The Role of Compact Storage in Green Building Design

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White Paper

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Executive Summary

Compact storage (also known as high-density mobile storage) reduces space needs, which in turn can minimize a building's total volume and reduce construction costs, as well as saving energy and reducing operating costs over the life of the building.

"Green Storage." To some it's just another stage in the greening of America. To others, particularly those designing, constructing or operating buildings, it's a very real solution to many of today's space and sustainability challenges.

Sustainable, or "green," design[1] solutions are not new to the design industry. In addition to cutting costs and benefiting the environment, it just makes good economic sense whenever you can save green space and reduce costs over the long run.

An example would be energy reduction. Buildings represent a third of U.S. primary energy use and two-thirds of U.S. electricity consumption. According to U.S. Environmental Protection Agency (EPA) research, tenants can save about 50 cents per square foot each year through strategies that cut energy use by 30 percent. This can represent a savings of $50,000 or more in a five-year lease on 20,000 square feet[2].

The EPA, in its own case study on "EPA's Research Triangle Park Laboratory Facility," cites minimizing the total volume of the building as one way to reduce the load placed on the heating and air conditioning system, thereby saving energy and reducing heating and cooling costs.

Compact storage (also known as high-density mobile storage), reduces space needs, which in turn can minimize a building's total volume and reduce construction costs, as well as saving energy and reducing operating costs over the life of the building. It has also helped reduce site disturbance in new construction and has aided in the adaptive reuse of existing buildings. In one project alone, it saved over 30,000 square feet and $6 million in construction costs. In others, it's helped prevent the need for costly additions. Compact storage is a viable alternative to traditional, fixed storage products, and green in terms of Life Cycle Assessment (LCA)[3].

Storage equipment has even helped buildings earn points towards LEED® Certification, the consensus-based national standard developed by the U.S. Green Building Council to support and validate green building, design, construction and operations.

The focus of this white paper is the role of compact storage in green building design, and how compact storage can help contribute to green building goals and possible points towards LEED Certification.

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[1] "Design and construction practices that significantly reduce or eliminate the negative impact of buildings on the environment and occupants." U.S. Green Building Council, *An Introduction to the U.S. Green Building Council and the LEED Green Building Rating System®*, December 2004

[2] U.S. Green Building Council Fact Sheet, April 2005; Sources: 2003 U.S. DOE Buildings Energy Databook and EPA

[3] "LCA is a tool to measure, assess and manage the environmental performance of a product from raw materials through production, use, and end-of-life phases." Five Winds International, Building Product Life Cycle Assessment Webcast, BDCmag.com, April 2005

Concept of Compact Storage

With over 28 percent of all office furnishings expenditures typically spent on storage equipment [4], and space at a premium in most industries, high-density mobile storage is a "smart" solution.

Case Study

Compact shelving helps Emory University avoid costly addition

High-density mobile storage recently helped Emory University in Atlanta avoid encroaching on adjacent green space, while enabling its Robert W. Woodruff Library to continue to house its active collection in the on-campus main library building.

The alternative to compact shelving would have been to consider a substantial addition to the building or off-site storage options, both of which would have cost considerably more and neither of which would have provided the necessary storage within the same time-frame.

The concept of compact or high-density mobile storage is "green" by its very nature. By eliminating the space required for multiple aisles, high-density mobile storage systems efficiently compact storage into a smaller footprint, while increasing capacity over stationary storage systems — or freeing up space for other activities.

Introduced in the United States over three decades ago, high-density mobile storage systems have become an increasingly popular alternative to stationary or fixed shelving. Mobile systems can compact virtually any kind of storage unit — from bookshelves and file cabinets to bins, drawers and custom cabinetry, computer media racks, museum cases, mail slots, tool cabinets, lockers, industrial pallet racking, and almost everything in between.

Mobile systems are available in three types — manual, mechanical and powered. All have carriages that move along a rail or track. Each type offers varying degrees of feature sophistication and overall storage density, with powered systems providing the highest levels of each.

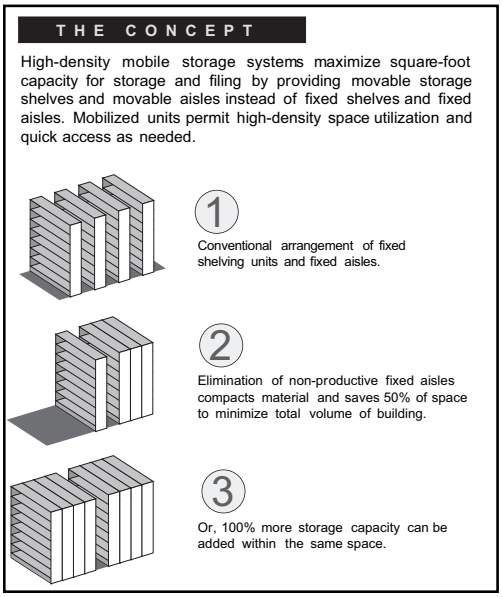
Manual mobile systems are hand-operated, i.e., the user moves the carriage by pushing or pulling it. The best systems glide with near-frictionless carriage tracking for smooth, easy movement and durability. A manual system is typically used in smaller spaces for lighter loads and in situations with limited, vs. public, access.

Mechanical mobile systems feature an assist mechanism, such as a turning wheel, to make the carriage movement easier and capable of accommodating moderate carriage lengths and loads.

Whether operated manually or mechanically, there are ergonomic issues that must be addressed.

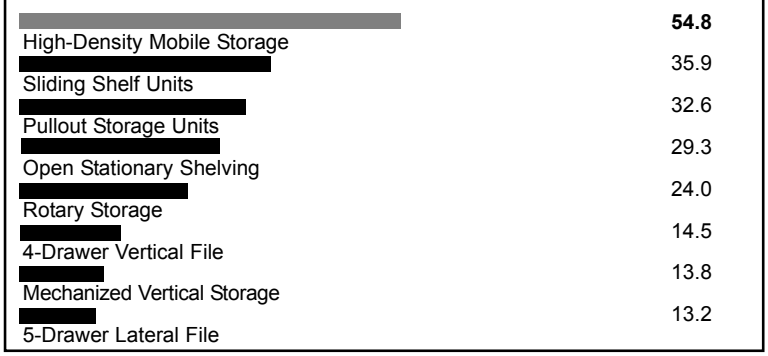
Providing the greatest space density are powered systems (electronically operated) and completely programmable systems that automatically open and close, adjust aisle widths and protect the users with several safety features. Powered mobile systems move at the push of a button. Therefore, they also provide the greatest flexibility and productivity, as well as the highest level of safety and item security, while allowing companies to easily meet Americans with Disabilities Act (ADA) requirements.

Powered systems offer a range of top-of-the-line features, including an energy-saving aisle-lighting option that illuminates only the occupied aisle and turns lights off automatically after a predetermined period of inactivity; an Internet interface that assures optimal efficiency of operation; passive, automatically activated safety sensors; and code-access keypad control for enhanced security. They can even be tied to a building's fire alarm and security system. ▶

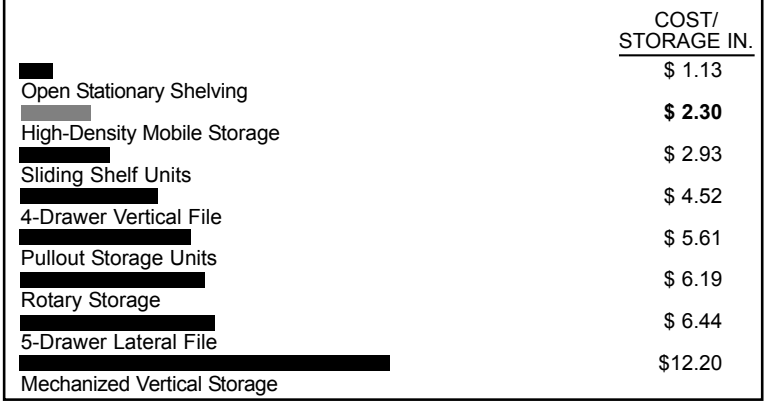


With over 28 percent of all office furnishings expenditures typically spent on storage equipment[4], and space at a premium in most industries, high-density mobile storage is a "smart" solution. It is the most space-efficient of all storage equipment in terms of optimizing space utilization, yet initial costs, per storage inch, for high-density mobile equipment are less than for most other storage products (*see bar charts, right*).

STORAGE EFFICIENCY COMPARISON



STORAGE EQUIPMENT COST COMPARISON



When LCA is used to evaluate energy-saving strategies, high-density mobile storage also gets high marks. The concept fosters the use of smaller buildings, reducing the amount of building materials consumed and saving energy by having to heat and cool less square footage over the life of the building. It also fosters the use of on-site storage, which requires less energy to retrieve than items stored in an off-site location. As a facility's needs change, high-density mobile storage equipment may be relocated and reused — and at the end of its useful life, because it is manufactured primarily of steel or aluminum, it can be recycled again.

Space conservation is the most obvious environmental benefit of compact storage. Economic benefits include savings in construction materials, energy consumption, and personnel costs associated with maintaining and staffing a new facility or addition.

Economic Benefits of Compact Storage

Switching to high-density mobile storage can immediately increase storage capacity in an existing facility by 50 to 100 percent, often helping an organization avoid the expense and hassle of a move or new construction.

Today's space planners and facility managers must evaluate not only current and anticipated space requirements, but also Life Cycle Costing (LCC)[5], including the costs associated with operating in that ▶

Case Study

High-density storage aids in adaptive reuse of historic landmark

High-density mobile storage contributed to the adaptive reuse of San Francisco's former Main Library, a 1917 Beaux Arts building and one of the city's most important historic structures, which is now home to the world-renowned Asian Art Museum.

Due to the historic nature of the building, expanding or changing the exterior look or footprint of the structure was not an option, so space-conserving storage solutions, including compact art racks and more than 200 environmentally controlled cabinets on high-density mobile systems, were incorporated into the museum's lower level for collection storage and preservation.

[4] BIFMA International, Rpt #9a, *2003 shipments of Office Furniture by U.S. Manufacturers*

[5] "LCC … the focus is on the economic impacts, not on the environmental and health impacts." James A. Fava, PhD, Managing Director, Five Winds International, Building Product Life Cycle Assessment Webcast, BDCmag.com, April 2005

Case Study

Green storage saves 30,000 square feet and $6 million in construction costs

When Central Michigan University's Charles V. Park Library in Mount Pleasant, Mich., recently underwent a four-floor renovation and expansion, architects specified high-density, powered mobile shelving to house the library's collection. The 1.1-million-volume collection, which was consolidated from several campus locations, would have required 75,000 square feet had stationary shelving been used. Architects reduced the overall building footprint to 45,000 square feet simply by utilizing mobile shelving.

The stacks were designed into the new addition, where the 30,000 square feet saved contributed to $6 million in construction cost savings, allowing the resulting structure to include a multi-floor atrium with an abundance of natural light.

space. Consider the following factors that make up the annual cost per square foot of leased space:

- Rental Cost
- Utilities
- Maintenance

By allowing facilities to reduce existing space or minimize the total volume of a new building, high-density mobile storage can yield (or "contribute to") savings in all these areas.

Another way to look at it is to multiply the annual energy cost per square foot by the square footage saved through the use of high-density mobile storage. With annual energy (electricity and gas) costs in the U.S. averaging $1.52 per square foot in office buildings and $2.15 in hospitals[6], an office building or hospital saving 10,000 square feet, could save $15,200 or $21,500 annually in utility costs alone. If you add the rental and maintenance costs per square foot, the actual savings from the use of compact storage increase dramatically.

Note ongoing costs per square foot for rent, utilities and maintenance of downtown office buildings in six major cities[7], right.

When the issue is expansion or new construction, space and cost savings can often be realized by planning for high-density mobile storage in advance — during the initial planning stages. This allows you to consider the structural system necessary to support high-density mobile storage, while reducing the overall footprint of the addition or building. With cost estimates for new construction running as high as $168, $180 and $315 per square foot for office buildings, libraries and hospitals, respectively, the savings can be enormous. High-density mobile systems recently helped Central Michigan University save $6 million in construction costs (*see case study*).

Note construction costs for six major cities[8], below.

CONSTRUCTION COSTS PER SQUARE FOOT OF FLOOR SPACE

	Hospital - 100,000*		Library - 30,000*		Office, Mid Rise - 50,000*	
	Preliminary Cost Est. Per Sq. Ft.		Preliminary Cost Est. Per Sq. Ft.		Preliminary Cost Est. Per Sq. Ft.	
	Low	High	Low	High	Low	High
Atlanta	$129	$230	$79	$132	$75	$124
Boston	$166	$297	$102	$170	$95	$158
Chicago	$161	$287	$99	$164	$92	$153
Dallas	$121	$215	$74	$123	$70	$116
San Francisco	$177	$315	$109	$180	$101	$168
Seattle	$149	$266	$91	$152	$86	$143

*Gross Sq. Ft.

ONGOING COSTS PER SQUARE FOOT OF FLOOR SPACE FOR OFFICE BUILDINGS, DOWNTOWN

	Rent*		Utilities*		Janitorial, Maintenance and Repair*	
	Low	High	Low	High	Low	High
Atlanta	$19.04	$22.76	$1.35	$1.50	$1.85	$2.33
Boston	$24.23	$35.00	$1.34	$2.85	$2.14	$2.88
Chicago	$13.85	$19.23	$1.20	$1.70	$3.11	$3.76
Dallas	$13.28	$19.42	$1.63	$2.33	$1.77	$2.55
San Francisco	$24.78	$38.15	$2.09	$3.06	$3.31	$4.13
Seattle	$21.28	$25.92	$1.21	$1.78	$1.94	$2.91

*Per Sq. Ft. ($ Per Net Rentable Office Area)

Most compact mobile storage installations can also be cost-justified by the increased productivity and efficiency that results from being able to store more materials closer to point of use. Optional features that can boost efficiency even more include aisle-end shelving for quick access to "active" files and materials, plus barcode and Radio Frequency Identification ▶

[6] Platts, a Division of The McGraw-Hill Companies, Inc., http://www.nstaronline.com/your_business/energy_advisor/CEA_home.html

[7] Institute of Real Estate Management, *2004 Income/Expense Analysis®: Office Buildings*

[8] RS Means, http://www.rsmeans.com/calculator/

(RFID) technology for enhanced tracking and retrieval of documents or inventory. A well-organized system improves workflow, decreases filing errors and inventory problems and gives employees better access to frequently needed materials.

Floor space remains a high, fixed-cost element in today's interior environment, whether the situation is new construction or an existing building. If a building's footprint can be reduced through the use of compact storage, a major benefit is less energy consumption over time.

A Commitment to Green

When selecting a storage partner and equipment today, it is important to look within the manufacturing company itself for a proven commitment to environmental sustainability. An environmentally responsible manufacturer will have well-established “green” manufacturing processes in place to minimize the impact on the environment.

Key Components of Green Manufacturing

- **Lean manufacturing principles:** Products are manufactured using a minimal number of parts, making them interchangeable, easier to assemble and environmentally sound. The company continually looks for ways to remove waste of motion, time, energy and resources from every step in the manufacturing process and regularly updates production practices, keeping up with advances in technology, as well as in health and environmental standards.
- **Recycled content:** Steel or aluminum with a high percentage of recycled content is used whenever possible.
- **Recycling:** The company uses recycled water to thoroughly clean its products before painting. This solvent-free process, called aqueous degreasing, along with strict product selection and quality control, prevents greenhouse gas emissions and eliminates heavy metals from wastewater, a process so effective that products need only be painted once. In addition to recycling water whenever possible, the company should also be recycling materials, such as steel and aluminum, from their fabrication process, as well as implementing programs to reduce the amount of corrugated cardboard used for packing and shipping.
- **Low-emitting materials:** Powder-coat painting is a highly efficient and solvent-free process, especially when a manufacturer confines and reclaims the powdered paint to minimize waste and avoid air pollution. At least ninety-seven percent of the paint should end up on the product. Powder-coat paint, which requires no primer, also smoothes metallic “burrs,” eliminating the need for grinding or filing.
- **Flexible, reusable products:** The company's finished products themselves should be easy to reconfigure, reuse and recycle to prevent them from ending up in the nation's landfills.

Space planning, densification of storage areas — especially to the interior of a project ... may also contribute toward daylight and views

Storage equipment recently helped the highly acclaimed, new Seattle Central Library building earn a Silver LEED certification ...

LEED® Rating System

Leadership in Energy and Environmental Design (LEED) is a green building rating system developed by the United States Green Building Council (USGBC). It was developed to assist owners, architects, contractors and vendors in designing, constructing and fabricating products that are environmentally friendly when compared to standard building practices. It, in effect, causes us to reconsider the way we do business and examine our practices in an effort to be more environmentally conscious.▶

The LEED-NC[9] (New Construction) rating system contains six separate categories:

1. **Sustainable Sites**
2. **Water Efficiency**
3. **Energy and Atmosphere**
4. **Materials & Resources**
5. **Indoor Environmental Quality**
6. **Innovation & Design Process**

Within these six categories there are also seven prerequisites, which must be met. The maximum score is 69 points. Projects must achieve a minimum of 26 points in order to be LEED certified, 33 points to attain a silver rating, 39 points for gold and 52 points for a platinum rating. The LEED-EB (Existing Buildings) and LEED-CI (Commercial Interiors) rating systems have similar categories, although prerequisites and points differ.

Compact or high-density mobile storage systems may assist projects in obtaining a LEED rating in five of the six categories:

Category 1 — Sustainable Sites: By allowing a dramatic increase — as much as 50 to 100 percent — in on-site storage over conventional, stationary storage methods, high-density mobile storage systems may help to reduce building size, thus **reduce site disturbance** and preserve open space. By greatly expanding the on-site storage capability, an existing facility could be renovated, thus allowing the shell to be retained.

Category 3 — Energy & Atmosphere: By compacting storage to reduce building size, high-density mobile storage systems may also help **reduce energy consumption** over the entire life of the building, since smaller buildings typically take less energy to heat and/or cool. Choosing an aisle-lighting option that illuminates only the occupied aisle of a high-density mobile storage area and turns lights off automatically after a predetermined period of inactivity may further contribute to energy savings realized by a project seeking LEED certification.

Category 4 — Materials & Resources: Recycled content in the high-density shelving could also contribute towards a project earning points. LEED allows you to assume that 25 percent of the steel content is post-consumer materials, however, since a manufacturer's recycled steel content may be as high as 80 or 90 percent, it is preferable to document the actual recycled steel content of the shelving. So always check your vendor for actual recycled content. Retaining the shell could assist a project in achieving points in the **building reuse** category. Depending on the location of your project, the use of high-density mobile products may also earn points for **local/ regional materials**.

Category 5 — Indoor Environmental Quality: High-density mobile products that are finished with a powder-coat paint that emits no volatile organic compounds may contribute towards **low-emitting materials**. Space planning, densification of storage areas — especially to the interior of a project — and/or limiting of storage system height may also contribute toward **daylight and views**.

Category 6 — Innovation & Design Process: If a project's environmental goals cited in any of the above categories are significantly exceeded, additional points may be earned for **innovation in design**.

Since the USGBC evaluates each project individually, the role high-density mobile storage systems play will be different for every project. It is the design professional's responsibility to ascertain a project's eligibility for any of the credits proposed and prepare the necessary documentation for submission to the USGBC. The final determination, however, will always be in the hands of the LEED Steering Committee.

[9] LEED-NC Version 2.1

Storage Equipment in LEED® Certified Buildings

Storage equipment recently helped the highly acclaimed, new Seattle Central Library building earn a Silver LEED certification from the U.S. Green Building Council (USGBC) for incorporating design elements that demonstrate environmental stewardship.

Other LEED certified buildings that have conserved space through the use of high-density mobile storage include the William J. Clinton Presidential Center in Little Rock, Ark., and the Mark Twain House & Museum Center in Hartford, Conn.

About the Authors

Alfred J. Herzog is a registered professional engineer in the state of Georgia and a LEED accredited professional. He is employed at Emory University in Atlanta, Ga. His career spans 28 years focused in facility-related activities, design, construction, operations and maintenance. He has been a member of Emory's Facilities Management Division since 1987 and, prior to that, served in the United States Air Force as a commissioned officer for 10 years.

Emory University is home to 11 buildings that have been, or are being, designed and renovated or constructed according to LEED principles, the rigorous process overseen by the U.S. Green Building Council. Five of the buildings have already earned LEED certification, one of which is the first ever on a university campus to earn a Gold LEED-EB certification, while two others earned Silver LEED-NC certification. Emory currently has three more buildings submitted for LEED review and three other registered projects.

Emory will serve as a showcase for LEED design and implementation at the U.S. Green Building Council's annual leadership conference in Atlanta, November 9-11, 2005.

Christopher T. Batterman, CIRM, Director of Market Development, Spacesaver Corporation, is an expert in high-density mobile storage applications and a nationally recognized speaker/presenter. He has recently led a team in developing a series of seminars for the American Institute of Architects (AIA) to educate architects and designers on mobile storage applications and space conservation. He is an Allied Individual member of AIA and Certified in Integrated Resource Management by the Association for Operations Management (APICS).

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- Ross Spiegel, AIA, FCSI, CCS, CCCA, LEED AP, Senior Specification Writer, Fletcher-Thompson, Inc.
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