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Green-Buildings.com performed a benchmark analysis of PGF Insulation Sdn Bhd. (PGF Insulation) products and determined that these products may:

- A. **Improve Building Durability**
- B. **Reduce Demand for Raw Materials**
- C. **Conserve Energy and Electricity**
- D. **Improve Indoor Environmental Quality**

Green-Buildings.com also believes that the use of PGF Insulation products is an effective choice when seeking to achieve certification under green building rating systems, such as LEED®.



EXECUTIVE SUMMARY

PGF Insulation, a subsidiary of Poly Glass Fibre (M) Berhad Company and a pioneer in glass wool insulation technology, is the leading manufacturer of fiber glass mineral wool products for building, HVAC and pipe insulation in Malaysia. The company also manufactures other specialty products for thermal and acoustic insulation for residential, commercial & industrial applications.

PGF Insulation's glass mineral wool product offerings, marketed under the brand name ECOWOOL, include blanket, board, batt and pipe insulation in various product thicknesses, widths, lengths and densities. The products are used in attics, floors and walls of every building type in new construction and existing building applications. PGF Insulation also manufactures other insulation and sound absorption glass mineral wool products including pre-insulated ductwork systems, flexible duct and sectional pipe insulation.

PGF Insulation worked with Green-Buildings.com ("Green-Buildings") to complete a review of their insulation products. For the purposes of this Certification Review, product analysis included:

- PGF Glass Mineral Wool Board
- PGF Glass Mineral Wool Acoustic Ceiling Panel
- PGF Glass Mineral Wool Batts
- PGF Glass Mineral Wool Blanket

Green-Buildings' team performed a benchmark analysis of PGF Insulation's glass mineral wool insulation products and determined that these products may:

- A. Improve Building Durability
- B. Reduce Demand for Raw Materials
- C. Conserve Energy and Electricity
- D. Improve Indoor Environmental Quality

Green-Buildings believes that the aforementioned characteristics of PGF Insulation's glass mineral wool insulation products are congruent with green building principles and may be considered applicable to high-performance building. PGF Insulation products may also contribute meaningfully to green building projects that pursue LEED® certification.

DETAILS

ECOWOOL insulation begins as a mixture of natural sand, recycled glass cullet and fluxing agents, which are melted utilizing electrically-powered electrodes at 1,450°C (2,642°F) to form a lava-like molten glass. The glass is then converted to fibers by extruding the molten material through thousands of tiny holes via a centrifugal rotating device, while simultaneously attenuating with high temperature gas jet streams. A binder is also added for cohesion and mechanical strength of the product.

The fiber mat is then heated to around 200°C (392°F) to polymerize the resin, and pressed to add strength and stability. After passing through a cooling conveyor, the cured glass mineral wool mat can then be cut and formed to each product application, adding facings and specific treatments as necessary (the scraps are recycled into the manufacturing process).

The manufacturing process of glass mineral wool is highly efficient. Indeed, independent consulting firm Solidiance reports that various studies have shown that over the course of fifty years, mineral wool insulation may save as much as 100 times the primary energy that was used in the insulation's production, transportation and disposal. This means that over the insulation's lifetime, it will save 100 times the energy that was used to make the material.

A. Improve Building Durability

A key green building principle is to improve building quality and durability to maximize building life while minimizing the need for repairs. Often, the greenest buildings are those that do not need to be replaced. Products that help promote a durable design and ongoing performance may result in a building that will last longer, thereby avoiding future downstream waste.

Because glass mineral wool products have been in use for over 70 years and have typical application lifecycle of 50 years, they have been proven to be a popular, ecological, and safe insulation material for residential, commercial and industrial applications.

PGF glass mineral wool insulation is non-combustible. Indeed, because the glass mineral wool insulation fibers have melting point of over 704°C (1,299°F) and are fire-resistant up to 300°C (572°F), they are often utilized in fire prevention applications.

Glass mineral wool is water-repellent and allows for reduced probability that deterioration may occur if moisture is introduced to a building's envelope. Glass mineral wool insulation products do not support mold, mildew and/or fungus, each of which may weaken interior building elements and/or require materials replacement.

B. Reduce Demand for Raw Materials:

Green buildings that utilize recycled content in their building materials may not only contribute to reduced demand for the extraction and processing of raw materials, but also reduce the volume of solid waste that is a byproduct of our built environment.

PGF glass mineral wool insulation is manufactured from a combination of sand and recycled post-industrial glass that would otherwise go to a landfill. Sand is the final product of rock weathering, and the amount of raw sand generated globally on an annual basis is far greater than the quantity used by humans. As such, the environmental impact from use of this raw material in production of glass mineral wool is minimal.

The combination of natural sand and fluxing agents is mixed with a recycled glass cullet that is a byproduct of local manufacturing. PGF Insulation utilizes recycled glass cullet that is a byproduct of the local industrial glass waste.

On average, PGF glass mineral wool contains 50% post-industrial recycled glass, but it can contain up to 80%, depending on the product in question¹. The use of recycled glass as a material in the manufacturing process results in less energy required for melting than would be needed with the use of raw material alone. As mentioned above, PGF Insulation also incorporates production scrap back into their primary production process, or when that isn't applicable, the Company reprocesses it into other products, helping reduce the Company's overall process waste.

Thanks to its resilient properties, glass wool can be compressed by a factor of up to 10 times at the time of packaging and palletizing. The result is that more insulation can be shipped in each truck, reducing the energy required for transportation.

PGF glass mineral wool products may also be easily removed and reinstalled, if necessary, saving costs, energy and resources in building renovations or expansions.

C. Conserve Energy and Electricity:

According to the U.S. Department of Energy, buildings are responsible for approximately 39% of the energy consumed in the United States. On a global scale, the building sector consumes as much as 40% of the total energy used, of which two-thirds is used for heating, cooling and ventilation. The Danish-Malaysian Energy & Environmental Forum reports that domestic and commercial electricity accounts in

¹ Based on a recent test sample report provided to Green-Buildings, Poly Glass Fibre was shown to contain 69.28% recycled glass in the final product, based on dry weight.

Malaysia account for 51% of electricity consumed and that the cooling of urban domestic households and commercial buildings consumes 30% and 40% of electricity, respectively.

It is estimated that a significant portion of this energy use would be unnecessary if all buildings were properly insulated. Indeed, McKinsey & Company has reported that investing in proper insulation is one of the most cost effective measures to save energy and reduce carbon emissions.

Glass mineral wool insulation provides excellent thermal resistance and can play a significant role in reducing the energy used in heating and cooling of residential and commercial buildings. This is significant because when buildings consume less energy, the amount of fossil fuels (generally) burned to produce that energy and their emission byproducts are also reduced. Good insulation can minimize heat penetration or loss through a building’s envelope. Glass mineral wool may be applied in roofs, ceilings, walls, internal partitions and floors. Installation of a good insulation product is one of the best and simplest options to reduce the energy consumption of a building.

ECOWOOL insulation’s thermal performance properties were tested in accordance with ASTM C518: Standard Test Method for steady-state thermal transmission properties by means of heat flow meter. Results are as summarized in the table below. When compared to the thermal conductivity results of typical insulation materials (0.035 – 0.16 W/m°K) or stonewool insulation (0.035 – 0.038 W/m°K) at mean temperatures of approximately 20°C, ECOWOOL provides low thermal conductivity, meaning they are highly effective in terms of reducing heat transfer.

No	ECOWOOL Glass Mineral Wool	K Value (W/mK)	Mean Temperature (°C)	Test Report Ref No
1	25mm x 16kg/m3 Blanket	0.03659	20.73	S09MEC00542//TKC
2	25mm x 24kg/m3 Blanket	0.03823	21.48	719178937-MEC10-CPC
3	25mm x 32kg/m3 Blanket	0.03085	22.83	719166283-MEC-1B-CPC
4	25mm x 96kg/m3 Board	0.03061	20.72	S09MEC01495/2/TKC
5	50mm x 10kg/m3 Blanket	0.04431	20.69	S09MEC01495/1/TKC
6	50mm x 16kg/m3 Blanket	0.0397	20.42	54S07405/1/TKC
7	50mm x 20kg/m3 Blanket	0.0384	20.46	54S07405/2/TKC
8	50mm x 24kg/m3 Blanket	0.0361	20.39	54S07405/4/TKC

9	50mm x 32kg/m3 Blanket	0.03321	20.65	S08MEC00209/1/TKC
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Glass mineral wool products also do not absorb moisture, nor does the insulation settle or the thermal resistance (K and R-values) deteriorate over time. Thus, the insulation has the ability to maintain its installed thermal performance for the life of the building.

According to a thermal conductivity test conducted by PSB Corporation, Poly Glass Fibre insulation requires only half of its product density to achieve same thermal performance as compared to a Stonewool insulation product.

D. Improve Indoor Environmental Quality:

Good indoor air quality enhances occupant health and comfort and is an essential goal for any green building.

The U.S. Environmental Protection Agency (EPA) estimates that indoor pollution levels may be two to five times (and potentially up to one hundred times) greater than outdoor pollution levels. Potential threats to indoor environmental quality include the presence of hazardous chemicals, high concentrations of airborne fibers, and smoke, mildew, mold and/or fungus contamination.

Glass mineral wool contains no asbestos or chemical additives. Whereas cellulose or natural fiber insulation products may require additional fire retardant chemical treatments, PGF Glass mineral wool products are naturally non-combustible. Neither the raw materials used in manufacturing nor the finished product contain any ozone depleting chemicals. Also, PGF glass mineral wool products are classified as a non-hazardous substance/non-dangerous good per Manufacturers Safety Data Sheets (MSDS) sheets provided by the manufacturer.

In addition, PGF Insulation offers BROWNIE, a formaldehyde-free version of their glass wool insulation. Air Quality Sciences, Inc., a third party ISO 9001 registered and ISO 17025 accredited company, performed an indoor air quality test on BROWNIE and found that it complies with the GREENGUARD criteria for TVOC, formaldehyde, and total aldehydes. It also complies with the GREENGUARD Children and Schools criteria for the same indoor air pollutants. GREENGUARD is a well-recognized standard for indoor air quality, so BROWNIE's compliance with its criteria means that it is guaranteed to promote a healthy indoor environment.

ASCC/NOHSC and international authorities do not classify glass mineral wool fibers as carcinogenic. Neither raw materials nor the finished product contains any ozone depleting chemicals and product binders will remain intact for the life of the product under normal atmospheric conditions. Glass mineral wool products, once installed, are

not a source of dust² and are not known to cause any negative health effects for building occupants.

ECOWOOL insulation offers excellent acoustical performance. It complies with ASTM standard test methods for sound absorption and sound absorption coefficients by the Reverberation Room Method ASTM C423-90a and E795-92. Its ability to absorb noises transmitted through ceilings, walls and floors helps reduce internal noise pollution and sound transmission from outdoors. Glass mineral wool insulation products may also aid in acoustical control for HVAC systems through their pre-insulated ductwork systems.

Ultimately, once installed, glass mineral wool is a stable product that does not contribute negatively to indoor air quality and helps enhance indoor environment for building occupants.

LEED CREDITS

To earn certification under the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED®) rating system, projects must not only satisfy all LEED system prerequisites, but also earn a minimum number of credits.

Projects may earn a range of sequentially higher LEED certification ratings as determined by their compliance, as well as exemplary performance, in the credit categories within each system.

Green-Buildings believes that PGF Insulation's products may contribute materially toward earning points in a LEED certification in the following prerequisite(s) and/or credit(s)³ under the LEED Green Building Design and Construction Rating System (BD +C, 2009), the LEED Existing Buildings: Operations + Maintenance (EB:O+M, 2009) Rating System and the LEED for Homes rating system (Homes, 2009).

Note that no individual material or product enables a credit or certification within the LEED rating system due to the fact that each category is dependent on the aggregate of all materials and their proportionate relationship to the total dollar cost of all materials.

² It is important to note that handling or removing glass mineral wool materials may result in some dust. Therefore, users are advised wear typical personal protective equipment (PPE) associated with other building construction or demolition activities when handling glass mineral wool products.

³ While Green-Buildings.com believes that certain products have characteristics that may contribute to a LEED certification, only the Green Building Certification Institute (GBCI) may award points and grant certification. Accordingly, Green-Buildings.com does not make any assurances, guarantees, representations, or warranties, expressed or implied, and specifically disclaims all warranties or representations, that products will earn LEED points, or any project that utilizes such products, will receive LEED® certification.

See individual product data for details and check with local sales representative for appropriate product applications and eligibility.

Table 1 - LEED BD+C Contribution Chart

LEED Category and Credit	LEED Requirement	Product Contribution
Energy & Atmosphere (EA)		
Prerequisite 2: Minimum Energy Performance (0 points)	Demonstrate a 10% improvement in the proposed building performance rating for new buildings and 5% in major renovations when compared with the baseline building performance rating as calculated per ASHRAE 90.1-2007 Appendix G using a computer simulation.	Glass mineral wool insulation products help make up an energy-efficient building envelope, which reduces energy associated with heating and cooling the space. In addition, proper application of insulation and continuous coverage helps ensure the thermal properties of the building envelope.
Credit 1: Optimize Energy Performance (1-19 points in New Construction and Schools, 3-21 points in Core & Shell, 1-24 points in Healthcare)	Demonstrate a percentage improvement over the prerequisite amount in the proposed building performance rating compared to the baseline building using a computer simulation.	
Materials & Resources (MR)		
Credit 4: Recycled Content (1-2 points)	Use materials with recycled content such that the sum of post-consumer recycled content plus ½ of the pre-consumer content constitutes at least 10 or 20%, based on cost, of the total value of the materials in the project.	Glass mineral wool insulation has been demonstrated to contain a minimum of 50% post-industrial (pre-consumer) recycled glass content on a dry weight basis.
Indoor Environmental Quality (IEQ)		
Prerequisite 3: Minimum Acoustical Performance (Schools, 0 points)	Design classrooms/core learning spaces to include sufficient sound-absorptive finishes to comply with ANSI standards and meet maximum background noise levels for HVAC systems of 45 dBA.	Glass mineral wool insulation contributes to an acoustically-sound indoor environment.
Credit 7.1: Thermal Comfort, Design (1 point)	Design HVAC systems and the building envelope to meet the requirements of ASHRAE Standard 55-2004, Thermal Environmental Conditions for Human Occupancy.	Glass mineral wool insulation contributes to a comfortable indoor environment through its insulating properties.

Credit 9: Enhanced Acoustical Performance (Schools, 1 point)	Design classrooms/core learning spaces to include sufficient sound-absorptive finishes to comply with ANSI standards to an STC rating of 35 and meet maximum background noise levels for HVAC systems of 40 dBA.	Glass mineral wool insulation contributes to an acoustically-sound indoor environment, and may aid in enhanced acoustical control when applied in interior walls, ceilings and pre-insulated ductwork.
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Table 2 - LEED EB:O+M Contribution Chart

LEED Category and Credit	LEED Requirement	Product Contribution
Energy & Atmosphere (EA)		
Prerequisite 2: Minimum Energy Performance (0 points)	If the building is eligible for an EPA ENERGY STAR rating, it must achieve a performance rating of at least 69, or demonstrate that the energy efficiency is better than 69% of similar buildings.	Glass mineral wool insulation products help make up an energy-efficient building envelope, which reduces energy associated with heating and cooling the space. In addition, proper application of insulation and continuous coverage helps ensure the thermal properties of the building envelope.
Credit 1: Optimize Energy Performance (1-18 points)	Demonstrate a percentage improvement over the prerequisite amount in the building performance rating as determined by ENERGY STAR's Portfolio Manager tool.	
Materials & Resources (MR)		
Credit 3: Sustainable Purchasing - Facility Alterations and Additions (1 point)	Maintain a sustainable purchasing program for facility renovations, retrofits, demolitions and new construction additions. Purchase sustainable materials for 50% of purchases by cost. Sustainable materials should meet one of a number of criteria (i.e. contains least 20% post-industrial material).	Glass mineral wool insulation has been demonstrated to contain a minimum of 50% post-industrial (pre-consumer) recycled glass content on a dry weight basis.
Indoor Environmental Quality (IEQ)		
Credit 2.3: Occupant Comfort - Thermal Comfort Monitoring (1 point)	Have a permanent monitoring and tracking system to ensure that the building is meeting thermal comfort requirements per ASHRAE Standard 55-2004, Thermal Environmental Conditions for Human Occupancy OR ISO 7730: 2005 & CEN standard EN 15251:2007.	Glass mineral wool insulation contributes to a comfortable indoor environment through its insulating properties.

Table 3 - LEED Homes Contribution Chart

LEED Category and Credit	LEED Requirement	Product Contribution
Energy & Atmosphere (EA)		
Prerequisite 1.1: Optimize Energy Performance - Performance of ENERGY STAR for Homes (0 points)	Meet the performance requirements of ENERGY STAR for Homes.	Glass mineral wool insulation products help make up an energy-efficient building envelope, which reduces energy associated with heating and cooling the space. In addition, proper application of insulation and continuous coverage helps ensure the thermal properties of the building envelope.
Credit 1.2: Optimize Energy Performance - Exceptional Energy Performance (1-34 points)	Exceed the performance requirements of ENERGY STAR for Homes. Use the Home Energy Standards (HERS) Index to calculate the appropriate number of LEED points.	
Materials & Resources (MR)		
Credit 2: Environmentally Preferable Products (1-8 points)	Use environmentally preferable products that meet one of the criteria chosen by USGBC (i.e. contains 25% post-consumer recycled or 50% pre-consumer recycled content).	Glass mineral wool insulation has been demonstrated to contain a minimum of 50% post-industrial (pre-consumer) recycled glass content on a dry weight basis.

CONCLUSION

PGF Insulation's glass mineral wool products meet four significant criteria used in green building initiatives. Through its recycled materials, fire resistant material qualities, and excellent acoustical and thermal insulating properties, glass mineral wool insulation can improve building durability, maximize energy efficiency, enhance indoor environmental quality, and minimize impact on the environment through decreased usage of raw materials for building construction.

These characteristics make PGF Insulation's products applicable for projects with sustainable, high-performance goals, and/or for projects pursuing LEED certification.