

# Masonry Intro



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## Masonry Overview

-Masonry is the building of structures from individual units laid in and bound together by mortar.

-Masonry is one of the first building techniques known to man and has remained fundamentally the same for thousands of years.

-While the techniques are the same, masonry shows that it can still evolve into a greener solution for everyday building using a variance in material composition and taking into account where these materials come from.

### -Most important factors in making masonry green (clay brick for residential use)

-Changing the material types: While clay is an abundant resource, there is opportunity to use materials otherwise considered trash in the composition of the bricks. It offers a unique opportunity for recycling items otherwise unrecycleable due to the fact that trash materials (fly ash, in some cases glass, and other materials) can be ground up and mixed in with the clay.

-Recycleability  
Clay brick has an expected useful life of 200 years or more. It requires little maintenance and is a sturdy structural material that can be reused in other buildings. Unfortunately only 70% of bricks are recoverable after standard demolition and in many cases the brick is not recovered as it requires manual labor to clean and prepare for future use.

-Embodied energy  
Brick is naturally a heavy material. It requires massive amounts of energy to move it and to mine it. Cutting down on the energy involved from its creation to its application is a major consideration in making masonry green.

## Types

(most common)



-Clay brick and mortar is the most common material type used in masonry building today.

-Seen mostly in residential structures; it also finds its way into some commercial buildings.



-Cinder block construction is the use of concrete formed units built up in the same manner that the clay brick is. Using mortar and the concrete bricks, it allows for the addition of fly ash and other readily available waste products to be mixed in to the formation of the blocks.



MASONRY

Intro/  
Classification

Types

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# Masonry - Cost and Maintenance



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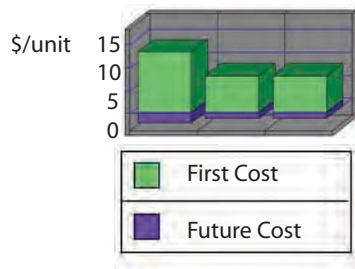
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## Cost

-The main cost of construction comes from the mining and transportation requirements that come with masonry.

### Economic Performance graph

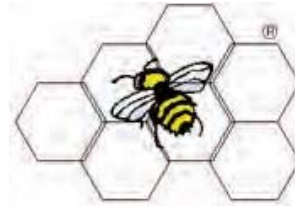


This graph shows the initial cost to get new bricks installed and shows the cost thereafter for maintenance etc. over its average life time. It shows that very little is required after the initial cost of brick creation and construction. The left most column shows average clay brick and mortar while the right two are anonymous data gather by the BEES researchers as alternatives that have been developed by companies that have shared their data but remain anonymous.

## BEES calculations

The BEES program is a reliable resource for easy comparison of materials and their properties. Simply choosing the materials in the system the BEES program can calculate an array of information from global warming potential, to human health, to cost of manufacturing etc. the graphs it produces are clean representations of the effect certain materials are having on the environment.

**BEES® 4.0**



Masonry

Cost

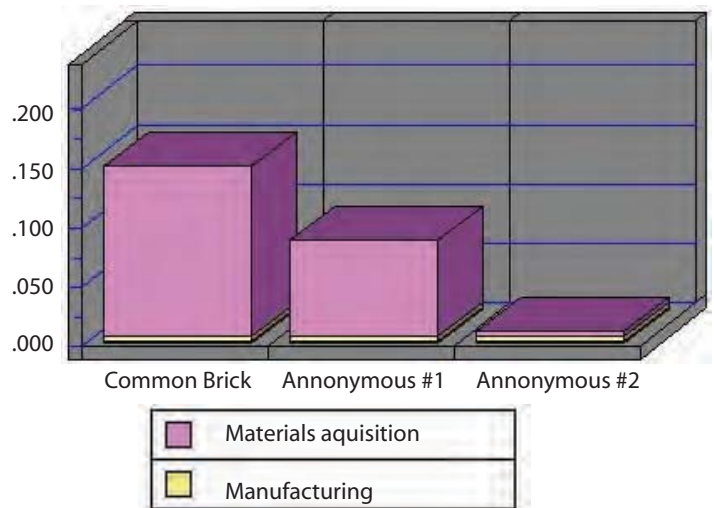
Maintenance

Analysis

Group A

-The graph to the right shows the comparison of the cost of material acquisition to the cost of manufacturing the finished product. As can be clearly seen: the anonymous brick companies are showing the evident reduction in cost of material acquisition as they are most likely using recycled materials, while continuing to use the same manufacturing process. The "score" is a BEES standard that takes into account not only cost but also affect on the environment, global warming potential due to all aspects of acquisition which include but are not limited to mining, production, and transportation etc.

### Economic Performance by material acquisition and manufacturing



# Masonry - Cost, Embodied Energy, Life Cycle



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## Cost analysis continued

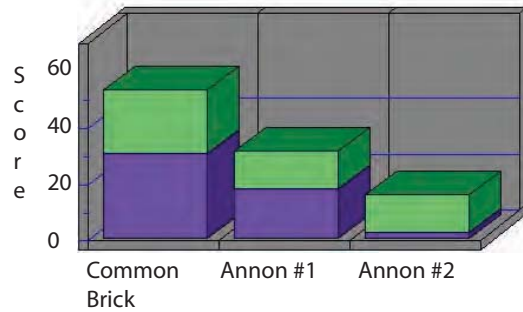
-Cost should not only be considered in monetary units but also in relation to the environment and human health. Below are graphs showing not only the economic impact but also the global warming potential, human health risk, and toxification of brick and where in the process (transportation, manufacturing etc) these detrimental factors are most prevalent. The graphs should provide a clear understanding of what parts of the process can or should be altered to make brick more green.

BEES analysis

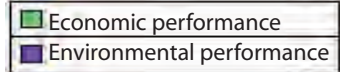
Cost

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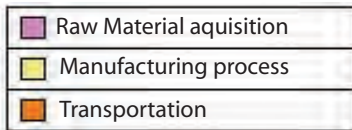
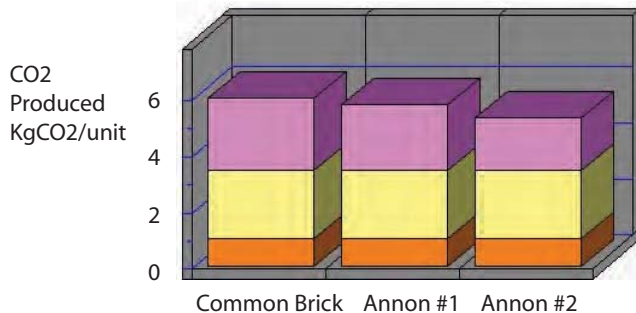
Overall Performance



Continuing to state that the environmental impact is the easiest to overcome, anonymous brick #2 shows that getting the materials from a recycled source not only reduces the economic factor of having to mine and transport it, but also shows that using recycled material cuts down on pollution filling our landfills and changes it into something usable to the public in the form of a building material. The economic factor is reduced in anonymous brick two, but masonry requires manual labor to be installed whose cost is most likely not to be overcome easily.



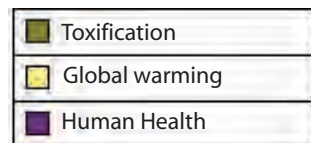
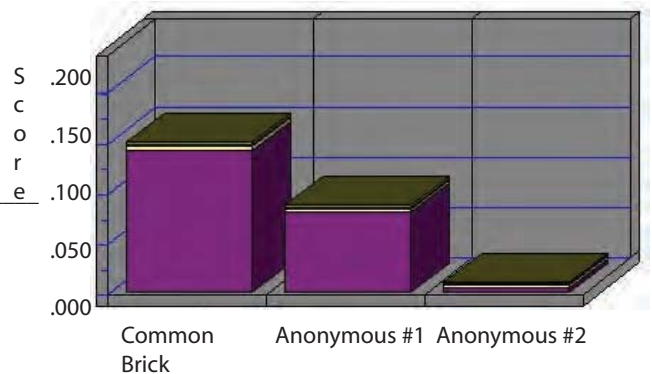
Global warming potential



All steps in the process show CO2 being put into the atmosphere. While anonymous brick 2 has been showing improvement in the environmental scoring, the energy required to produce these more environmentally friendly materials is still prevalent.

Human health seems to be the most prevalent factor when regarding the environmental performance of certain materials. Toxification in the means of processing and maintenance is equivalent in all three of the materials studied; however, the anonymous brick #2 looks to remove harmful materials from our landfills and places them in new construction melded inside the bricks and mortar that they use.

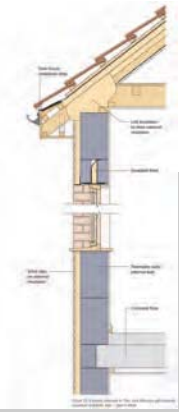
Environmental Performance







# Masonry - Properties and Benefits



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## Common properties of Masonry

-Masonry of all types (clay, cement, stone, etc.) all have the same process of construction and have many of the same attributes.

-Masonry requires bricks or stones to be stacked on top of each other with a binding medium known as mortar. Mortar is required to be clean and fine as it must fill in the tiny imperfections in the brick to create a solid insulating barrier. This allows for mixing in recycled materials such as pulverized concrete, glass, and other materials that are finely ground to be put into the mortar. This reduces the requirement of new material acquisition and also recycles materials that would otherwise be discarded.



-Masonry shows its greatest benefit as an insulator. Clay masonry can have R-values of up to R20 for just a 6 inch wall when traditional insulation is used along with it. Its tremendous heat capacity allows for warmth retention during summer days into colder nights and also acts as a barrier to cold weather protecting the insulation inside the brick wall allowing it to reduce heat loss significantly.



## Advantages

-Brick walls are fireproof and act as a passive fireproofing system to the structure.

-Bricks have high compressive strength and are able to support a heavy roof.

-Brick requires manual labor to be installed and recycled which cuts back on the environmental impact that would otherwise be done CO2 producing mechanical systems.

-Clay for brick can be found everywhere and allows for the reduction in travel distances per unit.

-In Colorado the abundance of river rock and stone can be utilized as an alternative to clay and cement brick construction.

-Brick requires very little maintenance over its lifetime. Only in cold weather climates must consideration be made for the expansion and contraction of moisture that may get into the porous brick and mortar.

-Brick does not off gas harmful elements into the air reducing interior comfort and overall health for the users.

-Reinforcing the brick is very easily done if needed with reinforcing rebar. If the brick stands alone without the rebar there is no loss due to the brick being overly strong for the application.

-Brick has an average life of over 100 years. If recycled properly it can be used for more than 200 years.



A mason reinforces the brick with vertical rebar to improve the wall's tensile strength.

Properties

Benefits

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# Masonry - Properties and Disadvantages



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## Properties

-Construction can be slow due to the fact that it must be done by hand and each laid unit is very small in most cases.

-Masonry has very poor tensile strength and in many it cases must be reinforced by rebar.

-Masonry is very heavy and adds tremendous weight to buildings.

-Special considerations must be made in earthquake prone areas and also to the foundations of buildings which plan to use brick as a main component in its construction.

Pre-construction: a reinforced foundation must be created to support a brick building



## Disadvantages

-Just as it is a benefit to the environment that masonry requires manual labor it is also a disadvantage as recycling requires that demolition be done in a very careful manner and the recoverable bricks must be hand cleaned of the mortar. This adds time and cost to any demolition team and the benefits of saving brick are hard to see when the environmental impact and other factors such as health are easy to overlook when money comes foremost most of the time.



The recyclability of brick is lost when the speed of demolition overrides the environmental impact and the recyclability of the material.

-Finding new acceptable mixes for brick takes time and few are interested in searching for these materials in landfills. Some popular options are cities' excess limestone and unrecycled glass. They are being used in some cases as mix ins with brick and mortar but not to the extent that we see a visible impact for the effort used to create these "new" materials.



Poor tensile strength is evident here. This brick would have benefited from reinforcing rebar, but now this wall must be demolished and rebuilt in order for it to be fixed.

Properties

Disadvantages

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# Masonry - Final Analysis

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## Green Masonry

Masonry as it stands has been around for thousands of years. Any sort of clay, stone, or mortar that can be created has been used in order to make highly insulated walls and sturdy structures throughout the centuries. For a process that has been the same for so long it is difficult to imagine changing it unless research, innovation, and motivation bring it to a new level. The motivation to be resourceful and green is present if not required by today's society. The innovation and research are slow to come by but there have been findings that have shown promise in making masonry a viable and prominent solution for sustainable building.

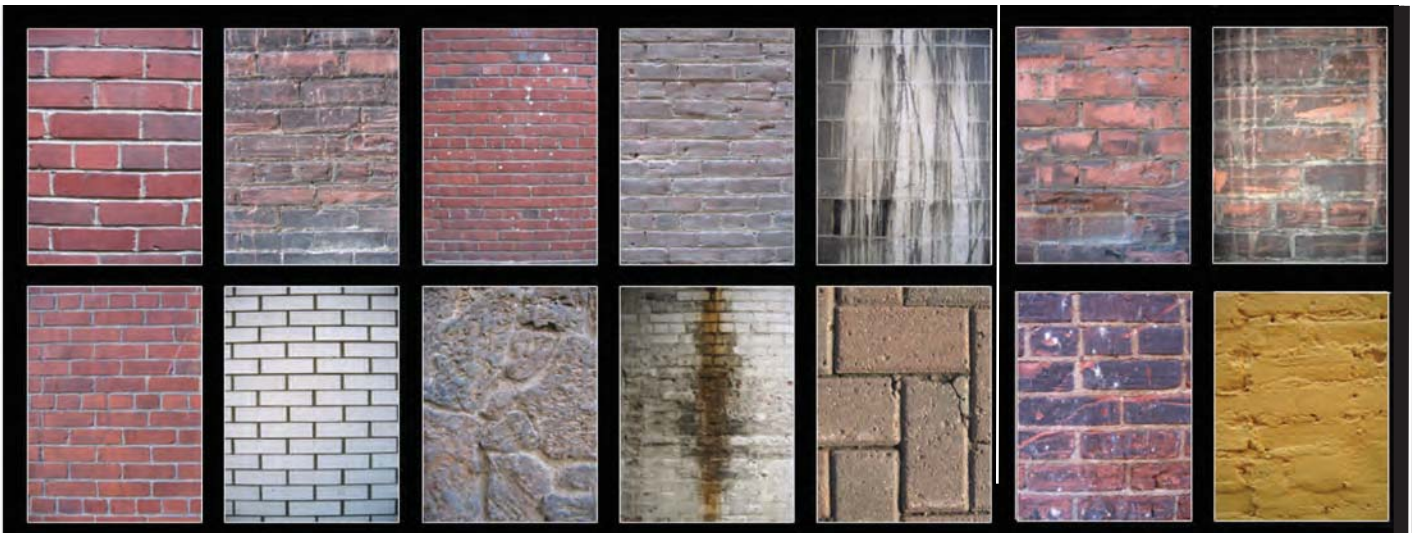
Communities are coming together and realizing that they have major problems in dealing with waste products. The most obvious and also the materials with the most research going into them are discarded limestone, glass, and fly ash from power plants and incinerators. These materials readily mix with current materials and in the process of doing so discoveries like that of adding fly ash in the right ratio adds tremendous strength show that there are many possibilities for brick and mortar construction. While the fundamentals of construction remain the same, the way

masonry can be a green material is only seen when all aspects of life cycle are taken into account. There is no one aspect of its extraction, manufacturing, transport, construction, recycleability etc that shows that it is the one aspect that needs to change. Masonry only becomes a more green material when all aspects of its full life cycle are taken into account and changed for the better. From reducing travel time by using local stone, recycling and reusing discarded elements in the manufacturing and construction process, and taking into consideration special design processes that take advantage of its long life span recycleability can masonry become a greener building material.

Masonry should be considered one of the foremost considerations in building green today. Under LEED certification it has the potential to claim up to 36 LEED points 10 alone in energy savings due to its insulative properties under the Energy and Atmosphere category and 11 points in the Materials and Resources category. Masonry needs to be considered as the main energy efficient and environmentally friendly materials in use today as we continue to search for sustainable materials.

Final analysis

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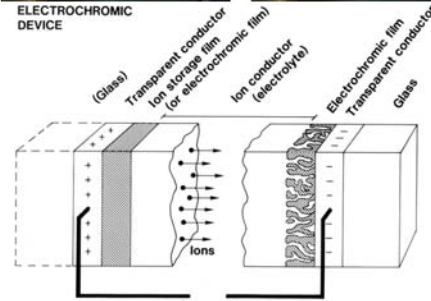
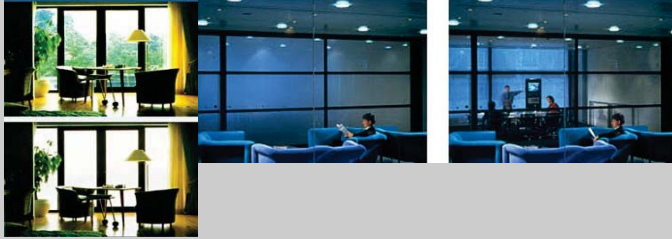
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Bibliography

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# Smart Windows



Basic design of an electrochromic device, indicating transport of positive ions under the action of an electric field.<sup>2</sup>

ELECTRO-CHROMIC DEVICES

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## Electrochromic Devices

Smart windows refer to electrically switchable glass or glazing which changes light transmission properties when voltage is applied. Different types of smart glass provide users the preference on the amount of heat and light passing through. The windows can change from transparent to translucent with the flip of a switch. Either the light can be, to some extent, blocked with a clear view of what lies behind the window or completely blocked providing complete seclusion.

Smart glass has a multiple array of applications including: electrochromic devices, suspended particle devices, and liquid crystal devices. The different uses of these windows can potentially save costs for heating, air-conditioning and lighting with the additional value of reducing cost on purchasing and installing screens and/or blinds. The advantage to buying smart windows can also reduce fabric fading.

Electrochromic devices have the capability of altering light transmission properties in response to voltage, enabling the feature of control over light and heat passing through the glass. Electrochromic windows can change between a translucent state, which is usually blue, to a transparent state. Electricity is needed for the switch between each state, but once in the changed state, there is no need for electricity to maintain that specific state. When changing from the transparent state into the translucent state, darkening begins on the edges, moving inwards, taking anywhere from seconds to minutes depending on the size of the window. Although the window darkens, visibility with the outside environment is still preserved.

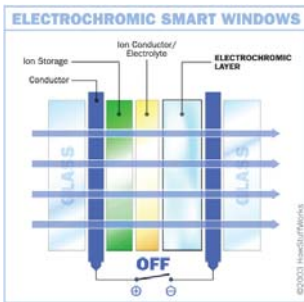
Electrochromic windows consist of up to seven layers of materials. The essential function of the device results from the transport of hydrogen or lithium ions from an ion storage layer and through an ion conducting layer, injecting them into an electrochromic layer.<sup>1</sup>

A small photovoltaic cell could be used to sense the amount of sunlight, darkening the window when the sun is brightest. This would be an appropriate application in a hot climate where solar heating is not desired. An alternate approach would be to only lighten the window when direct sunlight is available, but darken it for privacy at other times. This approach would be useful in areas where solar heating is desired. Either approach could feature an override switch for the convenience of the inhabitants.

In a building with ample solar heating, one could even conceive of using electrochromic windows as a thermostatic control, darkening or lightening the windows as needed to provide more or less solar heating to the living space.<sup>3</sup> In this case, the electrochromic window would be controlled by an electronic thermostat.

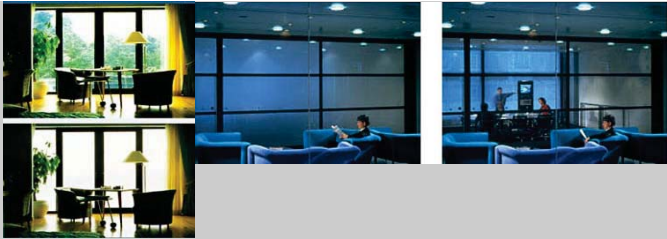
The National Institute of Standards and Technology believe that "smart" windows can reduce a commercial building's energy use by 30 to 40 percent. In the summer months, electrochromic windows can block ultraviolet rays and radiant heat from direct sunlight from passing through windows and skylights to help lower cooling loads. They can also help slow the fading of interior furnishings by blocking out the sun's ultraviolet rays. Electrochromic windows offer the flexibility of control not available in photochromic or thermochromic windows (windows that turn opaque when exposed to light or warm temperatures).<sup>4</sup>

A disadvantage is that the cost of electrochromic windows can be from 2 to 3 times that of a standard window. These costs of electrochromic glazing technologies, while currently high, continue to decline as the technology and manufacturing process matures.





# Smart Windows



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## Electrochromic Windows

The cost of electrochromic windows can be from 2 to 3 times that of a standard window. These costs of electrochromic glazing technologies, while currently high, continue to decline as the technology and manufacturing process matures.

The environmental benefits include the reduced use of energy and the reduced reliance on window coverings. The electricity used for switchable glazing is minimal compared with other energy savings. Low voltage products typically use less power than line voltage products and use virtually no power to maintain the glass in the clear state. PV-powered products do not require purchased electricity. No other operational costs are required for the lifetime of the product.<sup>5</sup>



Although the use of smart windows doesn't directly equate to the receiving of LEED credits, there are four such credits that can be earned if these windows are incorporated into a design in the correct fashion. The first of these credits is credit 1 in the category of Energy & Atmosphere. This is obtained because of the great energy savings possible with this unique product. The next three credits are within the category of Indoor Environmental Quality. Credit 7 – Thermal Comfort Design can be earned because of smart windows ability to stop solar heat gain without blocking the view. Credit 6.1 & 6.2 - Controllability of Systems could be given because smart windows are highly programmable and can be set up to operate individually or in zones. Finally credit 8.1 & 8.2 – Daylight and Views is possible because even in its darkest state, smart windows are still transparent and provide good views into the exterior environment.<sup>6</sup>

This technology has been seen in everything from all levels of building, to rearview mirrors in cars, to even picture frame glass in museums. The new Boeing 787 Dreamliner features electrochromic windows, which replace the pull down window shades on existing aircraft.



NREL's research goals align with the U.S. Department of Energy's goal to develop zero energy homes by 2020. Their objectives are to develop integrated energy efficiency and onsite renewable energy power solutions that can be successfully used on a large production scale to reduce whole-house energy use in new homes by 50% in 2015 and by 90% in 2025. With new technologies this is becoming a very bright light at the end of the tunnel.

Recent advances in electrochromic materials pertaining to transition-metal hydride electrochromics have led to the development of reflective hydrides, which become reflective rather than absorbing, and thus switch states between transparent and mirror-like.

ELECTRO-CHROMIC DEVICES

# Smart Windows



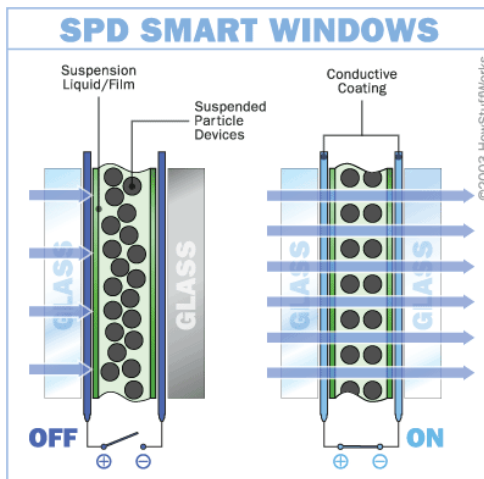
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## Suspended Particle Devices

Suspended particle devices (SPDs) have a thin film laminate of rod-like particles suspended in a fluid placed between two glass or plastic layers, or attached to one layer. The particles are dependent on voltage, so in the neutral state, they are arranged in random orientations and often absorb light, making the glass panels look dark.

Prior to recent advances the glass would appear blue, but now the glass can change to a grey or even black colour. SPDs are capable of being dimmed as well giving control of the amount of heat and light. In the case that voltage is applied the suspended particles align and allow light to pass. The downfall to SPDs are that keeping the window in its transparent state requires a small but constant electrical current.



Users apply a moderate amount of voltage to the conductive material on the window panes through a control device. Several control methods are offered with the SPD light-control windows, including remote and automatic devices. The windows can be controlled manually with a rheostat or remote. Or, photocells and other sensing devices could be used to control the level of light automatically.

Research Frontiers holds about 470 world-wide patents on this light-control technology and has several licensees, including corporate giants like Polaroid and GE. Suspended particle devices can be used for a multitude of other consumer products, including sunroofs, sun visors, rearview mirrors, ski goggles and flat-panel displays for computers.



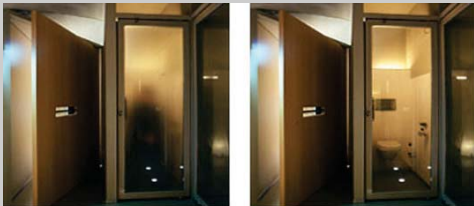
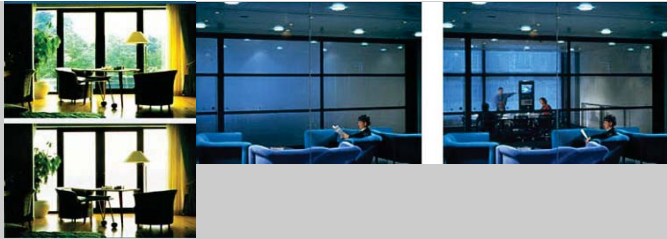
SPD-Smart film technology was awarded a "Best of What's New Award" from Popular Science magazine for home technology and was also recognized as one of the top tech technologies by the Society of Automotive Engineers' Aerospace Engineering magazine.<sup>7</sup>

Now, you may be thinking, "Well, this sounds great, but I don't want to have to replace all the windows in my home." You might not have to. Research Frontiers has a patent -- No. 6,429,961 entitled, "Methods for Retrofitting Windows with Switchable and Non-Switchable Window Enhancements" -- that will enable homeowners to upfit their existing windows with SPD technology. And, if you're wondering "How energy efficient can it be to have windows that you essentially have to turn on for a clear view outside?" Reportedly, you can power about 15 large SPD smart windows in your home for less electricity than it takes to operate a simple night-light.

SPD



# Smart Windows



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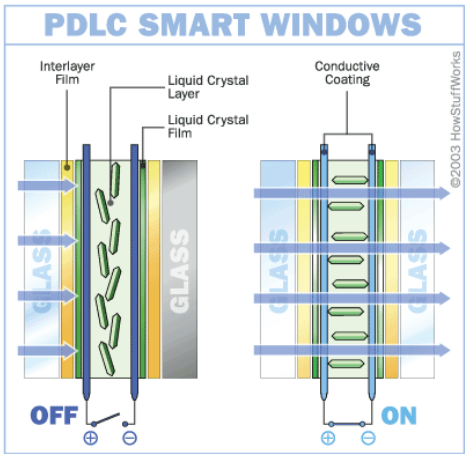
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## Polymer Dispersed Liquid Crystals

Liquid crystals are found in many of the products you use every day. Portable computers, calculators, digital clocks and watches, and microwave ovens all use liquid crystal displays (LCDs). In these displays, electricity is used to change the shape of the liquid crystals to allow light to pass through, thus forming figures and numbers on the display.



The technology behind an LCD is similar to the polymer dispersed liquid crystals (PDLCs) used in some smart-window applications. Polymer dispersed liquid crystal devices (PDLCs) contain liquid crystal droplets, which are arranged in a sheet between two layers of glass. In the "off" state, the crystals are randomly oriented. In the "on" state, they align according to the electric field.

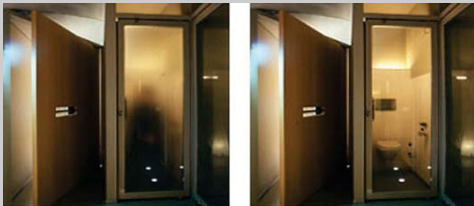
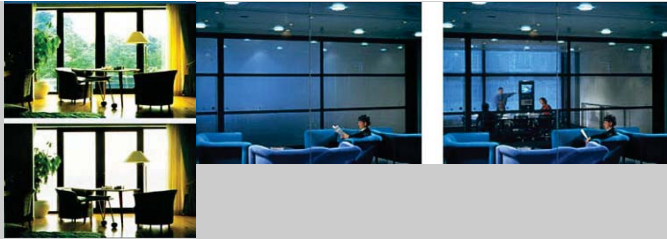


The unique quality that PDLCs offer is the ability of the liquid crystals to scatter light without blocking it. The glass always looks white, even in its transparent state. The only way to control the amount of heat and light in these windows is through special tints and inner layers are used. Liquid crystals, when they are in a thermotropic state, can also change light transmission properties in response to temperature. The dielectric properties of the lc and polymer, shape and size distribution of the lc droplets in the PDLC, while amplitude and frequency of the applied electric field are among the important parameters for optimizing the performance of such a device. Liquid crystal glazing can add in the upwards of about \$90 per square foot to the glazing. PDLC technology is great for homes and offices -- you get privacy without sacrificing all light.-8

The expression smart glass can be interpreted in a wider sense to include also glazings that change light transmission properties in response to an environmental signal such as light or temperature. All electrically switched smart windows can be made to automatically adapt their light transmission properties in response to temperature or brightness by integration with a thermometer or photosensor.

The topic of smart windows includes also self-cleaning glass and the automatic opening or closing of windows for ventilation purposes, for example according to a timer or in response to a rain sensor.

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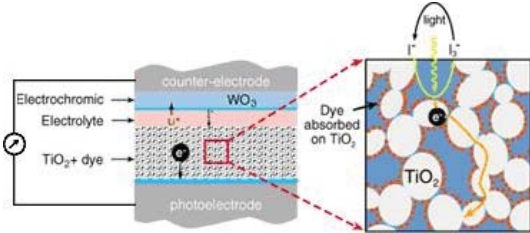
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## New Technology

Photoelectrochromic (PEC) devices use a dye-sensitized electrode to generate electrons, thereby creating the voltage necessary to drive lithium ions into the electrochromic layer and color it. The essential aspect of PEC devices is the use of a dye-impregnated layer of titanium dioxide. A low concentration of dye is used to maximize the transparency of the window. Between the titanium dioxide and the electrochromic layer is a layer of either lithium iodide solution or a solid polymer containing lithium iodide. This entire device is sandwiched between two layers of transparent conducting oxide material.



A photoelectrochromic device uses a dye-impregnated layer of titanium dioxide (TiO<sub>2</sub>) to generate electrons, which create the voltage necessary to color the electrochromic layer.<sup>9</sup>

When sunlight strikes this device, the dye absorbs some of the sunlight and releases electrons, which are injected into the titanium dioxide. The electrons are then conducted to the adjacent conducting oxide layer, and pass through an external circuit to the conducting layer adjacent to the electrochromic layer, on the other side of the device. This electron flow, in turn, causes iodide ions to migrate through the solution or solid polymer toward the titanium dioxide, and causes lithium ions to migrate into the electrochromic layer. As in a standard electrochromic device, the injection of lithium ions into the electrochromic layer causes it to color.

When sunlight stops hitting the device, the charge stored in the electrochromic layer drives the process in reverse, ejecting lithium ions from the electrochromic layer and causing it to bleach. Thus, with no external controls, the window will color in sunlight and bleach in its absence.

The external circuit can also be used as a control device: The disconnection of the circuit will cause the window to remain in its current state regardless of the presence or absence of sunlight. In addition, an external voltage can be applied to the device through this circuit to drive the device to either the bleached or colored state.

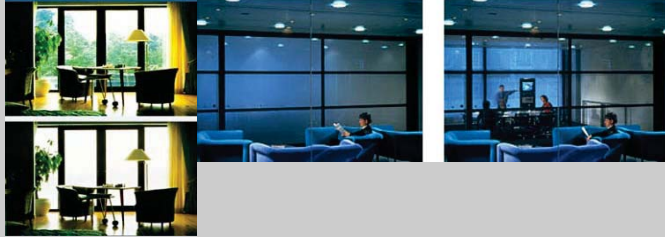
While taking advantage of not using energy in this window, one can save money on both overall electric bills for your home as well as what you would potentially spend with powering one of its precedents. Politically, there is talk about enforcing a carbon tax and possibly providing tax credits for people to use energy collecting technologies. This could be on the edge of that wave.



Photo-electrochromic Devices



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## New Technology

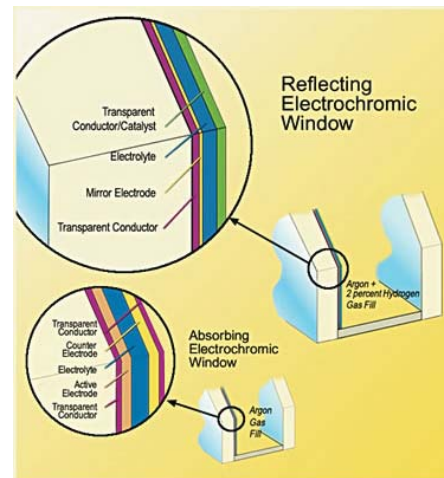
Transition-metal switchable mirrors are glass panels that are coated with thin films that can be converted from transparent to reflective and back again. This action is triggered by the application of an electric current as in normal electrochromic windows, or by exposure to dilute hydrogen gas, which is called gasochromic switching. The films that coat the glass consist of 40-nm-thick magnesium-titanium alloy, plus a 4-nm-thick layer of palladium.<sup>10</sup> The correct alloy mixture was essential to producing a transparent and energy efficient switchable glass.



Although switchable windows cost 2-3 times as much as conventional residential windows there are many benefits that can override the high initial cost. Applying switchable glass to a home, scientists estimate that reduced air conditioning needs could result in an energy savings of up to 30%.<sup>11</sup> Many types of switchable glasses have already been commercialized, but in comparison to switchable mirror glass these varieties have minimal advantages in energy efficiency.

One such example is electrochromic glass, which works by using electrical signals to change the color of the glass and absorb the sunlight. In this process the glass reaches high temperatures that in turn ends up re-radiating infrared radiation to the interior space. On the other hand switchable mirror glass doesn't absorb sunlight but rather reflects it. The greater dynamic range of transition-metal switchable mirrors, both in transmission — from 50 percent to 0.5 percent or lower, a factor of 100 — and in reflection — from 75 to 10 percent reflective — gives them considerable advantages in providing user comfort and energy savings.<sup>12</sup>

Other switchable windows use electricity to change the state of the glass, while in switchable mirror glass no electricity is needed. Only small amounts of hydrogen and oxygen are needed, which can be readily generated by the decomposition of water. The use of transition-metals instead of rare earth metals could significantly lower the cost of these windows. Transition-metal switchable mirrors are also easier to manufacture than electrochromic windows because they use fewer and thinner coatings.



Switchable Mirrors

# Smart Windows



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References



# Finishes Intro



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## FINISHES

Since our focus was on residential design, it was important for us to find sustainable products that would keep the air quality of a home healthy for those living in it, day in and day out. Therefore, we chose three products that could be used in several applications in the home from countertops, to walls, to floors, that would not off gas harmful chemicals into your home. Two of these products are low VOC, recycled composite boards that can be used for flooring, countertops, etc while the last product is a recycled vinyl surface finish used mainly for wall applications.

Some low VOC stains and finishes  
[www.inhabitat.com](http://www.inhabitat.com)



**Definitions:**  
**Low VOC** refers to the amount of 'Volatile Organic Compounds' that go into the making of the product, whether it be in the glue, binding material, or any other ingredient. Without VOCs, you will have better air quality contributed to this material and will not be exposed to many of the harmful toxins that can be found in traditional products, even those outside of the home improvement category.

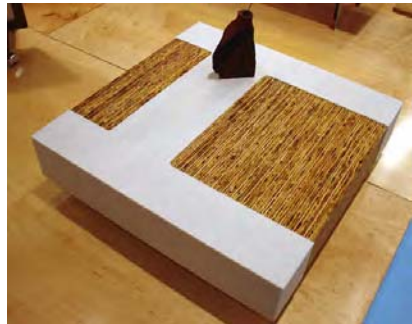
**Composite boards** are traditionally made up of a base material, in our case plant matter or paper, while also using an adhesive or other binding material to solidify the compound. In our studies we found products that were made out of recycled material for the base, and low VOC, 0 formaldehyde bond and adhesive.

Composite boards are usually very strong, durable and long lasting. They work well for counter tops, some wall finishes, flooring, and furniture, depending on their properties.

A **vinyl surface finish** is a thin layer of textured or colored vinyl that can be applied to flooring, walls, or furniture with low VOC adhesive.

### WHAT WE CHOSE:

#### Kirei Board



#### PaperStone



#### Lonseal



FINISHES  
 INTRO AND  
 DEFINITIONS

group 2

# What is Kirei?



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## KIREI BOARD BASICS

*Kirei = Japanese for 'clean' and 'beautiful'*

Kirei Board is a new form of sustainable composite board, which is very similar to bamboo products today, such as Plyboo. As a durable finish product, it can be used for many applications such as countertops, furnishings, flooring, wall coverings, etc. It can be a great choice for an environmentally friendly material in any home.

### PROPERTIES

Kirei Board is a lightweight composite board which is made from the Chinese Sorghum plant giving it characteristics that are very similar to bamboo boards. It is made by combining the stalks of the Sorghum plant, KR Bond as a low VOC adhesive, and very small amounts of wood for binding. This product can be a substitute for many surfaces that would normally use wood, but should be compared to a soft pine or cork in terms of durability and hardness. With a wide variety of finishing options available, Kirei Board is usually very easy to maintain.

Item #	Thickness	Dimensions	Sheet Weight
KB 3610	10mm	36"x72"	19.4 lbs.
KB 3620	20mm	36"x72"	35.1 lbs.
KB 3630	30mm	36"x72"	43.2 lbs.

### Physical Properties

Modulus of Rupture 1800mm 900mm  
 Modulus of Elasticity 1800mm 900mm  
 Internal Bond 1.5 kg/cm<sup>2</sup>  
 Screw Holding Power Face 25 Kg Edge 10 Kg  
 Flame Spreading 3.025 inch/second (UL-HBF)  
 kireiusa.com

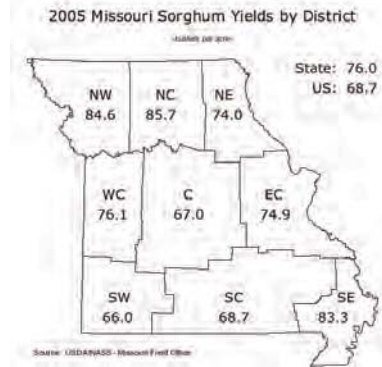
## The Sorghum Plant

The Sorghum plant is considered the 'camel among crops' for its ability to store water and grow through times of drought and intense heat. Currently, it is grown in Northern China and harvested for food. Normally, the waste from this product (the stalks) would be discarded; now this product is taken out of the waste cycle and compressed to make the Kirei product.

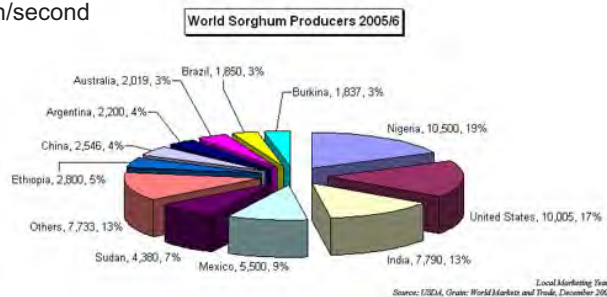
Another huge plus to the Sorghum plant is that it grows here in the US and is even considered 'invasive' in Nevada and Texas. If only we could produce Kirei Board here!!

Kirei Intro

group 2



A. Grain Head B. Leaves C. Stalk  
 D. Flower E. Roots F. Seed  
[www.gramene.org](http://www.gramene.org)



# Kirei Health and Benefits



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## HEALTH

This product is great to use as an indoor finish because it does not contribute to unhealthy indoor air quality. For instance, the KR Bond adhesive that binds the sorghum together is a newer product which does not emit VOCs (Volatile Organic Compounds), and uses such a low amount of formaldehyde that it is nearly undetectable, unlike many traditional adhesives still used today. The Kirei Board can also be finished with water based products rather than highly toxic ones.

"Kirei board is manufactured using KR Bond, a water-based polymer-isocyanate adhesive. Formaldehyde-free KR Bond does not contribute harmful Volatile Organic Compounds (VOCs) to the indoor atmosphere. Testing according to Japanese Government standard JIS A 6922-2003 resulted in 0.0 mg/L formaldehyde emission" KireiUSA.com

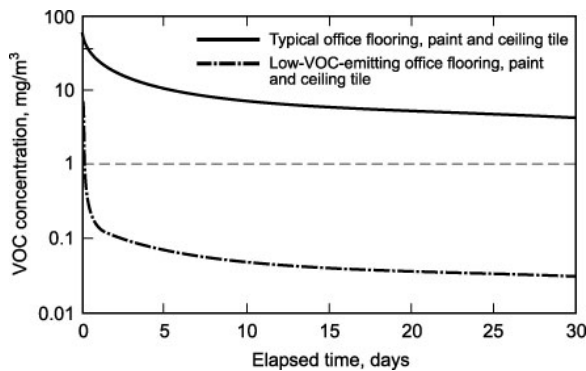
## BENEFITS

There are many benefits to using this product as is AND in the upcoming future:

- Reclaims a former waste product, resulting in an additional source of profit for agricultural regions.
- High aesthetic value
- Durable
- Easy to work with
- Opportunity to grow the sorghum plant in the US to cut back significantly on fuel costs and harmful emissions during transportation.
- Could support local economy with new agriculture in the US
- Organo pays the current employees in China "above average wages" and they "work in good conditions"
- Does not contribute to toxins within the home from off-gasing
- Low VOC, 0 formaldehyde bond

KIREI  
HEALTH AND  
BENEFITS

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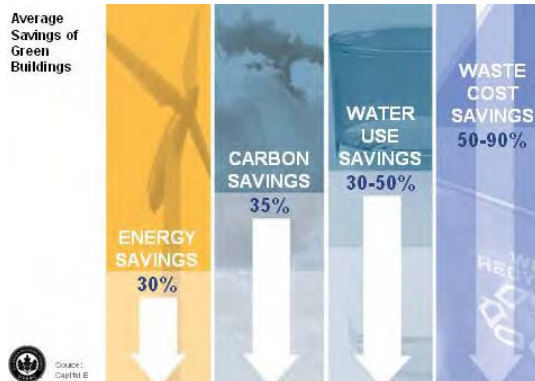
## LEED Credits:

Materials and Resources – Credit 4 – Recycled Content

Indoor Environmental Quality – Credit 4.1 Low-emitting adhesives and sealants

Materials and Resources – Credit 6 – Rapidly Renewable Resources

Supporting documentation for LEED certification is available upon request





# Kirei Cost and Maintenance



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## COST

Kirei will cost you more than the typical countertop or flooring product, unfortunately. The payback, however, is in the investment of a sustainable, attractive product made by a company that really tries to lessen its impact on the environment.

EXAMPLE: 3' x 6' = \$416.00 (on sale)

## MAINTENANCE

Kirei Board is worked using standard fabricating techniques applicable for wood-based products.

### Cutting:

Prefinishing material with a sealer coat can help avoid chipping along saw cuts. For best results use a high-quality saw blade, feeding the material at a uniform speed through the saw. Solidly back panels to prevent chipping along kerf on the saw tooth exit side.

### Drilling:

A high-speed drill is recommended. To avoid chipout or breakage on the exit side, back the panel with scrap material.

### Routing:

A speed of 20,000 RPM is recommended using double-fluted router bits.

### Filling:

Standard wood putty can be used to fill any chips or holes caused by cutting and sanding. Select a color that best matches the color of Kirei Board or your finish color.

### Fastening:

All fastening methods may be used, including nail, staples, rivets, screws, bolts, glue or combination. Type A or AB, sheet metal, twin fast types and fully threaded screws designed for use in particle board offer better withdrawal resistance than wood screws. Pre-drilled pilot holes are recommended for the size screw used. If nailing, use spiral or ring shank nails for extra holding power.

(Note: Nailing or screwing into edge grain may result in lower screw holding power due to fewer cross-layers being engaged.)

### Finishing:

Kirei Board panels can be filled, sealed, painted, stained or varnished with most commercial finishing materials including short and medium oil length primers, fillers, lacquers, and synthetic base coats and topcoats and high temperature bake and acrylic and epoxy systems. The panels should be at stable room temperature (70 degrees F and higher) when coated. Kirei recommends Low-VOC emission finishes.

### Edge Treatment:

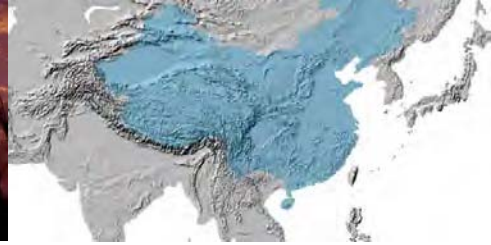
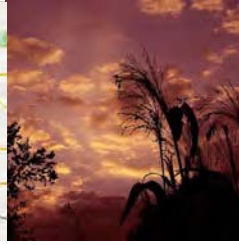
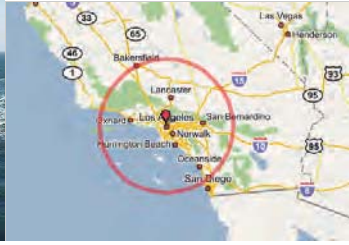
The exposed edges of Kirei Board are intended to be finished, unless the type of application does not require a more finished appearance than sanding affords. If shaped exposed edges are required, filling, sanding and painting of the edge will provide a satisfactory finish. Kirei Board can be edge banded with most commercial edge treatments using standard adhesives



KIREI COST AND CARE

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# Kirei Lifecycle/Embodied Energy



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## LIFECYCLE AND EMBODIED ENERGY

Fortunately, the company that manufactures Kirei Board, Organo, is trying to take the extra step in cutting transportation costs by placing their factory directly on the site of the Sorghum plants in Northern China, however, this still results in high transportation costs to the United States, where much of their product is sold and distributed. Hopefully we will soon be able to move this production to the states because sorghum grows throughout the US. This would obviously help to cut the pollution emitted from transportation, although at the higher cost of more expensive labor, so like many things it is a give and take.

Other items considered in the lifecycle and embodied energy of this product are the materials and energy (and human labor) required for cutting, binding and heat pressing the product. Cutting and binding use traditional methods, but heat pressing probably takes more energy.



Irrigation of grain sorghum.

## DISADVANTAGES

Fortunately, there are fewer disadvantages to using this product than advantages, but here they are:

- As of now, there are very high transportation costs and added pollution during shipping from China.
- Some cyanide in KR Bond
- Still uses small amounts of virgin wood

## RETAILERS

Colorado  
The Balentine Collection  
970-925-4440 Aspen

Blue River Hardwood Company, LLC  
303-307-8555  
sschmidt@blueriverhardwood.com

Denver  
Eco Products  
303-449-1876  
www.ecoproducts.com  
customerservice@ecoproducts.com

Boulder  
Eco Products  
970-547-0147

Breckenridge  
The Environmental Home  
303.731.3600

Castle Rock  
Green on Earth Design LLC  
505 920 3213  
www.greenonearth.com Denver

GreenSpot, Inc.  
970.963.4206  
www.greenspot.com Carbondale

Kirei Lifecycle  
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# PaperStone Introduction and Properties



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## PaperStone Introduction

PaperStone is a unique composite material with a soft and smooth appearance much like soapstone. Made from recycled paper cashew nut oils and water-based resins, PaperStone is non-toxic, stain resistant, repairable and has extreme heat resistance. Because it is so dense it is impervious to moisture and therefore will not support bacteria growth. This makes it easy to clean and very practical for kitchen countertops, vanity tops as well as desks, shelving and window ledges. It is also being used for tables, wall cladding, bathroom toilet partitions, exterior siding, rainscreens, structural applications, landscape components, window sills, door thresholds, paneling, chair rails, furniture, and signs. PaperStone has a warm matte patina that is mottled with subtle color variations. The manufacturer, Kliptech, has created a natural finish made from vegetable oils and waxes that can be applied to the surface creating a very silky feel. While PaperStone is stain-resistant and can withstand harsh chemicals from most household cleaners and food, they are not stain-proof. Homeowners and carpenters love this product because they can save money by fabricating and installing this product themselves. The finished product works easily with a triple chip carbide tipped saw blade and carbide tipped router bits. What sets PaperStone apart is the company's highly-skilled and creative technical staff, the company's own resin laboratory, resin plant and commitment to the cleanest and 'greenest' products and processes that are technically and economically possible. PaperStone resins have also been specially designed to produce a hardwood-like, highly workable and not brittle composite panel.



## Properties

PaperStone Certified is made of 100% FSC-Certified recycled paper, water-based phenolic resin with cashew nut shell binder and pigment. Heat and pressure transform this mixture into a thoroughly impregnated network of cellulose fibers that give PaperStone its hardness, density and strength in span or cantilevered designs. PaperStone is made in America and is widely available. It is a naturally warm looking product that fits well with most designs and is very durable and resists slice marks. It is also water and bacteria resistant. It is stain and heat resistant to 350 degrees and is Class A fire rated. PaperStone is completely non-toxic with no detectable formaldehyde. Unlimited in edge detail and easily repairable. It is made with 50% post consumer recycled paper content and is also available as a FSC Certified with 100% post-consumer recycled paper. It comes in 30" and 60" widths in lengths of 8', 10' and 12' with thicknesses of 1/4" - 2" and also has a variety of colors. PaperStone also receives five LEED credits for using recycled content, local regional materials, rapidly renewable materials, certified wood materials, and low emitting materials. Innovation and Design Process is also an area in which PaperStone may qualify for a LEED point.



INTRO

PROPERTIES

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Cashew-nuts and pods

PaperStone™  
The Earth's Surface™





# PaperStone Cost and Maintenance



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## Cost

PaperStone is sold as two different types, Original PaperStone and FSC Certified. Prices also vary by thickness and size.

Type I---Paperstone FSC Certified  
Obsidian, Indigo, Grass, Chocolate, Straw, Concrete Grey, Plum  
Contains 100% post-consumer recycled paper

Thickness	30" x 72"	30" x 144"
3/4"	\$638.40	\$1050
1"	\$781.20	\$1,348.20
1 1/4"	\$932.40	\$1,629.60

Type II--Paperstone Original  
Leather, Mocha, Denim, Evergreen, Cabernet  
Contains minimum 50% post-consumer recycled paper

Thickness	30" x 72"	30" x 144"
3/4"	\$562.80	\$919.80
1"	\$688.80	\$1,180.20
1 1/4"	\$819	\$1,423.80

	60" x 72"	60" x 144"
3/4"	\$919.80	\$1,709.40
1"	\$1,180.20	\$2,221.80
1 1/4"	\$1,423.80	\$2,271.60

## Maintenance

General cleaning of PaperStone consists of wiping down surface with hot soapy water or a mild abrasive kitchen cleaner.

Use hot pads or trivets under hot pots and pans.

Always use a cutting board.

Never use chemicals to clean or refinish PaperStone products.

Scratches and Refinishing: To remove stains and light scratches, use a maroon or green Scotch Brite pad with light buffing. If harsh scratches or burn marks accrue, we recommend the use of a maroon Scotch Brite or 220 grit or above sand paper on a random orbital sander to remove. Excessive sanding in the same area may result in light spots, refinishing of the whole area may be needed to keep a consistent look across the entire surface.

Surface Treatment: It is recommended for treating countertops to treat a with the PaperStone finish. After buffing the surface with the Scotch Brite pad wipe down surface with damp cloth to remove all particles. Apply a thin coat of the PaperStone finish to the portion of countertop you are treating, Spread with bare hands over the entire surface. Let finish set for a minimum of 20 minutes and wipe off excess. Finish using a clean, soft cloth to give an even, rich luster. For best results, do not use finished area for at least 12 hours so the finish can harden. Then wipe down with a soft cloth and buff until desired look is achieved. For ongoing maintenance, the use of the PaperStone Cleaner and Rejuvenator can be applied as often as the desired look is achieved.



## COST

## MAINTENANCE

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# PaperStone Recycling, Embodied Energy, and Fabrication



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## Recycling

Original PaperStone is made out of with 50% post consumer recycled paper content and FSC certified PaperStone is made out of 100% post consumer recycled paper content. KlipTech currently has a proprietary paper made for them by the Grays Harbor Paper Company that is made from 100% post consumer recycled wood fiber that is FSC (Forest Stewardship Council) certified by Smartwood in a factory that used 100% Green-e energy. PaperStone receives LEED credits for using recycled content. This contributes to Credits 4.1 & 4.2 of the "Materials & Resources" area.

## Embodied Energy

A 1" by 5' by 12' sheet of PaperStone Certified (versus a regular phenolic composite manufactured from virgin fiber and a regular, commercially available, solvent-based resin) saves:

- 1233 gallons of water
- 2.03 million BTU's of energy
- 131 pounds of solid waste
- 254 pounds of greenhouse gases
- 55 pounds of petroleum-based phenol
- 22 pounds of natural gas-based methanol

Regular PaperStone, with a 50% post-consumer recycled content product (versus 100% for PaperStone Certified), saves a similar amount of phenol and methanol but only 50% of the water, energy, solid waste and greenhouse gases listed above.

In either case, purchases of PaperStone products, versus the competitive products, have a surprisingly large impact on our environment.

## Fabrication

### FABRICATION METHODS

**Cutting Methods:** PaperStone works much like hardwood and solid surface. It is recommended to always wear eye protection and a mask when cutting. Like wood, PaperStone should be cut dry. Slow the blade speed or increase the feed rate if you detect excess heat. Fully support PaperStone before you begin cutting since the

blade could bind when the slab shifts as the cut proceeds. It is recommended using a triple chip carbide tipped saw blade if possible and carbide tipped router bits. **Seaming and Bonding:** Seams in PaperStone may show and should be incorporated into the design. Because seams show, built-up edges are not recommended. Plan seams so that they are not next to sinks. Standard biscuit joinery along with a slow drying, two-part epoxy works well to join countertop sections together.

Tint the epoxy by mixing dust from the countertop. Once the joint has cured, lightly sand it to blend the seam with the surrounding area. It is also possible to seal joints with standard caulking sealant. You can also seam using a 'superglue' type product like, CA-5 from 3M. With CA-5 you can attach two clean edges with a butt joint and clamp it, this will give a very strong and tight joint but is not one that can be tinted.

**Sanding and Finishing:** PaperStone may have small imperfections such as low and high areas. It is recommended that sanding and finishing be kept to a minimum. PaperStone is bonded sheets of paper and excessive sanding could put you through the top layer. We have found that a satin sheen provides the most beauty and least day to day care. To achieve, sand using a random orbit sander until an even sheen is achieved across the entire surface. Sanding should start with an abrasive no coarser than 150 grit and finish sand with 220 grit. You can use a maroon Scotchbrite pad on a vibration sander for an excellent finish treatment. Wipe surface clean with a damp cloth to remove dust and loose particles. PaperStone doesn't need to be finished or sealed because of its very low porosity, but most people like the consistent look of a finish. Most oil products work by applying them liberally across the panel and letting them sit for 15 minutes. After 15 minutes wipe all excess finish off with a cotton cloth. You can re-apply finish as needed.

**Holes & Screws:** Wood screws work well, but drilling pilot holes is absolutely necessary. PaperStone can also be tapped to accommodate threaded fasteners or threaded inserts.

RECYCLING

EMBODIED ENERGY

FABRICATION

group 2





# PaperStone Benefits, Health, and Technical Specifications



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- recycling
- embodied energy
- health**
- benefits**
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## Benefits

PaperStone is made from recycled paper content and environmentally friendly resins and oils, is non-toxic, stain resistant, repairable, durable, has extreme heat resistance, is impervious to moisture and therefore will not support bacteria growth, it is easy to fabricate and install, easy to clean, and comes in a variety of colors. PaperStone also has endless edging possibilities.

KlipTech Composites a division of Paneltech International, LLC warrants that its PaperStone product line will be free from any manufacture defects for a period of tens years from the time of purchase. KlipTech manufactures their own resin systems that are water based and petroleum free not because it is easy or cheap but because it is the right thing to do socially and environmentally. They are currently working on a new 100% bamboo fiber paper composite; this fiber is a rapidly renewable fiber that will give their customers yet another alternative in environmentally friendly products. They have spent and continue to spend millions of dollars on research and development of new cutting eco resins that are more durable and use ingredients that are organic, while removing material from the waste stream. PaperStone can also receive up to five LEED credit points for recycled content (credits 4.1 and 4.2 of the materials and resources area, 5% = 1 point, 10% = 2 points), local regional materials (credit 5.1 of the materials and resources area), rapidly renewable materials (credit 6.0 of the materials and resources area), certified wood materials (credit 7.0 of the materials and resources area), and low emitting materials (credit 4.1 and 4.4 of indoor environmental quality area).

## Health

PaperStone is completely non-toxic with no detectable formaldehyde or VOCs are emitted and because it is so dense it is impervious to moisture and therefore will not support bacteria growth. It is also warm to the touch and doesn't burn easily or off gas.

## Technical Specifications

### PaperStone Specifications

Water absorption: (by weight)0.82%

Density: (g/cm<sup>3</sup>)1.4-1.45%

Internal bond (psi)1,225 lbs.

Modulus of rupture (flexibility):

Face

X direction24,320 psi

Y direction24,080 psi

Edge

X direction21,834 psi

Y direction21,413 psi

Modulus of Elasticity:

X direction1724.25 ksi

Y direction1666.58 ksi

Compressive strength:

Z direction (face)45,324 psi

X direction23,200 psi

Y direction22,560 psi

Coefficient of Thermal Expansion:

Z direction2.62

X direction3.64

Y direction3.48

Izod impact strength:

Face

X direction (ft/lb/inch-width)3.29

Y direction (ft/lb/inch-width)2.76

Edge

X direction (ft/lb/inch-width).73

Y direction (ft/lb/inch-width).75

Hardness test:

Barcole meter (Barber Coleman)47 avg.

UV exposure: Slight darkening for light colors, dark colors are stable

Formaldehyde: No detected residues

(less than 1 part per million)

ASTM E84 Fire Test Results

Flamespread Index:(20) Class A Rating

Smoke Developed Index:(110) Class A

Rating



## BENEFITS

### HEALTH

### TECHNICAL SPECS.

group 2





# Introduction and Reclamation



Check List

introduction

reclamation of vinyl

embodied energy

threat to environment of disposal

sources

lifecycle assessment

maintenance

Standards

Cost

## Introduction

Lonseal is a manufacturer of resilient flooring and vertical products. Lonseal's designers are working to advance the market of sustainable, high performance vinyl products. Lonseal continues to push the envelope of vinyl convention, leading the vinyl surfacing industry in new directions through technological, visual, and textured innovations. These enduring technological advances show forth the positive reputation that Lonseal is trying to build upon. Advancing the properties of materials, encompassing new vinyl products. Lonseal is striving to make an environmental statement, developing eco-friendly and sustainable product attributes. Furthermore, appending glamour and charisma to Lonseal products, through the addition of color and texture.

## Reclamation of Vinyl



In the past, the vinyl industry has made major strides in the manufacturing of green products. Despite these advances, misleading misconceptions about vinyl products being "bad for the environment" have muted the voice of moving towards becoming "green".

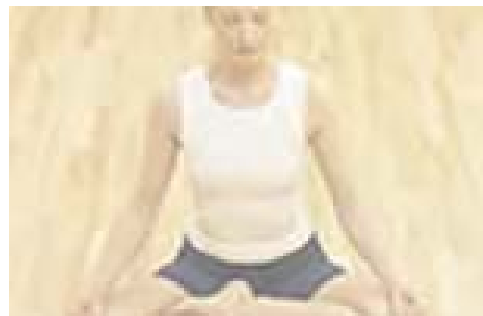
Setting the record straight on the misconceptions on production, installation, and disposal of vinyl products, is done by simply revisiting the new data of vinyl products and replacing it for the old.

The first misconception starts at the beginning stages, production process. In the past, the production of vinyl was essentially bad for people and the environment. This is presumed because of the delusion of carcinogenic gas called vinyl chloride monomer (VCM). Though, VCM is a carcinogen and a byproduct of vinyl production. Presently, critics neglect that harmful levels of toxins are not emitted into the environment by vinyl production. Due to changes in vinyl production, VCM gas is no longer a significant danger to vinyl plant workers or the environment.

In the past the installation process used to pose a threat of containing and emitting VCM and other carcinogenic chemicals, particularly dioxin and phthalates. During vinyl production, VCM gas is chemically transformed into a solid with completely different chemical properties called polyvinyl chloride (PVC). "Substantially stable and non-carcinogenic, saying that PVC is dangerous because the carcinogen VCM was used to make it is like saying that water is dangerous because unstable hydrogen was part of its formation.

After the vinyl is installed, it is presumed that carcinogenic chemicals, dioxin and phthalates, are emitted. PVC does not emit dioxin unless it is burned at low temperatures or heated to near-combustion temperatures. During a building fire, many, if not most, materials used in buildings emit dioxin and other toxins under such conditions.

Though, "plasticizers that include phthalates are added to many forms of vinyl to increase pliability. Over long periods of time, these plasticizers do indeed migrate out of the vinyl. Though there is an emittance, it is not substantial enough to harm humans. A case study shows in order to duplicated the carcinogenic effect in humans that researchers produced in rats, a person would have to ingest 500 grams of plasticizer over 100 days; an impossible feat under normal conditions with any room's vinyl. Both U.S. consumer products commission and national institute of health studies show that vinyl's plasticizers do not pose significant health risks. The result of installation is not harmful to the indoor environment.



Introduction and Reclamation

group 2



# Embodied Energy and Threat to Environment



## Check List

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reclamation of vinyl

**embodied energy**

**threat to environment of disposal**

**sources**

lifecycle assessment

maintenance

Standards

Cost

## Embodied Energy

In comparison with other products, such as linoleum, vinyl has the competitive edge. Lonseal vinyl was found to emit 1/10th the VOC emissions of linoleum and 1/2 the VOC emissions of rubber. The LonEco series averages 50% recycled materials content from post-industrial recycled vinyl and wood powder. Giving LonEco LEED credits under green building standards MR4.1 and MR4.2, indoor environment quality credit 4.1 for low emitting adhesives. With other compliances with California IAQ requirement section 01350.

Low VOC's are upheld by the green air collection, reformulating products that reduce VOC emissions by 80-90%, which are certified by the greenguard environmental institute.

## Threat to Environment of Disposal

After the life of the vinyl is reached, does the disposal of the vinyl pose a threat to the environment? The result of disposing vinyl, under normal conditions, into a waste facility does not pose a threat to the environment. Furthermore, some waste management facilities even line their landfills with vinyl to prevent their refuse from contaminating the local ecosystem and groundwater.

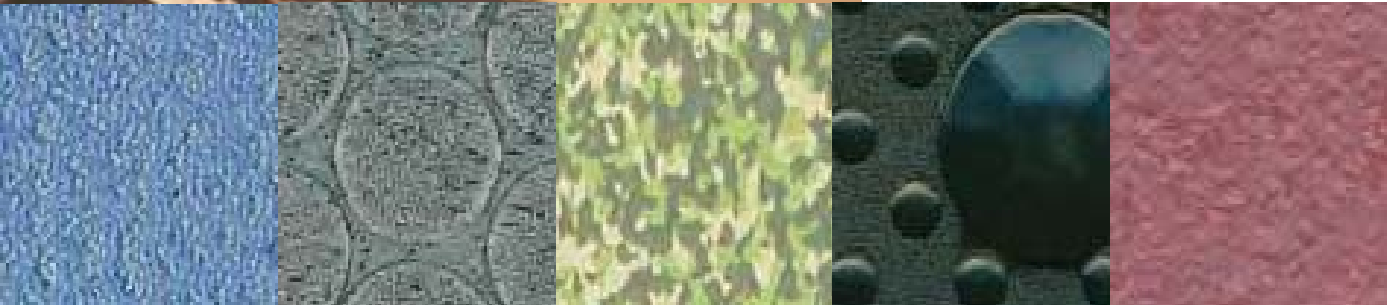
In conjunction to, leaching of microbial action on chlorinated solvents, found in some household cleaners, have been found in the ecosystem in proximity to waste facilities.

## Sources

<http://www.greenbuildingsupply.com/>  
<http://www.hardwoodhome.com/BuyKirei.htm>  
<http://www.kireiusa.com/>  
<http://www.millerstore.com/product.aspx?intprodid=3343&pid=485&cid=682>  
<http://www.paperstoneproducts.com/>  
 Clark (2007) Materials: Kirei Board Design, Build, Live Newsletter 1(14):2.  
 NM & NP (2006) Product News and Reviews Environmental Building News 15(4):1-2.  
<http://www.lonseal.com/>

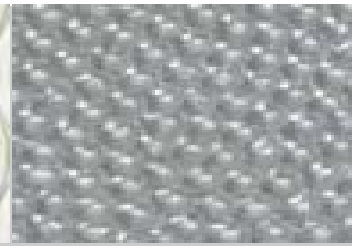
Embodied Energy and Threat to Environment

group 2





# Lifecycle Assessment and Cost



## Check List

- introduction
- reclamation of vinyl embodied energy
- threat to environment of disposal
- sources

## lifecycle assessment

## maintenance

## Standards

## Cost

## Lifecycle Assessment

The Lifecycle assessment shows reduced environmental impact and microbial resistance technology through; UV technology, extending lifecycle cost with dry-erase finish, dedicated vinyl products recycling plant, and greenguard for microbial resistance.

## Maintenance

To maintain the Lonseal product, remove surface contaminants, apply suitable floor polish, maintain by frequent sweeping and dust mopping. Mop with neutral cleaner. Lonseal recommends maintenance products by TASKI and 3M.

## Standard Specifics

### Standard sizes:

- Nominal thickness: .080"
- Co-calendared wear layer: .020"
- Middle and backing layers: .060"

### Roll Size:

- 72" wide x 60' long

### Weight:

- 0.7 lb/sq.ft., 250 lb./roll

### Colors:

- Seventeen available

## Lifecycle Assessment and Cost

## group 2



LONSEAL									
www.lonseal.com (310) 830-7111 (310) 830-9986 FAX		[800] 832-7111 TRADE PRICE LIST February 2007				928 E 238th Street Carson CA 90745			
Product	Surface/Patterns E = Embossed S = Smooth	Roll Per SY (40 SY +/-)	Roll Per Cut SY (< 40 SY)	Full Roll Price	Colors	Weight	Roll Size	Thickness	Full Material
Lonbead	E-Bead	\$34.40	\$38.70	\$1,378.00	10	300lbs	6' x 60'	100 MI	
Loncoin I	E-Coin	\$23.94	\$26.94	\$957.60	3	300lbs	6' x 60'	100 MI	
Loncoin II	E-Coin	\$30.34	\$34.14	\$1,213.50	5	300lbs	6' x 60'	100 MI	
Loncoin II Flecks	E-Coin, Flecks	\$30.34	\$34.14	\$1,213.50	7	300lbs	6' x 60'	100 MI	
Loncourt I	S-Plain (Solid Colors)	\$42.97	\$46.34	\$1,432.19	4	500lbs	6' x 50'	187.5 MI	
Loncourt I	S-Wood Grain & Marbelized	\$46.17	\$51.94	\$1,538.85	2	500lbs	6' x 50'	187.5 MI	
Loncourt UV	S-Wood Grain	\$51.89	\$58.37	\$1,729.49	1	500lbs	6' x 50'	187.5 MI	
Loncourt II	S-Marbelized	\$23.63	\$26.81	\$953.20	1	300lbs	6' x 60'	100 MI	
Londeck	E-Texture	\$20.57	\$23.14	\$822.80	8	245lbs	6' x 60'	80 MI	
Londeck Sierra	E-Slucos	\$20.57	\$23.14	\$822.80	8	245lbs	6' x 60'	80 MI	
Lonlite	E-Reggie Texture	\$35.66	\$40.11	\$1,426.40	10	300lbs	6' x 60'	100 MI	
Lonlot	E-Rivet Dots	\$34.97	\$38.34	\$1,388.80	4	280lbs	6' x 60'	100 MI	
Londura	Texture (Multi-Color)	\$60.57	\$66.14	\$2,422.80	8	300lbs	6' x 60'	80 MI	
LonEco	S-Plain, Wood Fibers	\$28.51	\$32.09	\$1,160.40	12	240lbs	6' x 60'	80 MI	
LonEco Mesa	E-Knobs, Wood Fibers	\$35.20	\$39.60	\$1,408.00	8	295lbs	6' x 60'	100 MI	
Lonfloor Plain	S-Plain	\$19.71	\$22.18	\$788.40	6	295lbs	6' x 60'	100 MI	
Lonfloor Flecks	S-Flecks	\$19.89	\$22.37	\$785.60	8	245lbs	6' x 60'	80 MI	
Lonfloor Galvanized	S-Galvanized	\$25.26	\$28.41	\$1,010.40	8	245lbs	6' x 60'	80 MI	
Lonfloor Galvanized UV	S-Galvanized	\$31.71	\$35.68	\$1,265.40	TBD	245lbs	6' x 60'	80 MI	
Lonfloor Vista	Texture (Solid Colors)	\$23.03	\$25.91	\$921.20	12	300lbs	6' x 60'	80 MI	
Lonfoam	S-Flecks, Foamed	\$29.09	\$32.72	\$1,163.80	4	255lbs	6' x 60'	120 MI	
Lonmetro UV	Texture (Solid Colors)	\$28.23	\$31.76	\$1,129.20	8	245lbs	6' x 60'	80 MI	
LonNova UV	S-Galvanized	\$32.00	\$36.00	\$1,280.00	12	245lbs	6' x 60'	80 MI	
Lonpearl	E-Pearl Dots	\$29.89	\$33.62	\$1,195.60	7	300lbs	6' x 60'	100 MI	
Lonplate I	E-Diamond Plate	\$37.43	\$42.11	\$1,497.20	9	300lbs	6' x 60'	100 MI	
Lonplate II	E-Smaller Diamond Plate	\$37.43	\$42.11	\$1,497.20	8	300lbs	6' x 60'	100 MI	
Lonplate Patina	E-Diamond Plate Galvanized	\$37.43	\$42.11	\$1,497.20	2	300lbs	6' x 60'	100 MI	
Lonpoint Moonwalk	E-Small Dots	\$24.00	\$27.00	\$960.00	9	245lbs	6' x 60'	80 MI	
Lonstage MT	S-Matte	\$18.51	\$20.83	\$740.40	1	250lbs	6' x 60'	80 MI	
Lonstage UV	S-Shiny	\$21.83	\$24.56	\$873.20	3	275lbs	6' x 60'	80 MI	
Lonstop	S-Matte	\$16.63	\$20.96	\$745.20	1	250lbs	6' x 60'	80 MI	
Lonwave Mirage	E-Waves	\$34.86	\$39.21	\$1,384.40	4	300lbs	6' x 60'	100 MI	
Lonwood Dakota	S-Wood Grain	\$28.06	\$31.56	\$1,122.40	12	245lbs	6' x 60'	80 MI	
Lonwood Natural	S-Maple	\$28.06	\$31.56	\$1,122.40	10	245lbs	6' x 60'	80 MI	
Lonwood w/Foam	S-Wood Grain, Foamed	\$39.26	\$44.16	\$1,570.40	2	255lbs	6' x 60'	120 MI	
Lonwood Performa	S-Wood Grain, Foamed	\$49.77	\$55.99	\$1,990.80	2	460lbs	6' x 60'	220 MI	
Lonzebra	S-Exotic	\$30.66	\$34.71	\$1,234.40	10	245lbs	6' x 60'	80 MI	
Lonzebra VS	S-Exotic, Vertical Surfacing	\$30.66	\$34.71	\$1,234.40	10	245lbs	6' x 60'	88 MI	

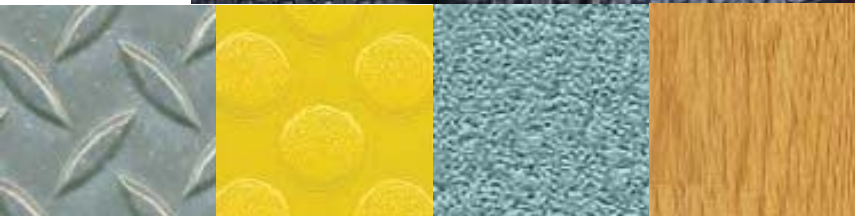
  

ADHESIVES/LINDRIES			
	Unit Cost	Size	Weight Coverage
Lonseal No. 300 - Epoxy Adhesive	\$46.65/Unit	1 gal./Unit	15lbs 11D sq.ft.
Lonseal No. 400 - Contact Adhesive	\$47.00/Can	1 gal./Can	8lbs 15D sq.ft.
Lonseal No. 555a - Adhesive	\$79.50/Pail	3 gal./Pail	35lbs 80D sq.ft.
	\$31.70/Pail	1 gal./Pail	11lbs 20D sq.ft.
	\$12.00/Can	1 qt./Can	5lbs 5D sq.ft.
Lonseal Double Face Tape (DFT)	\$8.35/Roll	2" x 60'/roll	11bs 60 lin.ft.
Lonsealer - Liquid Seam Sealer	\$20.25/Tube	4.5 Fluid oz.	11bs 200 lin.ft.
LonSealant Caulking Tape #700	\$55.60/Roll	2" Wide X 82' Long per roll	9lbs
		.90/LIN.FT. Less than a spool (10' min)	
Lonseal S/A Reinforcing Tape for Londeck	\$50.30/Roll	2 1/2" Wide X 100' Long	5lbs
Lonseal Welding Thread - PVC Seaming	\$55.00/Spool	500 Ft. per spool	10lbs 500 lin.ft.
	\$55.00/Spool	Less than a spool (100' min)	
Lonsealer Type C (Londeck/Vertical)	\$21.50/Tube	4.5 Fluid oz.	11bs See Manual
Geocol 2300 Sealant	\$8.30/Tube	10.8 Fluid oz.	2lbs 75' LF @ 1/4"
Lonseal	\$14.00/Sq. Yd.	6' x 60' roll	

MAINTENANCE SUPPLIES			
	Unit Cost	Size	Weight Coverage
Lonprime	\$24.90	1 gal./Unit	9lbs 3,500 sf/gal avg. coverage
Lonfish	\$22.10	1 gal./Unit	9lbs 2,500 sf/gal avg. coverage
Loncare	\$12.00	1 gal./Unit	9lbs 2,000 sf/gal avg. coverage
Lonstrip	\$17.10	1 gal./Unit	9lbs 2,000 sf/gal avg. coverage
Visior Matte-Dressing (Matte Finish)	\$25.95	1 gal./Unit	11lbs 2,000 sf/gal avg. coverage
Lonbuff	\$16.60	1 gal./Unit	9lbs 4,500 sf/gal avg. coverage

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# High Performance Wall Systems



## Check List

- Aerogel
- BioBased
- definitions
- cost
- maintenance
- properties
- lifecycle
- embodied energy
- health
- benefits
- disadvantages
- final analysis

## Topics Covered

**Translucent systems used in Daylighting:**  
Aerogel

**Achieving thermal performance with high tech insulation:**  
Aerogel  
Biobased Insulation

## Overview

-The concept of day-lighting makes use of an extremely available green alternative in order to achieve maximum indoor comfort, creating a guide for designers to utilize in their design process.

-Day-lighting is a technology which results from integrated design.

-Translucent wall panels reduce the need for electrical lighting during the daytime and can provide higher thermal resistance than many windows and skylights.

-Commercially-available translucent wall and ceiling panels cost more than residential window units. The additional first cost is offset by better thermal performance over the life of a home.

-Majority of materials used in day-lighting and insulation today are at odds with the environment (polycarbonates, acrylics, and fiberglass).

## Introduction

Scientific and technological advances are continually making huge impacts and changes to the way society as a whole views architecture and the systems that construct our built environment. There seems to be endless potential in the production of new and better materials and systems. Particularly, the possibilities within the design of residential structures have proven to be vast. In an attempt to narrow the spectrum of research this section will focus specifically on various high technology wall systems and the high tech. materials used within these systems. The concentration will primarily focus on materials and systems with exceptional insulation qualities in general, including both opaque wall structure and translucent screen surfaces.

## Intro/Topics



# High Performance Wall Systems



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## Aerogel

### Aerogel History & Development:

Aerogel was first discovered in the 1930s by scientist, Samuel S. Kistler. His publications can be found in a 1931 edition of Nature. Aerogel was invented through a scientific process called supercritical drying. This process creates a solid from a gel under high temperature and pressure. Many companies tried to commercialize the product but failed given the issues around the high costs, limited batch production and the dangers of using the supercritical drying technique. In the early 1990's, an alternative drying technique was developed enabling aerogel to be produced at a reasonable cost, through a continuous and safe manufacturing process.



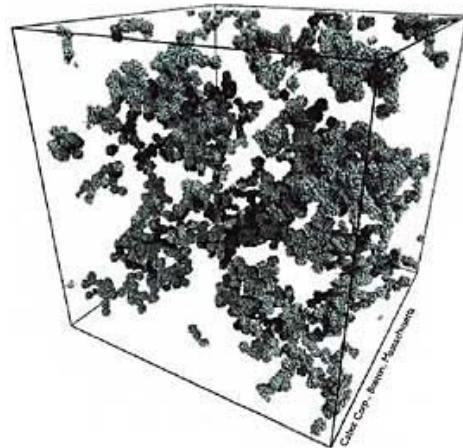
### Development Through NASA:

Aerogel's initial applications were used by NASA where it was included in atomic particle detectors and super insulation for aerospace applications. It was used to insulate the Mars rover.

### -Aerogel Used In Day-lighting & Insulation

#### Properties:

Aerogel is the most light weight solid know to science. It is the lightest solid because it is composed of more than 90 percent air. It is also one of the most insulating materials in the world. Aerogel features a very high density of interrelated pores. These minute pores measure with diameters of less than 100 nanometers. It is produced by dispersion of a gas in a solid or liquid.



Aerogel comes in a variety of make ups, including silica, alumina, chromia, tin and carbon. Silica Aerogels are the most widely studied and used. Silica aerogel strongly absorbs infrared radiation. It allows the construction of materials that let light into buildings but trap heat for solar heating. It is has also been called "blue ice". It is the color blue for the same reason the sky is blue. Extremely small particles that make up aerogel scatter blue light, in the same manner as our atmosphere scatters blue light. Aerogel has a thermal insulating quality equal to the thermal performance of 10-20 ordinary glass window panes. For Northern climates, this is an extremely substantial . Window replacement would be a wise investment, for both conserving energy and lowering heating bills.

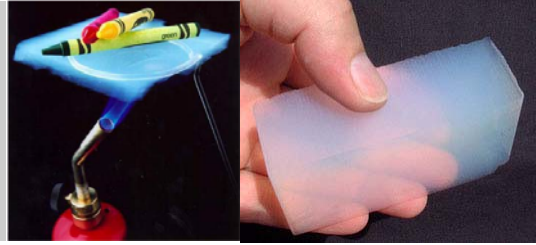
Aerogel  
History/  
Properties

LEED

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## Aerogel

### Performance Features:

Aerogel's unique combination of properties provide performance benefits unequalled in existing building materials:

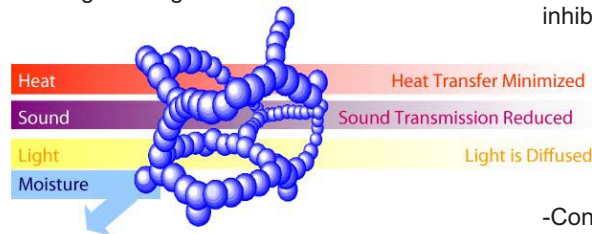


Illustration depicts the highly porous structure of aerogel (pore size: 20 nanometers)

Nanogel is Cabot Corporation's trade name for its family of hydrophobic silica aerogel. Its primary purpose in daylighting applications is for visible light to pass through evenly while maintaining excellent thermal insulation. Along with its incredible thermal insulation qualities, are its acoustic barrier qualities. Because of the porous structure of Nanogel, it reduces the transmission of airborne sound waves through either reflection or absorption. This is important in architectural designing, for creating happier and healthier environments.

### How Aerogel Minimizes Heat Transfer:

Aerogel's high porosity and fine structure ensure excellent thermal performance in inhibiting heat transfer.

-Conduction: Heat transfer is an exchange of kinetic energy. The low solid content of Aerogel reduces the transfer of heat through solid phase conduction.

-Convection: When heat is introduced, gas molecules move more quickly bouncing into one another 'convecting' energy. The pore size of aerogel traps gas molecules preventing them from colliding and transferring heat.

-Radiation: Aerogel can be opacified minimizing heat radiation by either absorbing it or reflecting it.

Aerogel is recognized as the most superior insulating material in the world.

Aerogel Performance Features

LEED

Energy & Atmosphere

Indoor Environmental Quality

Nanogel Thickness		Light Transmission	Solar heat Gain Coefficient	U *	R *
				(btu/hr.ft <sup>2</sup> .°F)	
0.5"	13 mm	73%	0.73	0.25	4
1"	25 mm	53%	0.52	0.125	8
1.25"	31 mm	45%	0.43	0.1	10
1.5"	38 mm	39%	0.39	0.08	12
2"	50 mm	28%	0.26	0.06	16
2.5"	64 mm	21%	0.21	0.05	20



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### How Aerogel Enhances Light Diffusion:

Aerogel's translucent color, low solid content and fine structure ensures excellent light diffusion properties. Aerogel has the ability to maximize daylighting while allowing for high diffuse light transmission.

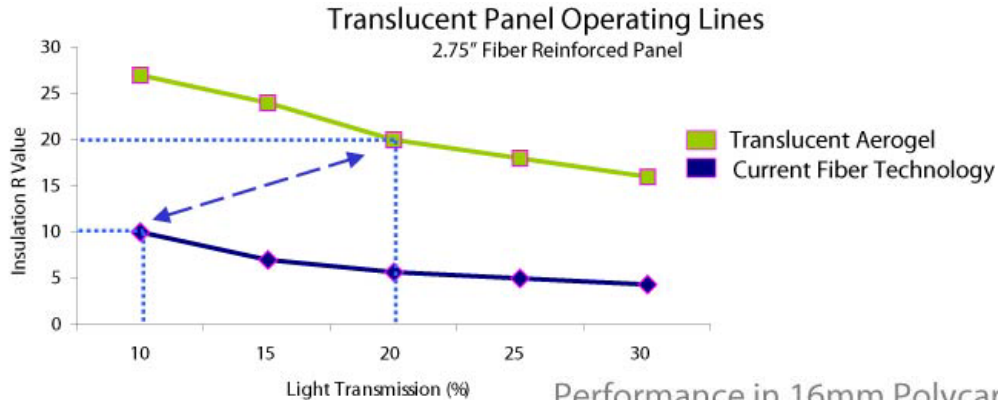


Aerogel Performance Features

LEED

Energy & Atmosphere

Indoor Environmental Quality



Translucent Aerogel can double both the light transmission and the thermal performance of existing fenestration technology.

### How Aerogel Minimizes Sound Transfer:

Aerogel's high porosity and fine structure ensure excellent acoustic performance. Aerogels address the mechanisms of sound absorption resulting in a lower sound transmission.

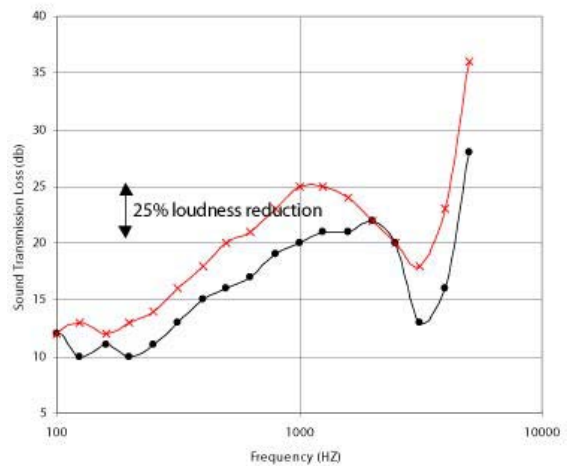
Effect on Sound:

-There is little solid-phase vibration due to the tenuous solid structure of the aerogel.

-Sound waves transmit through the air-filled low density porous medium at a much reduced speed compared to air.

-Sound insulating properties are particularly noticeable at lower frequencies (< 500Hz).

### Performance in 16mm Polycarbonate Panels \*

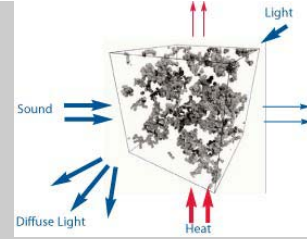


The graph demonstrates the effectiveness of aerogel as an acoustic insulator. At 1,000 hertz, we have improved the sound transmission loss by 25%.\*

— 16mm Polycarbonate Panel with Aerogel  
—● 16mm Polycarbonate Panel (empty)

The human ear can differentiate a drop of 3 dB, so a reduction of 5 dB is quite impressive, through a 16mm polycarbonate panel.

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## Aerogel

### Benefits:

In summary, there are many benefits with the use of Nanogel aerogel. Now architects and designers are able to design with more daylight to meet energy codes; improving inhabitant comfort and productivity in a healthier and safer environment. In addition, with the performance values of Nanogel, architects can use it in their design to diffuse high quality daylight, increase exceptional thermal insulation, while at the same time reducing solar heat gain as well as noise levels. Finally, designers can design with green in mind. Nanogel's green benefits are derived from the reduction of the building's consumption, emissions, and design loads. All of these benefits can help Architects overcome design challenges that exist today.

### Improved Thermal Insulation:

Solar heat gain is minimized:

In warmer months, comfort is based on reducing solar heat gain through glazing systems. High performance glazing with aerogel will reduce the amount of direct radiation through the fenestration, reducing the interior temperature of the system.

Downdrafts are reduced:

Downdrafts are created when air near glazing is cooled and drops to the floor. It is displaced by warmer air from the ceiling, which in turn is cooled creating a convective loop, establishing air movement that feels drafty and accelerates the effective heat loss. High performance glazing with aerogel will improve the glazing systems insulation performance reducing convective down-drafts.

Resistance to Condensation:

Under cold winter conditions, low glazing performance can create water formation and frost on the inside glass surface. High performance glazing with aerogel will

improve the glazing systems insulation performance by increasing interior glazing surface temperature and reducing the potential of condensation.

Cost Savings:

Through improved fenestration performance energy consumption can be reduced creating an improved building envelope with a need for smaller HVAC requirements.

### Aerogel's Performance Is Permanent:

The unique characteristics of aerogel provide exceptional benefit as a long term, high performing building product insulation solution.

Aerogel is UV stable:

Made from pure silica dioxide, aerogel is UV stable resulting in no deterioration or color change in the material overtime.

Aerogel is completely hydrophobic:

Insulation materials are susceptible to moisture infiltration and absorption. Aerogel is impervious to water, so there is no occurrence for the growth of mold and mildew, which can impact a system and its performance characteristics.

### Aerogel As A Green Building Product:

In 2002, McDonough Braungart Design Chemistry, LLC performed a "Cradle to Cradle" design assessment of aerogel (non-supercritical manufacturing method). "Green" material selection involves an assessment of a product's life cycle environmental impact in the following areas: Raw Materials - "safe for human and ecological systems". Manufacturing Process - "the closed loop process implemented best available technologies and is consistent with the principles of 'Cradle to Cradle' design philosophy". Characteristics in Use - "provides an elegant solution to the problem of thermal insulation". Disposal Options - "Aerogel is recyclable and can be re-used".

Aerogel Benefits

LEED

Energy & Atmosphere

Indoor Environmental Quality

# High Performance Wall Systems



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### Disadvantages:

Just as aerogel has vast qualities there are a couple disadvantages. Aerogel is still relatively expensive. Reason being is because it is currently made in very limited quantities. Another drawback of aerogel is, even though its levels of light transmission are two and four times higher than alternative products, it is still not fully transparent. Again, reason being is because of the hazy blue tint that is generated in the production process.

### Final Analysis:

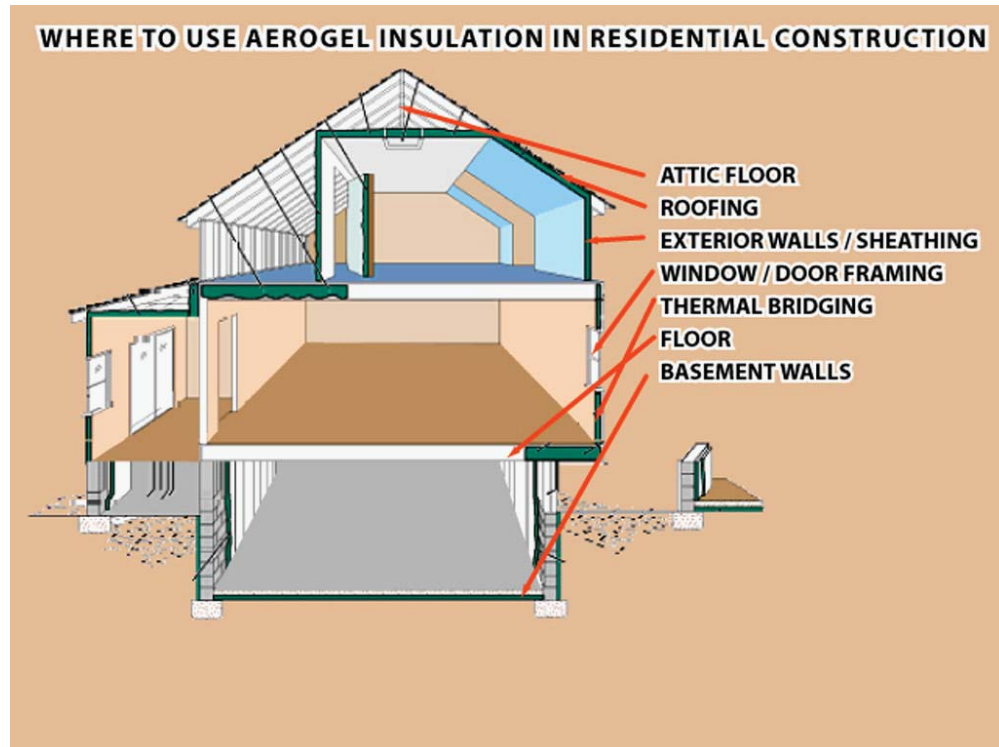
Overall, aerogel has unique thermal, acoustic, and optical properties which Architects can take advantage of now with the use of this product. Aerogel more than doubles the thermal performance of most existing insulation materials which makes it a product that deserves an enormous amount of attention considering the applications it could be greatly benefit.

Aerogel  
Disadvantages/  
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# High Performance Wall Systems



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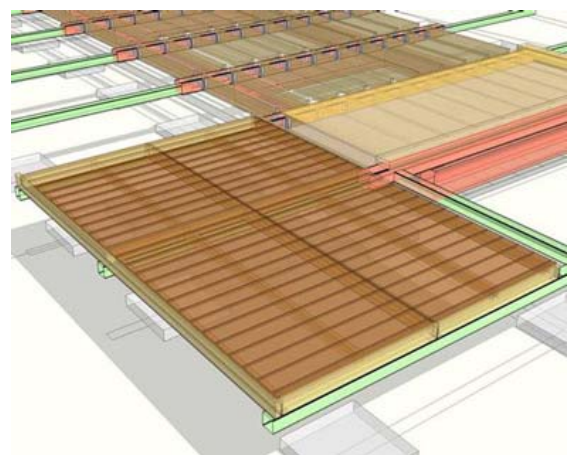
## BioBased Insulation:

BioBased Insulation is a soybean-oil-based polyurethane foam insulation that expands to 100 times its original size within seconds of its spray-on application. As BioBased is installed it expands to virtually and permanently fill all voids effectively guarding against air infiltration, which is often the most prominent source of heat/cooling loss. In addition creating a tight building envelope helps to eliminate moisture problems, consequently preventing the growth of mold.



This innovative product has excellent thermal and sound insulating properties that contribute to creating a healthy, comfortable, energy efficient, and durable residential structure. This insulation has revolutionized the residential construction industry by providing a largely superior and affordable product with the additional benefit of its application of breakthrough environmental technologies. BioBased Insulation is an award winning manufacturer of soy-based polyurethane spray foam insulation products. This product has the ability to reduce the cost of utility bills by 30-50% as compared to standard construction techniques. Its use of U.S.-grown soybeans provides an annually renewable resource, avoiding the typical use of petroleum oil. This product also avoids the use of harmful agents commonly used in insulation such as CFCs, HCFCs, COCs, or formaldehyde. The high R values and air tightness of BioBased Insulation allow for the use of smaller, more affordable heating and cooling HVAC equipment. It contains no fibrous material unlike traditional insulation which eliminated the existence of harmful particulates that can cause irritation or allergic reactions. In some select climates

this product can eliminate the need for building wrap and it minimizes the labor intensive and imperfect application process associated with conventional insulation. BioBased Insulation offers two products which are both suitable for either residential and commercial construction. These include BioBased 501, which is an open cell, semi-rigid spray foam, and BioBased 2000, which is a closed cell rigid spray foam. As conventional insulation materials age they tend to settle preventing them from performing from stud to stud, around outlets, or on horizontal surfaces due to an insufficient seal. Conventional insulation also loses its R value as moisture invades the building envelope. BioBased Insulation will not settle with time, lose its thermal performance from invading moisture, support mold growth, or offer a food or nesting source for rodents and insects. This product can be applied to the following areas of residential construction: In terms of new residential construction- stud walls, rim joists, crawl spaces, truss-ends, gables, dormers, attics, In terms of residential remodeling)-under floors, non-insulated walls, previously insulated walls, basement stud-walls, and attics.



The floor of Georgia Tech's 2007 Solar Decathlon house is built using economical "light frame" wood construction. Between the framing members, a "light" sponge-like bio-based insulation is sprayed throughout the house to produce an "air tight" assembly.

BioBased Insul. Overview

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# High Performance Wall Systems



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References:

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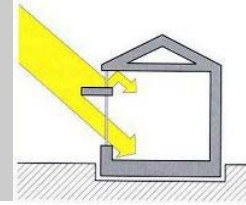
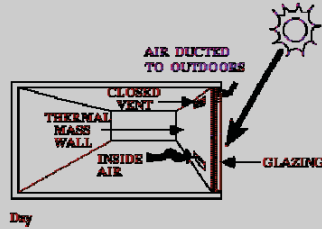
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References



# Passive Heating and Cooling - Intro



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## Passive Heating and Cooling

The term 'passive' describes a system in which very little, to no mechanical systems are required.

Passive heating and cooling is based on ancient techniques used by an array of cultures and applied in every climate.

It takes advantage of the natural energy of an environment, namely, the sun, and then controls that energy to enhance the thermal comfort of the user. When passive heating and cooling techniques are added to the building design, it will increase its energy efficiency along with adding a new aesthetic quality.

If using passive heating and cooling techniques, it can be extremely effective in limiting or eliminating mechanical air conditioning requirements.

## Properties

Passive systems are based on the buildings envelope design. The roof, floor, walls, and windows will control a buildings heat gain and loss by adjusting the outdoor conditions to fit the needs of the indoor occupants. The envelope design is generally intended to keep out summer sun and heat gains while containing the winter sun and heat.

When designing a building envelope one must consider the location's climate and the buildings orientation and placement. Assessing climate it is important to consider the regions temperature ranges, direction and temperature of breezes, humidity ranges, and other seasonal characteristics. Orientation should consider the optimal angle for solar access and the impact of surrounding buildings. The designer must assess whether he/she is in an area that needs heating, cooling, or a combination of the two

Inside the envelope the designer should consider the needs of each space in the program. Spaces with similar heating/cooling needs should be grouped together. For example living spaces like a kitchen and family room will need more heat than a bedroom.

Passive Heating and Cooling

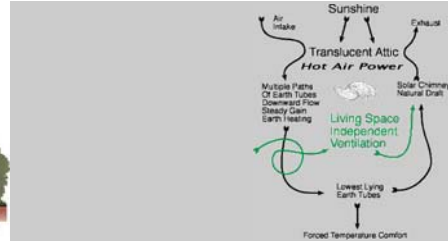
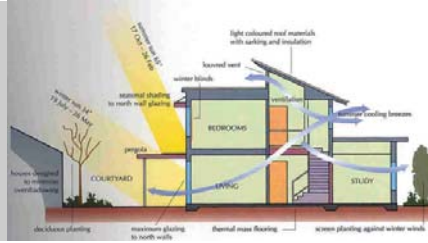
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# Passive Heating and Cooling - The Basics



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## Passive Heating and Cooling

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### COST

**cost**

Passive systems are the least expensive way to heat/cool a home because they rely on the natural energy flows of the surrounding environment. Passive heating and cooling systems use no mechanical appliances to control the thermal comfort of a home, and therefore create no additional energy expense.

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Certain systems could be an additional cost during a homes design and construction phase but will save the homeowner money when paying energy bills.

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### HEALTH

Designing passive heating and cooling systems will improve both the users comfort and the health of the environment. Passive systems are intended to reduce temperature swings by controlling the interior heat gains. The building will store the excess heat in its thermal mass and then re-release it when the temperature of the space decreases, therefore creating a buffer between the temperature swings on the exterior and the maintained thermal comfort on the interior.

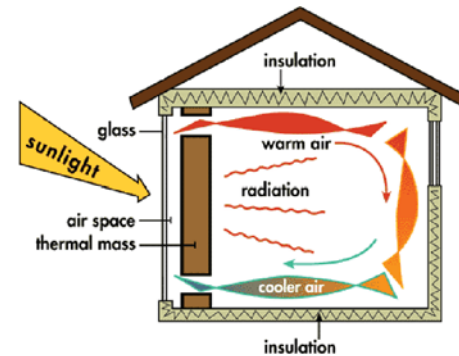
Utilizing the suns natural energy will in turn help the environment. Passive solar heating and cooling does not use any mechanical systems and therefore does not add any to the CO2 emissions into the atmosphere.

### ADVANTAGES

The largest benefit to using passive systems is the cost efficiency. They generally do not cost much more to add to your building and maintenance is limited to general home upkeep. Ex: Specially glazed windows only need to be cleaned like normal windows but can significantly alter the internal heat gains. In addition to low installation costs passive systems will dramatically reduce ones energy bills.

### DISADVANTAGES

A major disadvantage of passive systems is that it is dependant on the surrounding environment. Climate and other seasonal characteristics can be volatile and this will effect the temperature of the home. Passive systems must be one of the first considerations of the designer. Site evaluations must be accurate or the system could be useless.



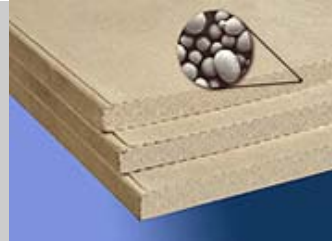
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# Passive Heating and Cooling - Technologies



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## Technologies

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### MICRONAL PHASE CHANGE MATERIAL

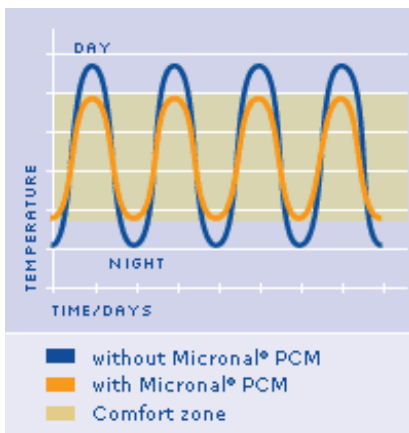
Micronal PCM is a phase change material consisting of small wax droplets contained in an acrylic polymer shell. The PCM can be incorporated within plaster or gypsum wall board and is designed to be used as a passive cooling system.

At 23 degrees Celsius, or 78.5 degrees Fahrenheit, the wax will absorb the excess heat in the room and melt. As the room temperature decreases the wax will then begin to freeze and harden, and the heat energy is re-released.

Through the wax melting and freezing process, the Micronal PCM will help regulate the temperature within the home.

BASF Global conducted a 16 month cyclic test that involved 24 temperature cycles per day on the Micronal PCM. The material remained leak tight and sustained its original thermal storage characteristics for the entire test period which would result in a minimum life of 30 years.

The diagram below shows that with the Micronal PCM utilized within a structure, that the temperature remains within a comfortable temperature zone. Without the Micronal PCM, the temperatures exceed the comfort zone.



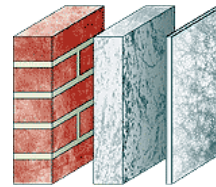
### SMART BOARD

SmartBoard plasterboard is very similar to the Micronal PCM in that it contains the same phase change material.

SmartBoard plasterboard has a thickness of only 1.5 centimeters, yet its thermal storage capacity is that of a 9 cm thick concrete wall, or a 12 cm thick brick wall.

Micronal PCM SmartBoard contains 3 kg of microencapsulated phase-change material per square meter, making it extremely dense relative to other insulative materials.

Using SmartBoard by itself, or combining it with other technologies, this technology opens doors for many new exciting possibilities.



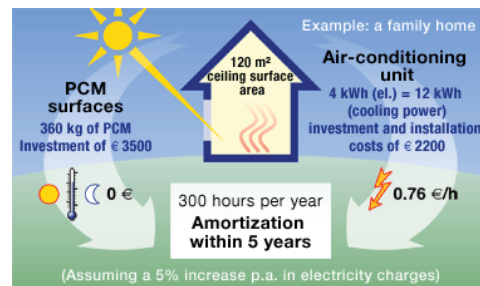
12 cm-thick brickwork,  
9 cm-thick concrete wall,  
1.5 cm-thick Micronal® PCM SmartBoard™  
(from left to right)

Passive Heating and Cooling

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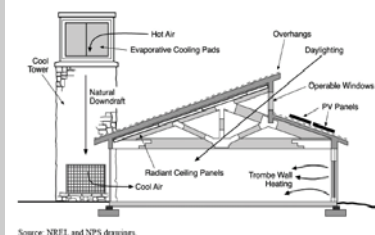
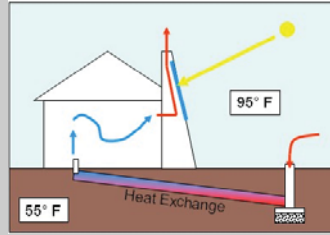
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# Passive Heating and Cooling - Technologies



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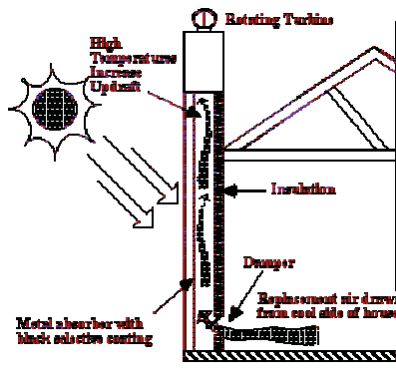
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## Technologies

### SOLAR CHIMNEY

A Solar Chimney is a natural draft drive device that uses solar radiation and convective currents to create a warm zone with an exhaust outlet where the mass of air can be drawn out of the structure

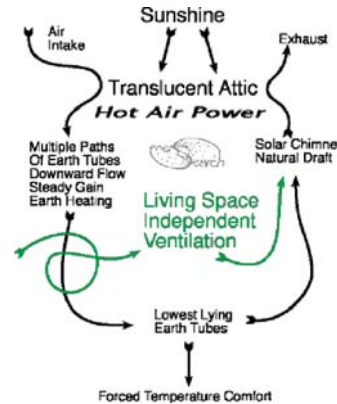


The basic elements of a solar chimney are the solar collector area, the main ventilation shaft, and the inlet/outlet air apertures.

The solar collector area contains the glazing and insulation. This section can either be the entire chimney or just the shaft. The orientation and thermal properties of the collector retain the thermal gains. The main ventilation shaft is dependent upon its location, height, and cross section. The inlet and outlet air apertures vary in terms of size and location. The chimney must be higher than the roof and should be constructed so it can face the sun. The side facing the sun should have a glazing that increases thermal gains and have a thermal mass on the other side of it to absorb the heat. The larger the surface area of the thermal mass the more effective the heat exchange will be. The direct gain will increase the temperature of the air within the chimney causing it to rise and then draw more air up the chimney. This convection current can be used to draw air through a geothermal heat exchange.

### OTHER TECHNOLOGY

A similar technology to a solar chimney is the down-draft cool tower. The cool tower uses evaporative cooling pads to evaporate water at the top of a tower. The evaporation will cool the incoming air causing a downdraft through the tunnel. One can then increase the ventilation within the building by using a solar chimney on the other side. The Visitor Center of Zion National Park utilized the two systems.



### SOL ARCH - Solar Architecture Design

SolArch Solar Architecture Design Software is a tool intended for professionals who are familiar with passive solar design. It offers thermal performance calculations as well as design checklists. Version 1.0 is in English and includes data for the UK and Ireland can be used worldwide. It is a free program that one can download from their website: <http://www.kahl.net/solarch/>

### ECOTECT

Ecotect is a software that helps test and analysis daylighting strategies. It allows the designer to see sun path angles for various climates and it will simply a conduct thermal analysis.

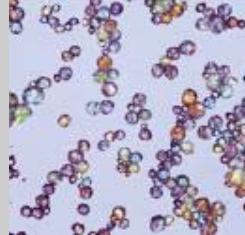
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# Passive Heating and Cooling - Advantages/Disadvantages



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### MICRONAL PHASE CHANGE MATERIAL

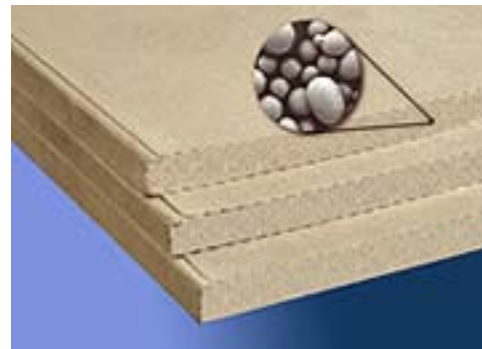
Micronal PCM offers a greater architectural freedom by offering easy to use building materials. The phase change material serves as a new type of insulation that is smaller and more condense than traditional methods of using cement or brick. Micronal PCM has been test to last for decades without any additional maintenance. In addition to enhancing the buildings value it will reduce the need for active cooling systems, saving energy, CO2 emissions, and a reduction on heating/cooling bills.

However, there is a disadvantage to go along with the material. Micronal PCM has shown to be flammable under certain circumstances, but researchers have found this material to be consistent with already developed insulators.



The image above depicts a man applying the Micronal Phase Change Material to a wall of a structure. The PCM may come in the form pictured above, or within a structure, such as the SmartBoard.

### SMARTBOARD



SmartBoard offers plenty of new opportunities as far as design principles. The properties of the SmartBoard make the material capable of being incorporated anywhere in the structure. At only 1.5 cm thick, it still offers the insulative properties of 12 cm thick brick wall. Maintenance is the same for any other common insulative material today, and installation is very easy. The SmartBoard may be used as a conventional building board or as structured panels. Also, the PCM material, as discussed previously, has a 30+ year lifecycle, which is a huge benefit from such a useful material

Again, there are some disadvantages to go along with the SmartBoard material. SmartBoard incorporates phase changing materials, which earlier, has been said to be flammable. Also, at such a small thickness, the load-bearing capabilities of such a material compared to cement or brick will be much smaller.

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# Passive Heating and Cooling - Advantages/Disadvantages



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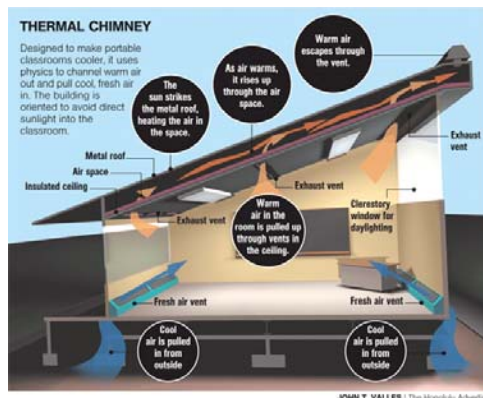
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### SOLAR CHIMNEY

Solar chimneys will improve ventilation rates and control and reduce the dependence on wind ventilation. They will increase night time ventilation rates, provide location options for air intake, and only need a small exposure to outside elements. They can be easily integrated with building facades and allow for a range of window sizes. Most designs, (ex: cylindrical chimneys), are cost effective, require minimum space requirements, and are simple to construct. Solar chimneys may also be an addition to a structure, and do not have to be considered in the design phase of the project.

However, there are some disadvantages. Some designs can reduce ventilation rates because of the angle of the sun hitting the thermal mass. They can also increase the houses heat loss coefficient because of aperture. Although most solar chimney design is simple some may be difficult to construct.

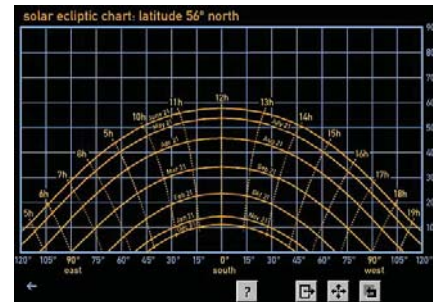


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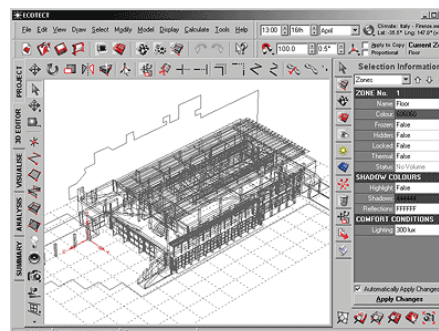
### COMPUTER ANALYSIS PROGRAMS

There are several computer analysis programs out there, designed to help with specific elements of passive design. These types of programs are great if you need a quick introduction to passive design. They also help in areas such as daylighting and passive heating and cooling according to location.

SOL ARCH software is a good program for examining thermal performance within a structure. It also offers design checklists which help make sure every element is covered in the design phase. SOL ARCH is also a free program that may be downloaded via the internet.



EcoTect software is a great program that helps in the designing phase. It allows the designer to see the sun path angles for several different climates, which in turn, helps in many different phases, including orientation, window orientation, shading, glazing, vegetation, solar chimneys, etc.



Passive Heating and Cooling

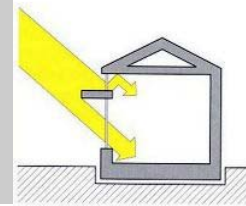
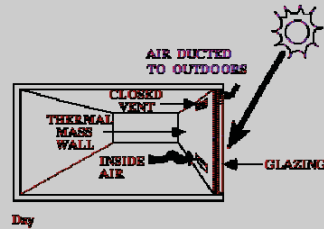
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# Passive Heating and Cooling - Mixing Technologies



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## Passive Heating and Cooling

### UTILIZING MIXED TECHNOLOGIES

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The great thing about passive heating and cooling is the fact that they may all be used together. Passive design is not all about the focus on just one system within the design.

A solar chimney or cooling tower may be utilized with Micronal PCM or SmartBoard technologies in order to maximize energy savings, to limit harmful elements escaping into the environment, and to save the user money as well.

As well as using many different materials in conjunction, the software design programs are designed for just this: to enable the usage of many different systems within one structure. Daylighting strategies, orientation of the structure, which in turn notifies you where more SmartBoard should be located.

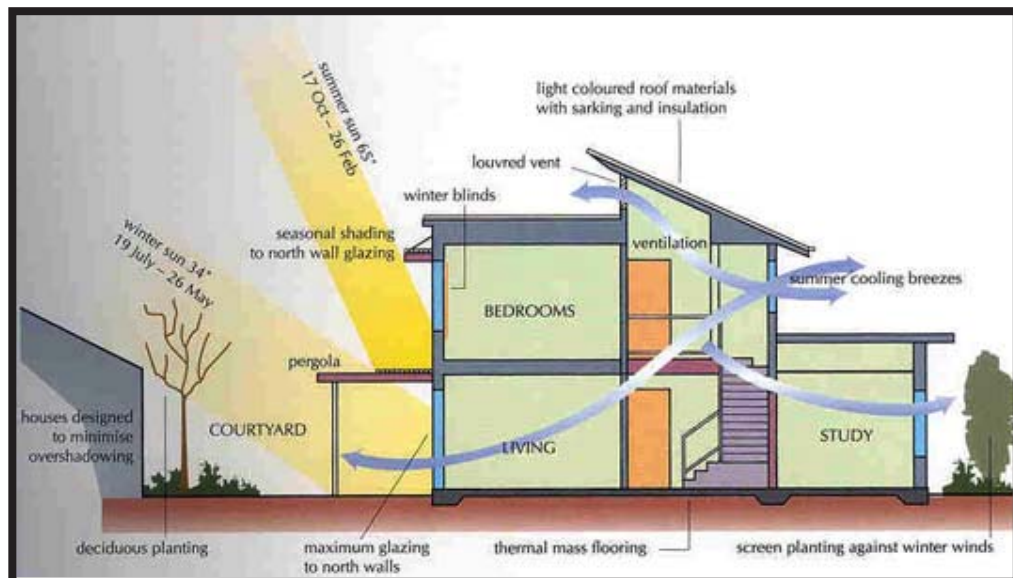
Passive Design is one of the most overlooked aspects in the world of design today. There are numerous elements that can be added to a home in order to increase its efficiency.

Passive Heating and Cooling

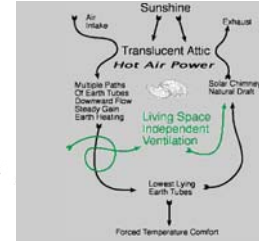
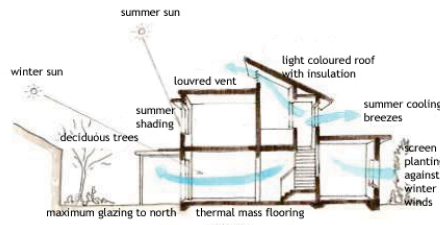
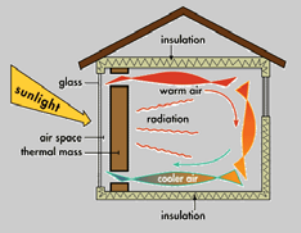
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# Building Utilized Wind Technology



## CHECKLIST:

- Small Wind
- Turbine Parts
- Embodied Energy
- Cost
- Site
- Aesthetics
- Swift Turbine
- Mag. Lev.
- Advantages
- Disadvantages
- Conclusion
- Local Resources

## Small Wind

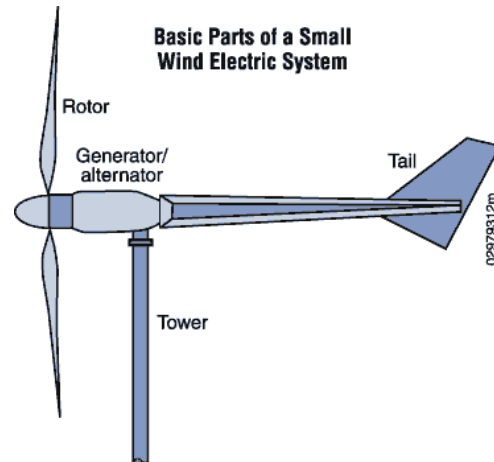
The wind's energy has been harnessed for thousands of years as one of our greatest renewable energy resources. Recent research in the power of wind in the past decade has given a wealth of information on the abilities and capacity of humans to use wind to generate clean energy. The first automatically operating wind turbine was produced in 1887, producing 12 kilowatts of power and lasting for twenty years. At five megawatts, today's largest turbines are capable of producing four hundred times the power of the earliest models. As the search for renewable energies continues to boom, wind power has shown to be a great alternative to fossil fuels.

Current trends in wind technology have attempted to utilize and harness wind at a micro-scale more suitable for residential environments. Aesthetically speaking, the integration of wind turbines into the built environment has yet to be thoroughly explored and there are further problems with noise and vibrations that have also yet to be solved. Together, designers and engineers are teaming up to create a more functional and aesthetically pleasing product for the residential market.



## Turbine Parts

There are five basic parts that make up a typical residential wind turbine; the blades, shaft, generator, tail and tower. When the blades are turned by incoming wind, the shaft turns along with them. This shaft is connected to a generator or alternator which creates electricity. An important detail to remember is that the power output of a turbine increases exponentially with increased wind speeds and rotor diameter. It was therefore logical to install the tallest and largest wind turbine your site and code will allow.



Energy

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# Building Utilized Wind Technology



## CHECKLIST:

- Small Wind
- Turbine Parts
- Embodied Energy
- Cost
- Site
- Aesthetics
- Swift Turbine
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## Cost Efficiency

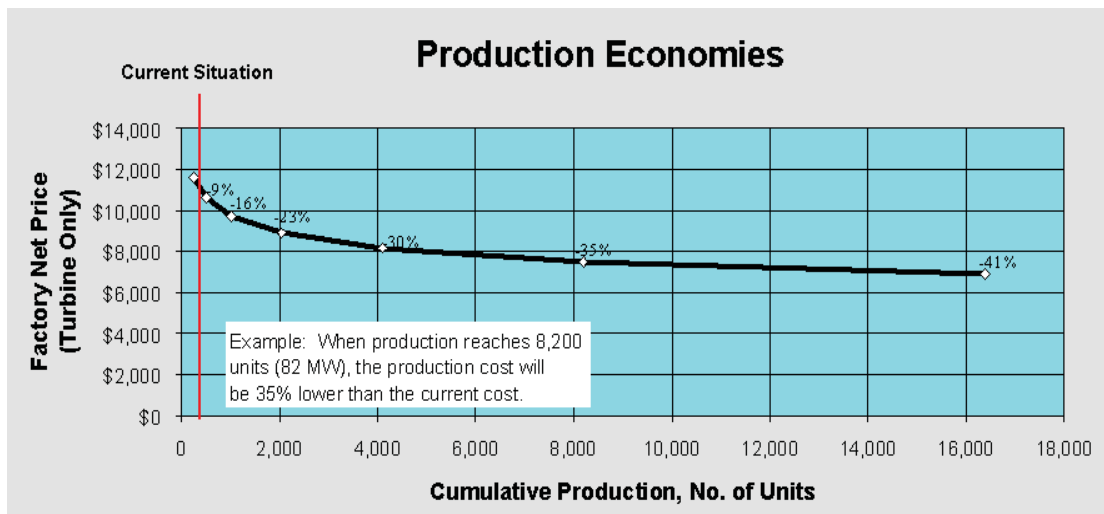
Although the initial cost of wind technology is typically high, the savings over its lifetime make it a competitive alternative to conventional energy sources. The time it takes for its savings to pay off the initial cost depends on a number of variables. These include; the system you choose, wind availability, your electricity costs and how you use your wind system. A typical small wind system installed in a residential home generally costs about \$2-4 per watt. For example, a 10 kilowatt system will generally cost between \$20-40,000 to install. Since a typical home uses between 800 and 2000 kilowatt hours of electricity per month, a 10 kilowatt system can usually meet this depends. In areas with average wind speeds of 10 mph or more, the system generally pays itself off in 8 to 16 years.

## Embodied Energy Payback

Most small scale residential turbines only take a few months of operation to payback the energy used in manufacturing processes. Depending on the materials utilized in the production of the product, embodied energy payback time may vary. Rotor and tower length are also a contributing factors, as system parts increase in size, embodied energy also increases due to the amount of raw materials that need to be extracted

Energy

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Production Cost/Sales Graph

# Building Utilized Wind Technology



## CHECKLIST:

- Small Wind
- Turbine Parts
- Embodied Energy
- Cost
- Site**
- Aesthetics
- Swift Turbine
- Mag. Lev.
- Advantages
- Disadvantages
- Conclusion
- Local Resources

## Site

The exact location of a micro-wind turbine can greatly affect the system's energy output. Small turbines are not typically suitable for urban or small lot homes and require at least one acre of land. When installing a small scale turbine to your residence, it is important to take in a number of other factors involving your site:

**Average Wind Speed** – Ideal speed is ultimately determined by the individual turbine. Typical micro-wind turbines need an average annual wind speed of 10 mph.

**Obstructions** – Includes the built environment and vegetation; 20-30 feet of clearance is suggested.

**Height** – Taller turbines are typically most effective.

**Noise** – Created by blade speed and vibrations, noise production should be taken into account when placing a micro-wind turbine near a home.

**Topography** – Avoid steep slopes as they tend to create turbulence as well as have high installation costs.

**Wildlife** – Although wind turbines have small footprints, blades have been suspected to harm flying wildlife.

**Distance to Grid** – Cost to connect to grid for buyback programs can be extremely expensive as transmission lines can cost anywhere between \$15,000 and \$50,000 per mile.

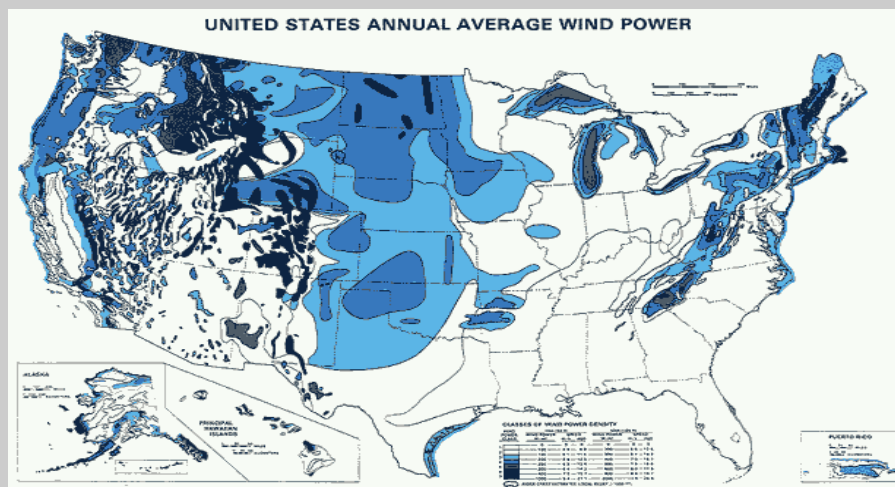
## Aesthetics

Technically speaking, wind turbines can vary greatly in appearance. As residential use of building utilized wind power becomes more prevalent, the need to find aesthetically pleasing turbines has arisen. Horizontal axis and vertical axis turbines already allow for some variation in design. However, residential applications of small wind turbines continue to be little more than a freestanding wind turbine next to or near a building. The question is, how can architects and engineers team up to create a product that will make these clean energy sources more appealing to the human eye? Although conceptual models combining wind turbines with large commercial buildings have been proven to be successful, small residential applications have yet to be explored.



## Energy

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Darkest Spots Represent Highest Average Wind Speeds

# Building Utilized Wind Technology



- CHECKLIST:
- Small Wind
  - Turbine Parts
  - Embodied Energy
  - Cost
  - Site
  - Aesthetics
  - Swift Turbine
  - Mag. Lev.
  - Advantages
  - Disadvantages
  - Conclusion
  - Local Resources

## Swift turbine

Designed in the United Kingdom, the Swift is the world's first silent building mountable wind turbine. Since many people have long considered wind turbines to be unattractive and noisy, Renewable Devices has created solutions to these problems. Its unique patented diffuser ring encompasses the rotor's blades and reduces the noise caused by turbulence to near silent operation. It is also widely acclaimed as one of the most attractive micro turbines on the market. Rated at 1.5 kilowatts, it is estimated that in an average installation, one Swift turbine can produce between 2,000 and 3,000 kilowatt hours per year. Depending on the location and energy needs of the client, the Swift can be used by itself or in combination with more turbines or alternate energy sources.

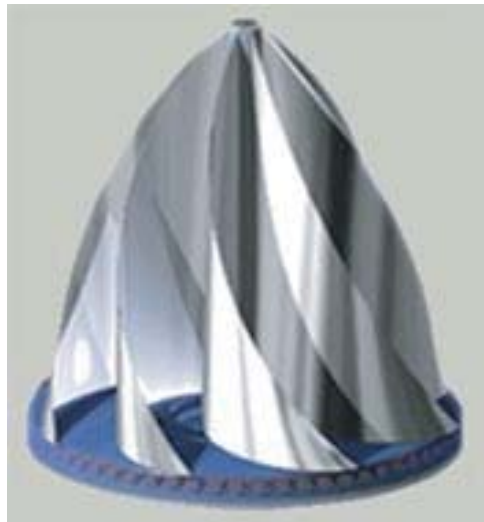


## MagLev:

Introduced in 2006, the MW 1100 is the first magnetically levitated residential wind turbine. This revolutionary technology has dramatically increased both the efficiency and power of turbines. Because it floats on a magnetic cushion, friction is eliminated which not only allows for the free movement of the turbine, but also significantly reduces noise.

Its specifications surpass every small wind turbine on the market. With a cut-in speed of less than 5 mph and a rating of 1100 kilowatt hours per month with an average wind speed of 13 mph, the MW 1100 is the most powerful and efficient small wind turbine on the market today. The payback period is also shorter than many renewable alternatives. At a mere 3.5 cents per kilowatt, the system generally pays itself off in three years or less.

The MW 1100 is designed to be placed on rooftops of residential and commercial buildings. Standing four feet tall with a sweeping cone-shaped design, it was widely regarded as one of the most attractive residential turbines available. Another advantage of this turbine is that it works well in turbulent air and has increased power generation due to the "roof effect." Studies have shown that a roof with a 10-foot vertical rise and 30 degree angle will provide close to a 200% increase in the amount of wind energy that is available to be turned into electricity.



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# Building Utilized Wind Technology



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## Benefits

Compared to other renewable energy resources, building utilized wind power maintains some advantages. Primarily, small scale wind can be a great resource for homes disconnected from the grid due to the high cost of installation transmissions lines. In cases where wind systems are connected to the grid, most states have benefit and incentive programs. For example, most states offer net metering and others offer sales and property tax exemptions, rebates, grants, and buy-down programs. Furthermore, once installed, wind turbines require very little maintenance.



## Disadvantages

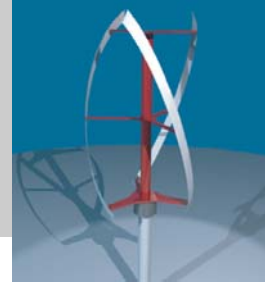
Although small scale wind turbines can be the optimal solution or energy problems, there are several disadvantages to consider. More often than not, residential wind turbines cannot be used and applied to urban or small lot homes. There are several siting issues to consider and miscalculation could lead to undesirable results. As rotor size decreases, the amount of available open land must also increase. The general rule of thumb is one acre for a rotor diameter of three feet. Another disadvantage of small wind turbines is the great vibration produced by spinning blades. When mounted directly on a building, these vibrations can produced noise and weaken building structure. The simple spinning of blades can also produce a lot of noise, so it is advisable to play the turbine in a more remote location. Lastly, in a large number of places, zoning laws and building codes can prevent these installations.



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# Building Utilized Wind Technology



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## Conclusion

The benefits of wind power have been clearly demonstrated for decades. As the urge for renewable energies becomes more imminent, wind power has the ability to provide electricity in most corners of the globe. Most home owners report electricity bills of only \$8-15 for nine months out of the year after installing wind power. Compared to similar renewable energy technologies, small wind devices maintain low embodied energy and long life spans. When considering small wind power for your home, be sure to evaluate your sight properly and have a professional decide where it should be placed on the site. Although wind is a great energy resource, poor location can easily interfere with energy output results. Make sure your turbine also complies with with local codes and zoning ordinances, as these can vary greatly town by town. Furthermore, investigate potential buyback options with your power company and see if tax exemptions are given in your area. With the right knowledge and professionals, wind power can be a great opportunity for many residences.

## US Manufacturers

Below are companies that produce small wind turbines for residential applications within the United States. In [brackets] are the rated capacities of their micro-wind turbine models. Consider distance from the manufacturer to the project site when purchasing turbines as to keep the embodied energy low.

Abundant Renewable Energies  
[1 kW]

Bergey Windpower Co.  
[1 kW, 10 kW]

Distributed Energy Systems  
[100 kW]

Energy Maintenance Systems  
[35 kW, 65 kW]

Lorax Energy  
[25 kW, 30 kW, 100 kW]

Solar Wind Works  
[600 W, 2.5 kW, 6 kW, 15 kW]

Southwest Windpower Co.  
[400 W, 900 W, 1 kW, 3 kW]

Wind Turbines Industries Corp  
[10 kW, 20 kW]

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## Resources

- <http://www.bergey.com>
- <http://www.mag-wind.com/mw1100.php>
- <http://www.seco.cpa.state.tx.us/index.htm>
- <http://www.windtech-international.com>
- <http://www.nrel.gov/wind/>
- <http://www.energyatlast.org/default.asp>
- <http://www.bwea.com>
- <http://www.awea.com>
- [http://www.freesource.co.uk/pages/wind\\_turbines.html](http://www.freesource.co.uk/pages/wind_turbines.html)
- <http://www.wind-works.org>
- <http://www.renewabledevices.com/swift/index.htm>
- <http://the-green-company.com/wsn/page14.html>

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