Energy Efficiency MARKETS.com

The Supercharged Building

brought to you by TERMOBUILD™ smart floors

Introduction

Where smart grid meets age-old building principles

As we've improved human shelters from caves to condos, we have engineered increasingly complex systems to maintain our comfort. Modern central heating and cooling systems give us the freedom to live and work almost anywhere and be spared exposure to weather. This is, of course, a good thing. But humankind pays a price for so much comfort; it is highly energy intensive.

In fact, buildings account for 36 percent of total energy used in the US and 65 percent of electricity. Moreover, energy makes up almost one-fifth of a typical office building's costs. Energy expenses are particularly high for hospitals, hotels and universities that run 24/7.

Thus, architects and engineers worldwide are trying to find ways to design large structures in a more energy conscious way. Often this means embedding ever greater complexity into construction. And while this achieves energy savings, the added systems and technology drive up the price of any building, and especially green building.

This whitepaper describes a better way, one that costs no more than conventional construction, yet offers superior energy management and comfort.

But before we explain the solution, let's look at where contemporary building often goes wrong.

Today's building industry relies heavily on technology, but neglects age-old practices used for centuries to naturally heat and cool inner spaces. These practices paid attention to air flow and used temperature-moderating materials.

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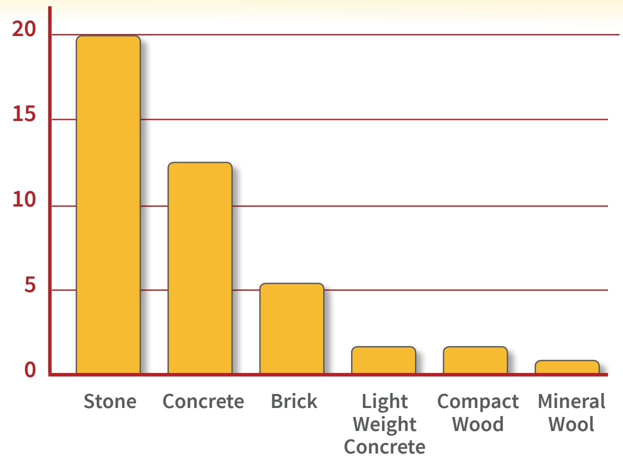
Consider the Egyptian earthen homes or Pueblo adobe structures that incorporated mud brick for floors and walls. The concrete-like materials absorbed the cool air of evening and radiated it during the heat of day. Or conversely, at night they held the warmth of day inside when the air outdoors grew cold.

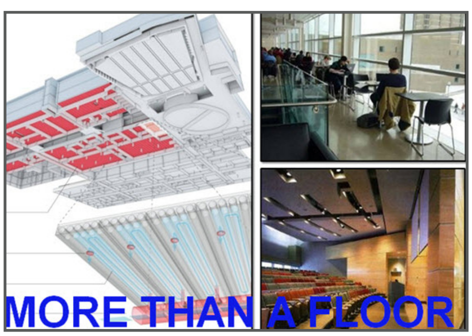
Comparative Thermal Inertia of Various Building Materials



“Mass absorption” or **thermal accumulator** refers to the process whereby energy is stored in a building’s material for a later use. Thermal storage typically relies on the inertia of concrete floors which are reliable, stable, solid and durable.

By integrating this pragmatism with today’s smart technology, we can significantly reduce the cost of high performance construction. We call this solution Termobuild, an innovation that costs no more than conventional building, but provides superior comfort, healthier indoor air, and energy savings.

Termobuild can revolutionize the way we design our buildings. How does it work?



A ‘smart floor’ is the key design element. Like the earthen structures of old, the floor is made out of material, in this case concrete, which easily absorbs and radiates heat and coolness. The concrete floor slab has a hollow core for air flow. Couple this smart floor with sensors, energy harvesting, air ventilation keyed to outdoor temperatures, and air-driven radiant heating and cooling, and you have the beginning of the Termobuild system.

In a 24-hour period, these buildings undergo a kind of ‘supercharging’ with predominately free low-grade energy*, which provides increased comfort and energy efficiency.

As a result — and this is important — they require 40 to 50 percent less mechanical heating and cooling equipment than does a conventional building. Termobuild is able to do more with less, which results in a significant price advantage over competitors’ systems.

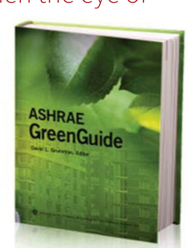
Equally important, these remarkable buildings act as a form of advanced distributed energy. As such, a Termobuild structure provides a way to achieve some of the most sought-after — and elusive — goals in green building:

- Exceptional energy efficiency
- Thermal energy storage and built-in standby heating and cooling
- Storm resiliency and energy security
- Energy management that takes full advantage of dynamic pricing and demand response

Termobuild’s proven approach has been used over the last decade in the construction of new schools, universities, medical facilities, offices and other buildings. Today, interest is heightening in Termobuild as the world increasingly seeks cost-competitive energy-efficient construction.

The building is local, the design is global

Termobuild design is conducive to a wide-range of climates worldwide, even some of the most severe. For example, Chennai, India has scorching heat on par with Arizona, and is notorious for high power prices and blackouts because of grid limitations. But the Husky Corp. building in Chennai, with its Termobuild design, is spared from the grid’s unpredictability and punishing pricing structure. Stored energy in smart floors allows the building to stay cool even when power supply is restricted. Moreover, when the eye of a cyclone came within 14 miles of the building, those inside experienced no disruption in comfort, demonstrating the exceptional storm resiliency of Termobuild structures.



ASHRAE GreenGuide 2003 has selected night pre-cooling in any climate as Green tip#1 out of 50 tips.

*Low-grade energy is the aggregation of the heat from lights, computers and bodies, which is absorbed by smart floors.

How Termobuild Offers Better Return and Lower Risk

The market demands that new buildings be ever more comfortable, energy efficient and safe. They also must be smart, taking advantage of the latest technology to monitor and manage peaks and valleys of energy use. They must be responsive to energy markets, adjusting power consumption as price signals change. And they must be reliable, maintaining indoor comfort and keeping on the lights during storms and grid failures.

These requirements create a sizable challenge for architects, capital project managers and engineers in the early planning stages of a project. While the industry has the technology and design know-how to produce this kind of building, it comes at a high cost. 'Green' and 'smart' construction can carry a significant capital and maintenance price premium.

Is there a way to design super-performing buildings that cost no more than conventional construction?

Yes, Termobuild's supercharged building offers all that is expected of today's smart construction, yet at a lower capital cost. How?

First, Termobuild creates a unique form of energy storage and distribution that uses only conventional building materials, with particular reliance on concrete.

Second, Termobuild's design combines three mechanical systems into one. So heating and cooling, ventilation, and energy storage become one system. As a result, Termobuild requires half the mechanical equipment — chillers, boilers, ground-source heat pumps or simple roof top units — as in a conventional building. This is important because mechanical systems represent a significant expense in building construction, as much as $25 to $40 per square foot.

These two hallmarks of Termobuild design — use of standard building materials and less mechanical plant — create super performance at a cost no higher than conventional construction.

And Termobuild does this while at the same time capturing the Holy Grail for modern electric power systems: energy storage.

Of course, there are other forms of effective energy storage now in use, particularly for existing buildings. But they typically come up short when matched against Termobuild in new construction.

For example, compare Termobuild's system to one that uses ice to achieve energy storage, an equipment-intensive and energy-intensive undertaking. The ice is made at night. By day, fans blow air over the ice to cool the building. Ice storage systems require pumps and ice-making equipment, along with fans to move the cool air to the building interior, often from the distant rooftop or basement. This can require significant duct work, which not only adds to costs, but also takes up valuable real estate space.

Termobuild, on the other hand, stores and radiates energy not by adding extra equipment and complexity, but by incorporating an element already, and always, designed into any building: the floor.

How Termobuild's smart floor works

Termobuild's engineering feat begins with its unique 'smart floor' kit, which includes hollow concrete slabs paired with a ventilation system. The ventilation system activates the dormant concrete placed between the building's walls and floors. The slabs store heat and coolness to be gradually released as needed.

In summer, if the temperature is cooler outside than inside at night, a simple ventilation fan draws in the cool air, circulates it through the hollow slab and supercharges the concrete. The concrete efficiently absorbs the coolness and then behaves like a battery; it stores the free, cool air and gradually discharges it by day as the building warms up. This radiant cooling dramatically cuts back on use of the building's air conditioning system.

What if it is warmer outside than inside at night? Then, the Termobuild system stops drawing in the cool air and goes into mechanical cooling in re-circulation mode to supercharge the concrete floor.

What's significant here is the timing. The air conditioners are working at night when they operate most efficiently. Think about what a building is like at night. The sun is down and the building is empty. So the air conditioners can cool it down without fighting against solar radiation or the heat generated by bodies, computers and lights. Thus, the air conditioning equipment is able to cool the building more easily, using less electricity than it would during the day.

Most conventional buildings operate in the opposite way. They cool by day when everyone is at work, so the air conditioning system must work hard. As a result, they use excessive electricity.

Equally important, by running air conditioning mostly at night — rather than mostly by day — Termobuild takes advantage of the low night-time pricing offered by many utilities. Power prices drop at night because demand minimizes on the electric grid. Again, conventional buildings do the opposite; they operate cooling equipment most intensely when the electricity prices are highest. Termobuild offers a better, lower cost way to manage electricity use.

HVAC + Summer Day Time Imposed Loads

Energy Source	Percentage
Sun	20%
Computers	15%
Lights and People	20%
Ventilation	45%

Consist of: heat gains from sun, people, plug loads and compliance with the latest ASHRAE Ventilation guide.

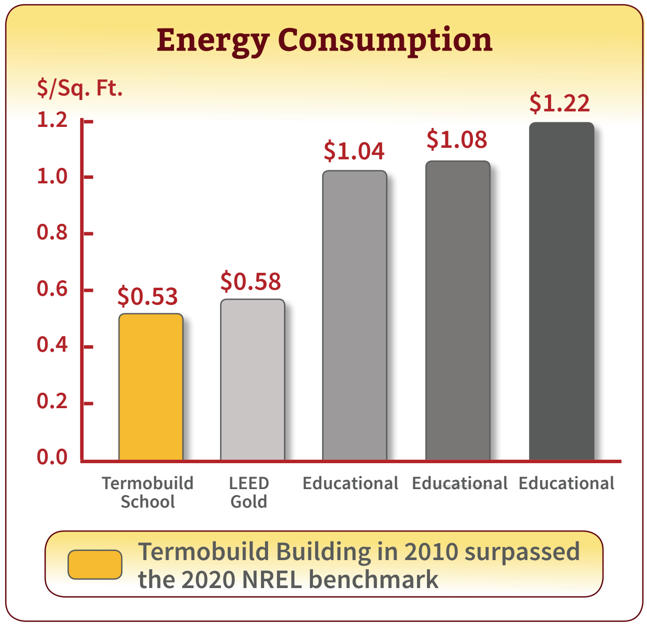
Winter and energy harvesting

During the winter, Termobuild incorporates energy harvesting, which takes advantage of the natural heat generated by a building's occupants, electrical equipment and lights.

Conventional building design often ignores this considerable heat resource, and as result incorporates more heating equipment than is needed for comfort. Termobuild's engineering takes into account this natural heat, which further minimizes mechanical equipment, and therefore lowers not only capital costs but also energy bills.

The bottom line

Termobuild's design also incorporates other favored technologies — which will vary based on location and building needs — to achieve maximum energy performance. These include on-site generation, ground source heat pumps and solar thermal energy. Pairing Termobuild smart floors with these technologies can reduce energy capacity needs by 40 to 50%.



The bottom line is that Termobuild's military grade distributed energy storage system does more with less. It achieves super performance using only standard building materials, requires less mechanical equipment than conventional buildings and reduces energy bills. But higher return and lower risk is only one advantage offered by Termobuild Comfort is another. It simply feels better to be inside a Termobuild structure.

Why it Feels Good to be Inside a Thermal Storage Structure

A building might achieve high metrics for energy efficiency and return on investment, but if people are uncomfortable inside the building, it fails the most important test. And unfortunately, discomfort is the reality in too many commercial structures today.

The Center for Building Performance and Design at Carnegie Mellon University found that the top two complaints in offices are that they are either too hot or too cold. Discomfort leads to lower worker productivity. For example, other studies have shown that more typing mistakes occur when a room is too cold. Conversely, workers in 'green' buildings are absent less often due to illness.

Given that employees typically represent the top expense for businesses in office buildings — far more than energy — worker comfort is crucial to the bottom line.

Mimicking solar radiation

Heat loss through radiation can provide a higher perception of thermal comfort

The natural flow of energy starts from elbows, shoulders and peaks at the head as illustrated in the image. Termobuild structure lifts the heat buildup by allowing the structure to absorb part of the heat. The structure itself radiates coolness to maintain superior comfort without drafts associated with conventional cooling systems.

Termobuild structures are pleasant to be inside because they use radiant heating and cooling. This approach offers a superior comfort aesthetic. The heating and cooling system mimics what we feel when we stand near a roaring fire or when we emerge outdoors on a spring day and the sun's radiation gradually warms our skin. But in this case the gradual warmth or cooling radiates from the structure's concrete floors and walls.

In contrast, forced-air systems blast cold or hot air from ducts. Blowing air — even if it is hot — can actually make us feel chilly rather than warm. That is one of the reasons radiant systems are more energy efficient than forced-air systems. A radiant system offers the feeling of warmth at a lower thermostat setting. And the cement in the Termobuild design holds the warmth or coolness for long periods of time; there is no need for the constant running of motors and fans to keep the temperature consistent. Moreover, radiant systems avoid the notorious leakage caused by forced air, as it propels air against duct work seams, doors and windows.

Supercharging with fresh air

The Termobuild system also is healthier — for more than one reason.

First, radiant heat does not dry the atmosphere as forced-air systems do. And it does not spread pathogens by constantly blowing air, providing important health benefits.

Perhaps most important, the Termobuild system offers extraordinary fresh air exchange. A thermally charged building normally can afford the luxury of over-ventilating because it harvests free low-grade energy while cleansing the building. This multi-tasking feature is built in and free. Fresh air not only adds to the 'feel good' sense of a room, but it also helps prevent the spread of communicable disease from one room to another.

Moreover, Termobuild cleanses at exactly the right time. Night air is cleaner than day air because it contains less car exhaust and other toxins. It is during this period — when the air is freshest — that Termobuild draws the outdoor air in to supercharge its smart floor. Thus, when workers arrive in the morning, they enter a building where the indoor air is often cleaner than the outdoor air. Medical workers, in particular, appreciate this Termobuild feature.

Add today's smart thermostats and building management systems — to the already superior performance brought by fresh-air supercharging and radiant heating and cooling — and a Termobuild structure offers a combination of comfort, energy efficiency and health benefits rarely found in a commercial building.

Where You Want to be if the Electric Grid Fails

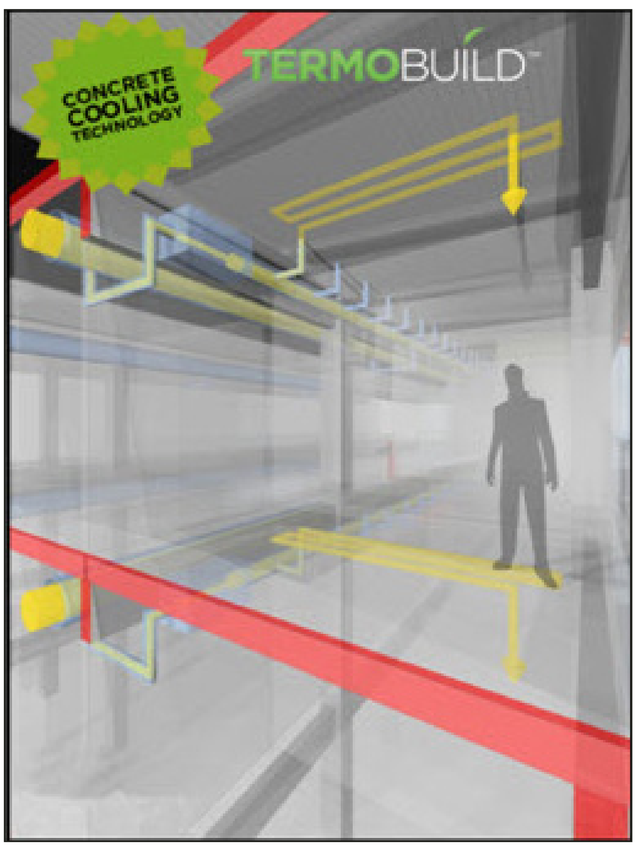
Highly dependent on electricity, contemporary buildings operate on a kind of life support. Shut down the energy supply, and the building effectively dies. Doing business within its walls becomes nearly impossible.

This is why power outages cost the US economy so much money — nearly $80 billion per year, according to federal researchers. The commercial and industrial sector bears the brunt of these costs.

SuperStorm Sandy drove home the vulnerability of our electric grid in 2012, when it crippled New York City. Some buildings went without power for as long as two weeks. As a result, New York City is now seeking ways to fortify the electric grid against storms, as are other cities in hurricane zones.

New York City intends to 'harden' its grid, an effort that will cost $19.5 billion Wisely, the city includes distributed energy storage as part of the endeavor.

Termobuild is a form of distributed energy storage that uniquely eases one of the most significant hardships that commercial buildings face during power outages — a lack of air conditioning.



Free standby heating and cooling

You only need to be in a Termobuild structure during a grid failure to understand why they withstand power outages better than conventional buildings.

Because of its cement construction and smart floors, a Termobuild structure retains its temperature far longer than most buildings. Occupants remain comfortable for up to three days as the structure gradually radiates stored coolness (or warmth in winter) from the supercharged floors and walls. Some workers have reported that they were completely unaware that the mechanical heating and cooling system shut down.

By its very design, Termobuild offers free standby heating and cooling. No additional capital equipment needs to be installed because the standby thermal energy is embedded in the engineering of these supercharged buildings.

That's one way Termobuild helps ensure reliability. But what about keeping the lights, computers and other electrical devices going? Like many of today's smart buildings, Termobuild structures can include back-up generators. These systems are often necessary — but they do add yet another capital expense to smart construction.

Here is the good news. Termobuild's design reduces this expense because it requires less back-up capacity.

When engineers calculate how much back-up capacity a Termobuild structure needs, they take into account its dormant thermal energy. This offsets part of the capacity requirement. A conventional building needs back-up power for air conditioning from the moment the power goes out; a supercharged building can refrain from using back-up generators to run air conditioners for days. This advantage, combined with the building's efficiency, reduces the amount of back-up generation required and therefore lowers equipment cost.

Lower capacity and less run-time for generators also means reduced fuel use. This is important because back-up generators often use diesel, a highly polluting fuel.

So the ultimate result is a building that offers exceptional reliability during a power outage — and at a price advantage — and with an environmental edge.

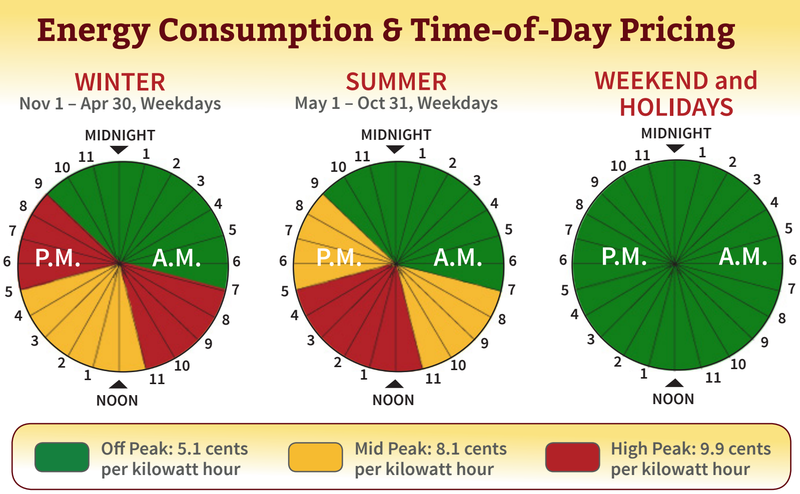
But the benefits of Termobuild are even broader, especially when you consider them in the context of the growing requirements and expectations society places on building owners, architects and engineers.

How to Meet Society's Mandates for Today's Buildings Grid Fails

Today's buildings must be more than functional, comfortable, safe and cost effective. Society also expects them to further its larger energy and environmental goals.

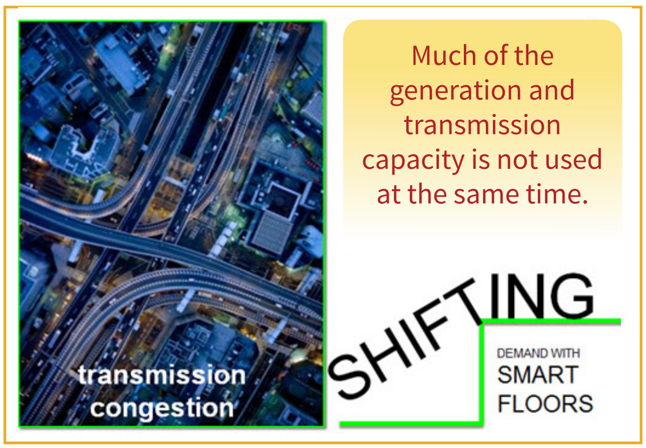
These mandates place tremendous pressure on architects, engineers and project managers, especially given current cost constraints. But Termobuild gives them the tools they need to meet society's expectations with its unique **smart floor** and thermal energy storage.

Here we describe how Termobuild's supercharged building fits into the larger energy puzzle.



Pricing represented in this chart is for reference only. Actual kilowatt hour and peak demand prices may vary and is subject to local utilities pricing policy and incentives.

Demand response and the supercharged building



The power grid is much like a highway that suffers from peak congestion. A hot summer afternoon is rush hour; at night the traffic is light. Utilities increasingly reflect this supply/demand equation in their rates, charging more during peak hours and less off peak. Many utilities and grid operators also offer demand response programs that give financial incentives to energy users who agree to ramp down power use when the grid is under strain. In North America, this tends to occur when air conditioners operate full-tilt on hot days.

There is very good economic reason for discouraging use of power during peak periods. Utilities and grid operators must ensure that enough electric supply is always available. No one wants to suddenly experience a blackout on a hot summer afternoon. So enough power plants must be built to serve the peak, even if those plants only operate for a few, very hot or very cold days per year. A plant that sits idle most of the year represents a very poor return on investment; it drives up everybody's electric rates. Utilities and grid operators, therefore, work hard to find ways to reduce peak demand and build fewer power plants.

Supercharged buildings naturally play to this grid need. Their smart floors act much like rechargeable batteries that smooth the grid's peaks and valleys and virtually expand power generating capacity.

During hot afternoons, when most buildings rely heavily on air conditioning, a supercharged building is radiating natural coolness from its concrete floors and walls. With little need for electrically powered air conditioning, the building takes strain off the grid at just the right time. Meanwhile, at night when power supply is plentiful, the building supercharges its concrete, consuming energy by running its fans, ventilation system, and if needed, air conditioning.

So in this way, supercharged buildings act as a highly economic form of virtual distributed energy. The system not only lowers utility costs for the building owner, but also for everyone by reducing the need for new power plants. This creates triple bottom line benefits (social, economic and environmental). The graphic below provides an example of the potential savings possible in California schools, alone, with use of Termobuild design.

Easier on the environment

So, supercharged buildings use less energy than conventional buildings. But more significantly, they use less energy at the right time.

Many power plants run continuously day and night because it is not easy to turn them on and off. However, much of the energy they produce is not needed at night; it's wasted. They produce excess power and therefore excess emissions. This can be compared to letting a car idle all night when it's parked in the driveway. In contrast, supercharged buildings fuel up on night air, taking advantage of 'nature's green gas station'. So they help grid operators improve night time performance.

Moreover, if implemented on a larger scale, the Termobuild solution could reduce the need for building new power plants to serve the grid and optimize existing plants for better return on investment. In our estimation, if our method is utilized on a larger scale, two power stations can do the job of three — and a lot better!

As mentioned before, Termobuild does more than even out peaks and valleys of consumption; these buildings offer exceptional energy savings — a 45 percent reduction when compared to others. Consider the fact that saving one watt of energy negates the need to produce four watts. That means using our approach, the grid would need only 70 power stations (500 MW each); where under a conventional scenario it would need 100 power stations of the same capacity.

Thermal Energy Storage

Energy experts recognize that it is far more cost effective to save energy than to produce it. It is four to five times more economical to save one megawatt than to produce one megawatt. Moreover, 'negawatts,' or energy saved, produces no emissions. So the US government is encouraging development of net zero energy buildings — structures that produce, on average, as much energy as they use. Thermal energy storage offers a highly effective way to help buildings achieve this goal.

It is important to improve the efficiency of buildings since they account for 30 percent of greenhouse gas emissions, according to the federal Environmental Protection Agency. Termobuild has seen up to a 65 percent reduction in use of heating equipment and a 40 to 60 percent reduction in air conditioning, depending on climate zone and humidity factors. So, Termobuild design means significantly less energy use and therefore lower emissions from buildings.

It's also important to note that in addition to supercharging, Termobuild construction can incorporate renewable energy, such as wind, solar electric and solar thermal with greater efficiencies. It also includes the best of today's smart energy technology. For example, Termobuild's digital benchmarking dashboard not only offers instant diagnostics, but also acts as a great tool for busy executives to visualize real time consumption from various sources on hourly, daily, weekly, monthly and yearly basis.

Peak Power Reduction Potential in Schools in California

Item	Description	Need for Cooling Peak Power in KW
1	Conventional 100 schools in California	$32600.0
2	Termobuild 100 schools	$12700.8*

***Executive Summary**

- **Use of building management systems** is recommended for peak power reduction management.
- **Thermal lag of energy storage** may allow for even more aggressive demand reduction with advanced control strategies.
- **No new technology or additional equipment** is required since in most of the buildings have the right building blocks in place already.
- **Multi-billion dollars savings** can be realized by tapping into dormant properties of concrete floors.

Paving the way for more supercharged buildings

Energy efficient buildings often sell or lease at a premium. This market advantage is likely to expand as more and more cities require that buildings file public reports about their energy usage. Several cities already do require such benchmarking, among them New York, Boston, San Francisco, Austin, Washington, Seattle, Minneapolis and Philadelphia to name a few. Given the superior performance of the supercharged building, it is likely to fare well and thrive under these systems.

Several supercharged buildings have been built in North America. (See Appendix for examples.) But there is far more to be done to encourage broader adoption of this highly efficient structure — which not only serves as an energy storage vessel, but also meets and exceeds energy benchmarks of the National Renewable Energy Laboratory for 2020 and complies with latest fire and safety codes.

Building codes are evolving and have yet to widely incorporate mandatory standards for energy storage and integrated solutions like Termobuild. Distributed energy storage eventually will become a code requirement, a prerequisite for any building. A cost analysis of various building structures confirms that it makes good business sense now for wider implementation across the US and Canada.

Distributed energy storage also is increasingly recognized for its importance by key rating organizations, such as the US Green Building Council, which sets requirements for Leadership in Energy and Environmental Design (LEED).

That's a start.

But forward-thinking architects, capital project managers and real estate portfolio managers aren't waiting for regulators and ranking systems to catch up. They are taking advantage of Termobuild's competitive advantage now.

This white paper provided an overview of the Termobuild supercharged building. For greater detail, we encourage you to contact Termobuild's green team directly:

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About Termobuild

Termobuild offers high-quality, cost-effective solutions for Net Zero Energy and Sustainable Hybrid Buildings. Our motto, 'Building green in a concrete world,' describes our commitment to promoting healthy indoor living and low carb (on) buildings.

Termobuild engineers know how to translate the value of dormant concrete floors and thermal storage into simple to understand heating and cooling requirements. Using a system based on the modern Hollow Core Platform invented in the early 1950s, Termobuild is creating a new generation of hybrid buildings.

Our team of environmentally minded engineers considers your value-added business case a top priority. By working with Termobuild engineers during the pre-construction stage, our clients discover how they can reduce not only on long-term energy costs, but also their impact on the environment. Termobuild makes good business sense right from the start. And, in an industry where initial expenses rule, our method does not cost more to implement than the blueprint.

By building green, one project at a time, we are transforming the building industry and leading the way towards an environmentally healthy future.

Appendix I

Examples of Termobuild projects

Medical Building – Platinum clinic uses the roof as thermal energy storage and radiant panels.

Brook University – Book store with perforated metal ceiling panels to allow contact with thermal storage above (hollow core slabs).

Howthorne School – Main duct c/w branch ducts with a dropped ceiling. Precast concrete and hollow core slabs delivered and installed in any weather with minimum waste.

Humber College – Tilt up construction was used for the project.

International Fire Training School – Integrated solar thermal system with thermal energy storage. Hollow core slabs perform efficiently as thermal energy storage medium. Night sky cooling is enabled via solar thermal wall (STW) — an unexpected benefit to the client since the manufacturing specifications called for heating only. Paring STW with a Termobuild energy storage kit improves round trip efficiency as well as accelerates return on STW investment.

Learning Center – Social Services Building

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Appendix II

Analysis of cost models for schools: the Termobuild advantage

Many indoor comfort systems are now on the market, and all of them can benefit from being paired with Termobuild smart floors. The cost comparison below assumes that a typical educational building follows a predictable peak occupancy patterns from 8 am to 5 pm on weekdays, with some limited occupancy in the morning and from 6 pm to midnight for janitorial activity. Based on this pattern, we show below the capital, operating and maintenance advantages of using Termobuild design for schools.

Capital, Operating & Maintenance Costs for 100,000 Sq. Ft. School

Option	Description	Capital Cost	Maintenance & Operating Cost Factor (BOMA)	Maintenance & Operation Over 25 years
1	Boilers and chillers	$12 million	$3	$36 million
2	Termobuild using same equipment	$11.4 million	$1.80	$21.6 million

**Cost savings to maintain and operate 1,000 Termobuild schools over a 25-year period equals $14.4 billion in savings. (Based on BOMA references and Termobuild's actual factors.)*

Calculate your savings

Energy Costs for California Schools (per student per year)

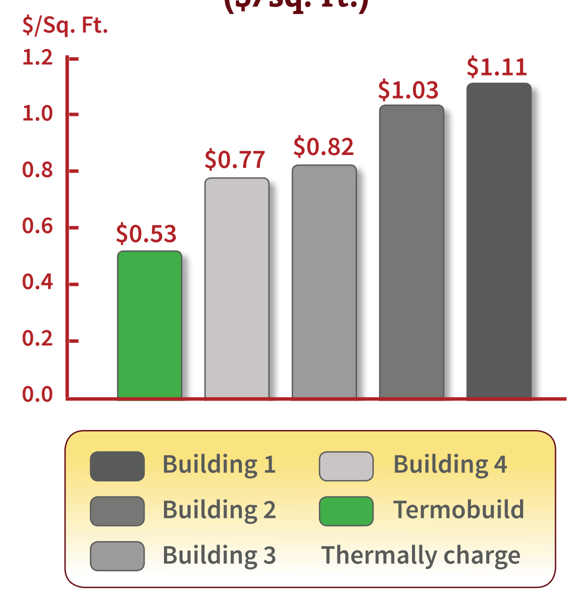
Item	Description	Annual Energy Cost Per Student Per Year
1	Conventional schools	$126.0*
2	Termobuild schools	$59.36
3	Termobuild schools with smart metering	$45.0

**Source: EPA – United States Environmental Protection Agency*

Savings may vary because of climate and building characteristics. But the California example indicates the Termobuild option offers a compelling business case worthy of exploration in other states.

Termobuild vs conventional buildings energy use per sq. ft.

Annual Electricity/Natural Gas Cost ($/sq. ft.)



Source: Termobuild

The green bar in the chart above represents a Termobuild school. Its energy costs are 53 cents per sq. ft/year, while similar conventional buildings pay 77 cents to $1.11 per sq. ft/year. The Termobuild structure uses 32Kbtu, outperforming NREL projections for 2020 of 35Kbtu.

