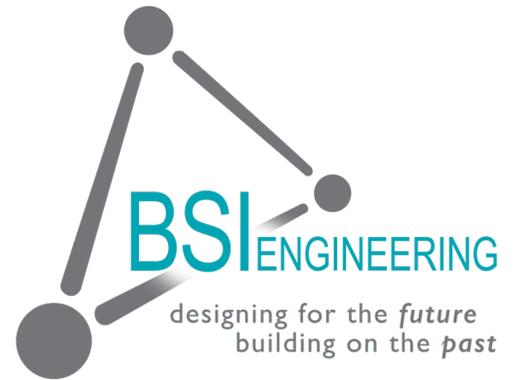


Sustainable Design in the Industrial Building Sector



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The industrial building sector has the most to gain from implementing sustainable design practices. These buildings are often in operation across multiple shifts throughout the year and have the potential of consuming large amounts of natural resources in the form of water and energy. If the decision is made at the inception of the project to incorporate sustainable design policies, then there is an appreciable potential of being able to minimize the initial environmental impact as well as the long-range use of said natural resources.

In response to a more holistic approach to building design, Leadership in Energy Efficient Design (LEED) began to be developed in 1993. Since then, one downside has been the fact that there is a higher first cost investment which gives owners and investors pause but there can be a return on that investment over the course of the building's life. Full LEED certification is not necessary to abide by the spirit of sustainable design thus there are savings by just following the principles. As an example, a LEED certification in California has a minimum cost of \$2,900 for a new building under 50,000 square feet with LEED certification fees for a newly constructed building over 500,000 square feet amount to \$20,000 (plus a \$900 initial registration fee). In California, certification of a new hospital exceeded \$1 million. A 1.2-million-sq-ft mixed-use office building with a \$400 million budget estimated the cost of LEED certification is "only 0.27 percent of the total cost," which represents an additional \$1.08 million.²

From a high-level perspective, projects are either green or brownfield in nature and each type can benefit from sustainable design

concepts. Greenfield sites are brand new sites that have never been built on while brownfield sites have been built on and whose reuse may be complicated by the presence or potential presence of a hazardous substances, pollutants, or contaminants. Obviously, the most sustainable approach is repurposing an existing building or site but there are potential costs for environmental remediation if it is determined to be needed. Industrial buildings were often thought of as being expendable with little thought given to the potential reuse once the original program has been deemed obsolete, but the past decade has begun to prove otherwise. Fallow or underused warehouses in suburban areas are being converted to house state of the art pharmaceutical manufacturing while other industrial buildings in urban environments are becoming mixed use commercial and housing properties.

The following are several important aspects to discuss with the client to determine their level of acceptable commitment to incorporate sustainable design in industrial buildings.

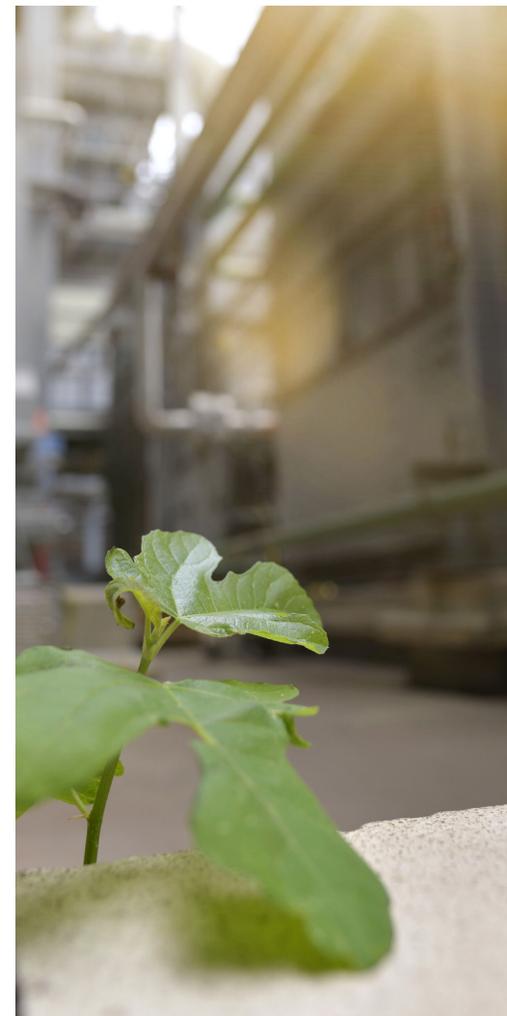
SITING

Siting a building is one of the first activities undertaken with a client and their corporate real-estate representatives. According to WBDG, The Whole Building Design Guide, the process of properly siting a building within its landscape and community should have the following considerations, which have been truncated to represent those that are most applicable to industrial sites.³

- Minimize land disturbance through the selection of disturbed land, re-use of brownfield sites, retrofit existing buildings, and minimize new impervious surface creation.
- Understand existing watershed plans and environmental goals of the jurisdiction and local watershed organizations that may be regulated.
- Consider energy implications and carbon emissions in site selection and building orientation.
- Apply best practices for erosion control, through both improved grading and landscaping methods.
- Use native plants and remove any invasive species at the site.
- Reduce the heat island effect.
- Reduce, control, and treat surface runoff through effective storm water practices that treat both the quantity and quality of runoff created through the development process.
- Consider site security concurrently with sustainable site issues. Location of access roads, parking, vehicle barriers, and perimeter lighting.
- Work closely with lighting designer to reduce security lighting and its associated light pollution.

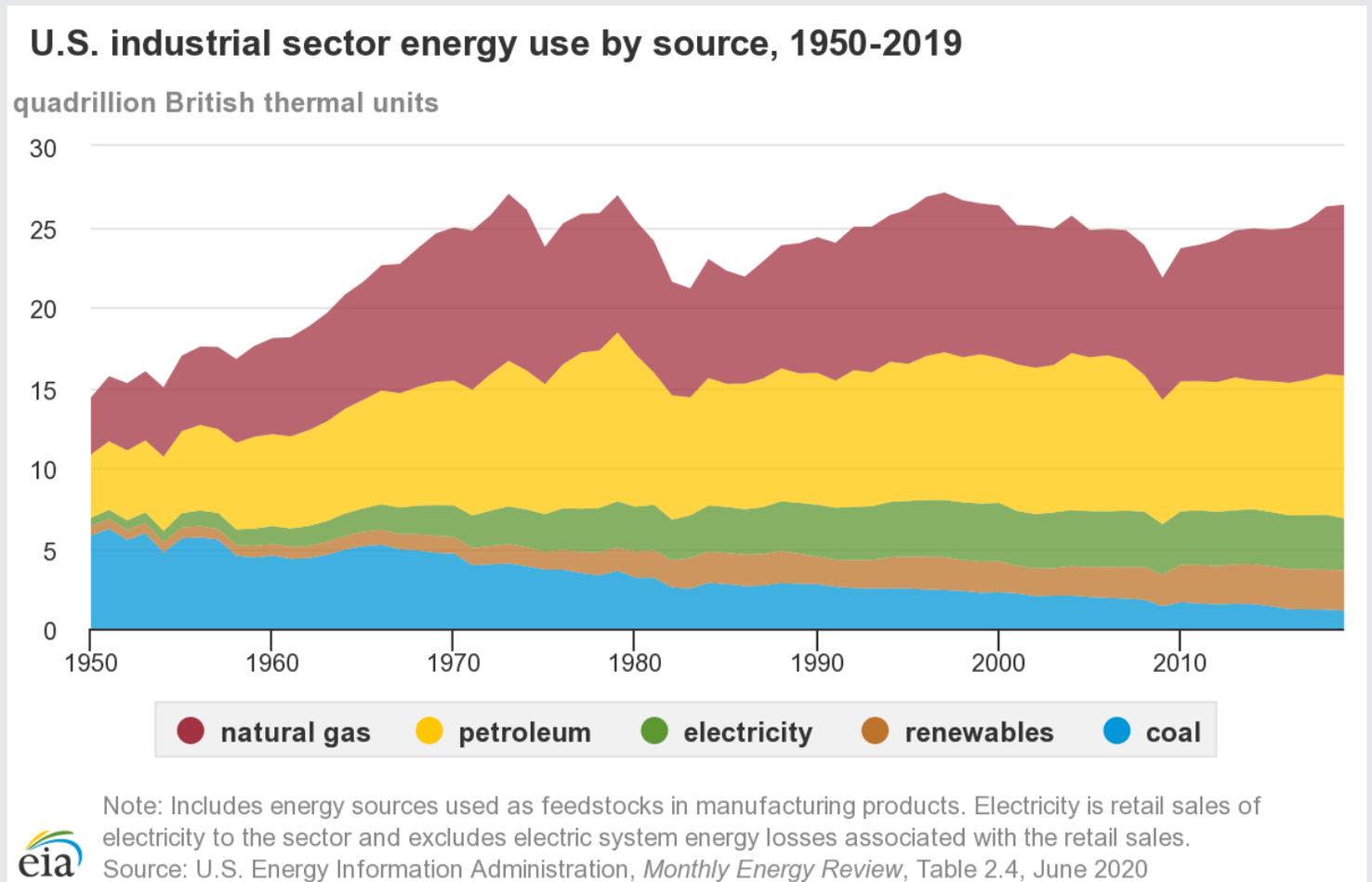
The full list can be found at:

<https://www.wbdg.org/design-objectives/sustainable/optimize-site-potential>



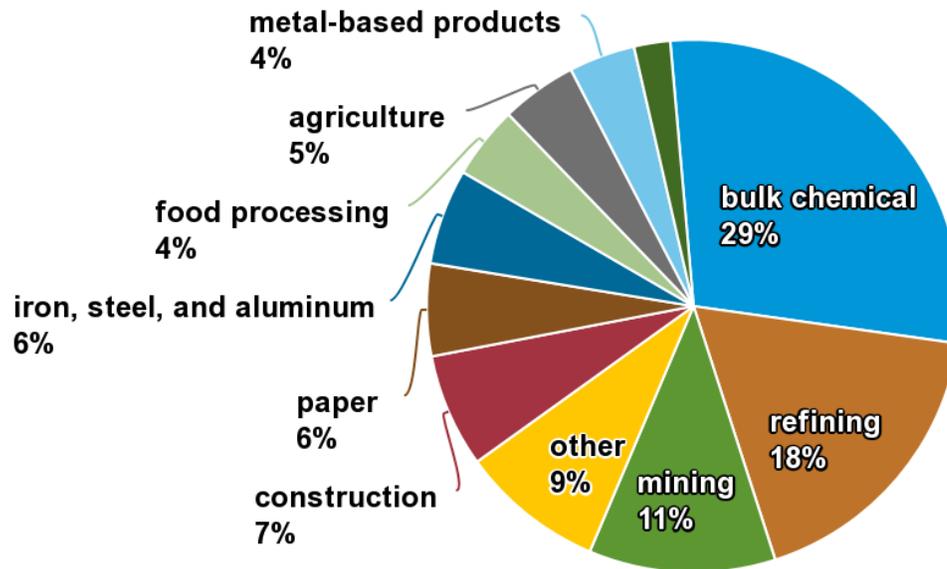
BUILDING ENVELOPE

According to the US Energy Information Administration, the total end-use energy consumption was greater than 100 quadrillion British thermal units (Btu) in 2019 with industrial energy demand sources shown in the graph below.¹



Of the 100 quadrillion Btu(s) used, the following graph shows the consumption rate by sector.¹

U.S. industrial sector energy consumption by type of industry, 2019



Note: Includes electricity purchases and energy sources used as feedstocks for making products. Other includes wood products (2%), plastics products (1%), and all others (6%).

Source: U.S. Energy Information Administration, *Annual Energy Outlook 2019*, Tables 25-35, January 2019

The building envelope is a simple and cost-effective way to try and help offset energy costs. A thoughtful design will vet materials of construction, wall and roof insulation thicknesses, roof coverings and glazing. Each needs to be viewed in terms of durability and point of diminishing return to determine the proper level of response.

Wall assembly choices to strive for in the sustainable design of an industrial building are higher R-values, increased air tightness, continuous insulation and enhanced durability/ enclosure lifespan which all contribute to improved occupancy comfort and lower operating costs.

Roof assemblies should be selected with the specific climatic region in mind with care given to the appropriate R-value, reflectivity, and emissivity. Reflective coatings on dark-colored membranes are beneficial, but only if they stay reflective. Retention of reflectivity depends upon good substrate preparation, so the coating doesn't flake off, and requires positive drainage so dirt, algae, and atmospheric pollutants don't build up. Since reflective coatings do not last as long as the roof membrane, periodic recoating must be included in life-cycle analysis.

BUILDING ENVELOPE (Continued)

Glazing choices are of concern to the designer with emphasis needing to be placed on high performance, spectrally selective glazing. The orientation, amount and performance of vertical and horizontal glazing should be appropriate for the climate of the building. Carefully analyze the thermal (U-factor), solar (solar heat gain factor-SHGF) and daylighting (visible transmittance-VT) performance of glazing on each elevation of the building. The performance criteria will vary depending upon orientation and dominant strategy.

It should be noted both the wall and roof performance are impacted by air leakage, water leakage and condensation. Poor deck-to-wall connections and deck penetrations allow airflow, thermal migration and water infiltration. Not all roof systems require vapor retarders or air barriers; however, with high internal relative humidity and cold exterior conditions, condensation results in wet insulation which decreases the R-value.

Each item above needs to be viewed in terms of durability and point of diminishing return to determine the proper level of response in excess of current adopted codes.

WATER CONSUMPTION & STORM WATER MANAGEMENT

The Centers for Disease Control and Prevention states that "Manufacturing and other industries use water during the production process for either creating their products or cooling equipment used in creating their products. According to the United States Geological Survey (USGS), industrial water is used for fabricating, processing, washing, diluting, cooling, or transporting a product. Water is also used by smelting facilities, petroleum refineries, and industries producing chemical products, food, and paper products. Large amounts of water are used mostly to produce food, paper, and chemicals."⁷

The CDC continues by stating the Louisiana tops the list of states that use the most freshwater per day for industrial use, mostly for its chemical and paper industries. Other top users of industrial water include Indiana and Texas. Industrial water use is declining in the United States, with the year 2000 showing the lowest level since reporting of industrial water use began in 1950. However high-income countries use 59 percent of their water for industrial use, while low-income countries use 8 percent.

Lower water consumption can be achieved via:

- Water-efficient plumbing fixtures (ultra low-flow toilets and urinals, waterless urinals, low-flow and sensed sinks, low-flow showerheads, and water-efficient dishwashers and washing machines)
- Irrigation and landscaping measures (water-efficient irrigation systems, irrigation control systems, low-flow sprinkler heads, water-efficient scheduling practices, and Xeriscape)
- Water recycling or reuse measures (Gray water and process recycling systems), and
- Methods to reduce water use in HVAC systems.

The Environmental Protection Agency states that urban stormwater is a major reason why nearly half of all U.S. rivers, streams, lakes and coastal waters fail to meet national water quality standards.⁶ WBDG, The Whole Building Design Guide recommends to “reduce, control, and treat surface runoff” by:

- Minimizing the amount of natural land converted for impervious surfaces such as parking lots, buildings, and travel lanes.
- Applying low impact development principles:
 - Install site practices that encourage the natural absorption of rain such as disconnecting roof leaders and using effective storm water practices such as rain gardens, rainwater cisterns, vegetated swales / depressions, constructed wetlands, pervious paving, and other on-site storm water storage methods.
 - Understand that the site boundaries for LID extend beyond the building construction site and may include the whole campus, including future construction sites, or even an entire watershed surrounding the building site.
- Using Integrated Pest Management to reduce water pollution from pesticides.
 - Consider incorporating green roofs into the project where feasible.
- Planning for extreme storm-water events in the overall management of surface water runoff.
- Following EPA's Green Infrastructure policy for managing storm-water.

Solar energy is one of the cleanest sources of energy, and it is an effective way of making buildings more efficient and sustainable. They are not however, 100% green as one may think or inexpensive but neither of these facts outweighs the benefits of their use as opposed to fossil fuels.

Most solar cells today start as quartz, the most common form of silica (silicon dioxide), which is refined into elemental silicon. The initial refining turns quartz into metallurgical-grade silicon, a substance used mostly to harden steel and other metals. The metallurgical-grade silicon is then processed into polysilicon, whose byproduct is the very toxic compound silicon tetrachloride. The refinement process involves combining hydrochloric acid with metallurgical-grade silicon to turn it into what are called trichlorosilanes. The trichlorosilanes then react with added hydrogen, producing polysilicon along with liquid silicon tetrachloride creating three or four tons of silicon tetrachloride for every ton of polysilicon.

The cost of producing a solar panel is calculated using dollars per watt. In 2018, the average installation cost was between \$2.87 and \$3.85 per watt. For every 5 kilowatts (kW), solar panels cost from \$10,045 to \$13,475 after tax credits are applied. If photovoltaics are being considered for a project, these costs need to be researched and verified for each geographic market based on availability and potential tax credits.

The previously mentioned aside, solar panels are a renewable energy source that can reduce an owner's electrical costs within reason. Typical applications are roof mounted arrays as well as parking lot car port arrays.

SUSTAINABILITY AFTER THE FACT

Some owners have asked about sustainability for buildings that will not undergo a major renovation and there is guidance from USGBC on how this can be accomplished. In 2008 USGBC came out with LEED for Existing Buildings: Operation and Maintenance and it is touted as a guide on how to "drive down costs while increasing occupants' productivity".⁹ Since design is not the focus of this certification, O&M is based on the building operating performance by addressing:

- Building Exterior
- Site Maintenance Programs
- Efficient and optimized use of energy and water
- Purchase of environmentally preferred products and food
- Waste stream Management
- Ongoing indoor environmental quality

Specific documents and check lists can be found at:

www.usgbc.org/leed/v41#om

SUMMARY

All the avenues reviewed in this paper offer ideas for making industrial buildings more sustainable but each needs to have their applicability to a specific project evaluated against the expected goals. Owners and designers must be in alignment from a cost and program perspective to ensure implementation of the ideas a team will come up with to make a building more sustainable. There is no doubt that sustainability and LEED certification costs more money, but that investment has the potential of being able to save natural resources (and buildings) for future generations. Remodeling a building often requires specific items to be brought up to current building code compliance or existing systems to be upgraded or replaced due to poor performance or depreciation. Parking lots often need to be repaved which affords the opportunity to incorporate porous paving, bioswales and bicycle racks. Depending on the age of the building, plumbing fixture units often need to be rebalanced which affords the installation low flow urinals/ toilets and hands-free faucets. Inevitably roofs need to be replaced which affords the installation of additional layers of insulation to increase R-value and provide a membrane that can reduce heat island effect.

RESOURCES

1. www.eia.gov
2. www.hpac.com/archive/article/20926453/the-true-cost-of-leedcertified-green-buildings
3. www.wbdg.org/design-objectives/sustainable/optimize-site-potential
4. www.wbdg.org/resources/water-conservation
5. www.nrdc.org/stories/green-infrastructure-how-manage-water-sustainable-way
6. www.epa.gov/green-infrastructure/integrating-green-infrastructure-federal-regulatory-programs
7. www.cdc.gov/healthywater/other/industrial/index.html
8. www.powerelectronics.com/technologies/alternative-energy
9. www.usgbc.org/leed/rating-systems/existing-buildings

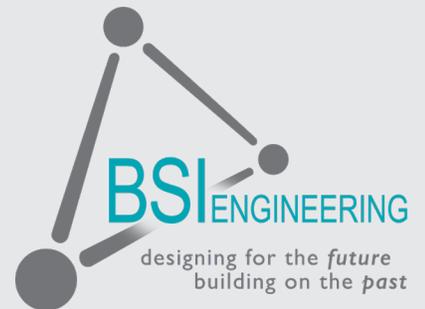


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