

UBC Social, Ecological Economic Development Studies (SEEDS) Student Reports

An Investigation into Sustainable Alternatives for Building Components

Oliver Kaulfuss

Amrit Mahal

Chris Cable

University of British Columbia

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An Investigation into Sustainable Alternatives for Building Components

Oliver Kaulfuss

Amrit Mahal

Chris Cable

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Dr. Carla Patterson

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ABSTRACT

This report investigates a sustainable alternative to a building component, and more specifically focuses on insulation. This report and research was done to develop suggestions in relation to the construction of the new Student Union Building at the University of British Columbia. Insulation was chosen due to its importance in the energy management of a building. The proper insulation leads to interior building comfort with good energy efficiency, no energy waste, and the lowest operating costs. The goal was to compare the most common option for insulation to a more sustainable alternative option using a triple bottom line assessment. The triple bottom line assessment looked not only at economic factors, but also took social and environmental factors into consideration.

This report compares the most common insulation material, fibreglass, to an alternative, cellulose insulation made from recycled newspaper. It examines: the employment opportunities and health concerns in the social aspect; the embodied energy, manufacturing processes, packaging, recycled content, and energy use in the environmental aspect; and the material costs, installation costs, and energy savings in the economic aspect.

The research showed that the employment opportunities are similar for each product, while the health concerns from cellulose insulation were less than with fibreglass insulation. Cellulose insulation had a much higher recycled content than fibreglass and also required much less energy to produce. The material and installation costs of cellulose insulation are higher than fibreglass, but the effectiveness of cellulose is greater than fibreglass. This results in less costs for heating and cooling and the initial cost of installation will be recovered in lower building operating costs. For these reasons cellulose insulation should be considered for use in the construction of the new Student Union Building.

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GLOSSARY

Batt - a sheet of matted cotton, wool, or synthetic fibers.

Cellulose - an inert carbohydrate, $(C_6H_{10}O_5)_n$, the chief constituent of the cell walls of plants and of wood, cotton, hemp, paper, etc.

Endotoxin - A toxin produced by certain bacteria and released upon destruction of the bacterial cell.

Fibreglass - a material consisting of extremely fine filaments of glass that are combined in yarn and woven into fabrics, used in masses as a thermal and acoustical insulator, or embedded in various resins to make boat hulls, fishing rods, and the like.

Insulate – to cover, line, or separate with a material that prevents or reduces the passage, transfer, or leakage of heat, electricity, or sound.

R-Value - a measure of the resistance of an insulating or building material to heat flow, expressed as R-11, R-20, and so on; the higher the number, the greater the resistance to heat flow.

1.0 INTRODUCTION

This report is an investigation into a sustainable alternative for a common building material, and will compare the most common insulation material to an alternative insulation material. The decision to analysis insulation was supported following the presentations of Allan Dobie and John Robinson, concerning “Net Zero Housing”, and the new “Centre for Interactive Research on Sustainability”, respectively. These presentations described the utter importance of insulation on the interior comfort, energy use and energy efficiency of a building.

The chosen insulation will potentially be used in the construction of the new Student Union Building (SUB) at the University of British Columbia. The choice of insulations to compare was complicated by the unknowns involved with the new SUB building, with no design plan in place, the potential types of insulation to be used were unknown. As a group, we wanted to compare two products that would be used no matter what design was chosen for the SUB. We narrowed the scope of the project and decided to compare the most common and one alternative type of insulation used in interior wood framed walls.

The comparison of the two insulation types was done with a triple bottom line assessment, where social, environmental, and economic aspects are all taken into account. After determining the most commonly used material and choosing what alternative to look at, we compared fibreglass insulation to cellulose insulation with a triple bottom line assessment.

2.0 MATERIAL SELECTION

Our first task was to determine what insulation products we would compare as our most commonly used and alternative material.

2.1 MOST COMMON MATERIAL

Our initial assumption was that fibreglass insulation was the most commonly used. We contacted two construction material suppliers, Home Depot and Northern Building Supply, and asked what type of insulation they sold the most of and what type they thought was most common. Both suppliers confirmed our assumption.

2.2 ALTERNATIVE MATERIAL

In order to determine our alternative material, we did web research to get an overview of some of the alternatives available. We found an array of options that included: soy based spray foam insulation from recycled plastics, pre consumer recycled denim insulation, cellulose insulation from recycled newspapers, as well as sheep's wool and hemp based insulations. We chose to examine cellulose insulation due to its high percentage of recycled content, simplicity of materials used, non toxicity, and because of the versatility of installation.

Cellulose insulation comes in two types: loose fill and wet blown. Loose fill is dry, and is installed with a hose and blower through holes in the exterior sheeting. It is mostly used in attics, sloped roofs and floors. Wet blown cellulose insulation is mixed with water to make it similar to a paste. It is then sprayed directly onto unfinished walls. It forms to all contours, must be trimmed before drywall is applied, and requires a longer drying time.

3.0 SOCIAL COMPARISON

The comparison of social aspects between fibreglass and cellulose insulation consisted of an analysis of employment opportunities and health concerns.

3.1 EMPLOYMENT OPPORTUNITIES

The employment opportunities for each insulation type consist of manufacturing and installation.

Both products are currently manufactured at various locations throughout North America by companies that include Johns Manville (fibreglass) and Green Fiber (cellulose). Therefore, the use of a particular insulation instead of another will not create, or utilize, more manufacturing or transportation jobs in North America. The number of installation jobs for each insulation type is equal as well. A contractor will not have to hire out more people to install either product. Normally, two skilled and professionally trained installers are required for either product (Breum, Schneider, Jorgensen, Valdbjom Rasmussen, & Skibstrup Eriksen, 2003, p. 655).

3.2 HEALTH CONCERNS

The main social concern concerning insulation is the health concerns of the installers and the final building occupants. The health concerns regarding insulation are mostly based on the chemical additives used as glues, fire retardants and mould retardants. The use of fibreglass as an insulation material itself was a concern but has been taken off the list of known carcinogenic materials (NAIMA, 2005).

The largest concern with the current use of fibreglass insulation is the use of formaldehyde based glues used in production. This use leads to the exposure of formaldehyde directly during installation and through off gassing for the products lifetime. Formaldehyde is a known toxic material and also carcinogen with serious health concerns (National Cancer Institute, 2009). Its

use has been in decline recently with companies now offering formaldehyde free fibreglass insulation, for example Johns Manville.

The chemicals used as fire and mould retardants are not easily traceable. The main chemical in cellulose insulation is boric acid. It is mixed in dry and does not chemically bond to the cellulose (Breum et al., 2003, 654). Boric acid exposure is not considered a health concern, especially in the low levels of exposure from insulation (SSPM, 2009). Contact exposure to chemicals during cellulose installation is not as much of a concern as fibreglass due to cellulose insulation being blown in with machines.

There is a concern for exposure to dust particles with installation of both types of insulation. An experiment was done to measure “personal exposure to dust and fibers, the dust was analyzed for content of endotoxin and some trace elements (boron and aluminum) from fire-retardant or mold-resistant additives” (Breum et al., 2003, 653).. The experiment also looked at the amount of dust in the materials. Cellulose was found to be very dusty while fibreglass was found to be not dusty. The dust level corresponded directly to dust and fibre inhalation. Low exposure to inhalation was found for fibreglass, while higher risk of inhalation was found for cellulose, which included boron exposure (Breum et al., 2003, 668).

Both types of insulation have a risk involved with their installation. The itch, and more importantly the risk of chemical contact from fibreglass have to be considered against the exposure to dust and fibres from cellulose insulation. After installation the off gassing from the chemical additives of both insulations has to be considered. The exact chemical makeup of the additives is very difficult to determine, but all research has shown that there is greater concern with fibreglass insulation, especially if the use of formaldehyde is present, versus the boric acid exposure of cellulose.

3.3 CONCLUSION

We believe that cellulose insulation is the better product considering the social aspects. The employment opportunities for both insulations are similar, while the health concerns, especially concerning off gassing, are believed to be more severe for fibreglass insulation.

4.0 ENVIRONMENTAL COMPARISON

The decisions people make in choosing building products can affect the earth's environment more than one may think. When considering cellulose insulation versus fibreglass insulation it is important to research the environmental impacts each has. To weigh the negative and positive impacts of each insulation material it may be wise to consider their complete life cycle.

4.1 RAW MATERIAL IMPACTS (TREES AND SAND)

Cellulose insulation and fibreglass insulation are both recycled products; cellulose being recycled from news paper and fibreglass being recycled from glass bottles and other glass material. The production of news paper and glass may, in a way, feed off its recycled value of these two insulation materials (*Secondary Energy Info Book, 2004*).

Trees are cut down in our forests, transported, ground up into wood chips, cooked into pulp, rolled and then dried into paper which is then used for news paper. Therefore, when choosing cellulose fibre insulation, one is supporting the forestry industry and the environmental impact the forest industry places on the earth. Fibreglass insulation is produced from glass products which originate from heated sand. This may have less impact on the earth's environment. The majority of people would likely favour choosing the consumption of sand over the consumption of our forests; therefore, support fibreglass insulation over cellulose insulation in this aspect.

4.2 RAW MATERIAL PRODUCTION IMPACTS (PRODUCTION OF PAPER AND GLASS)

Producing news paper from trees and glass from sand takes another environmental consideration when choosing between these insulations. "To produce a ream (500 sheets) of cop paper requires 27, 500 Btu's of energy, the equivalent of about two gallons of gasoline. In 1973, it required 47, 500 Btu's, or the equivalent of 3.7 gallons of gasoline, to produce the same amount of paper (*Secondary Energy Info Book, 2004*).” To produce glass containers from raw materials in the ground, on average, requires 21.9+/-4.2 MJ per kg of saleable glass produced

(Jancock, 2009). The majority of this energy comes from natural gas to run each of these two production plants; this in turn supports the fossil fuel industry which has a very high negative impact on the environment. Producing paper requires the least amount of energy consumption and lower negative impact on the fossil fuel industry.

4.3 RECYCLABILITY IMPACTS

After considering the environmental impacts in making news paper and glass it is then important to consider their recyclability. Newspaper is far easier for people to recycle, due to its homogenous make up in comparison to glass bottles containing plastic/paper wrap and varied materials used for caps (Black, 2010). The overall energy consumptions required to recycle newspaper is far less than recycling glass products. 66% of the energy required to recycle a glass product goes into recycling the non-glass items (Black, 2010). As well, glass products support other materials such as plastic wrapping and packaging (Black, 2010). The plastic industry has a huge negative impact on the environment. Considering a newspaper's recyclability, one may choose cellulose insulation over fibreglass insulation.

4.4 IMPACTS OF PRODUCING INSULATION

After the recycled material is available the production of the cellulose insulation and fibreglass insulation can begin. Cellulose fibre is made up of 70-80% recycled newspaper or other cellulose products and 20-30% chemicals (Furst, 2009). Fibreglass is made up of 30-40% recycled material and 60-70% raw material (Furst, 2009). To produce fibreglass in a plant requires approximately 10 times the energy than producing cellulose fibre insulation in a plant (Furst, 2009). Cellulose insulation plants can easily be turned on/off at any time and are often turned off during coffee, lunch and any other time needed to save energy (Superseal, 2009). Fibreglass production plants continually run and require a complete shutdown, usually done to provide maintenance to any faulty equipment (Furst, 2009).

4.5 PACKAGING IMPACTS

Packaging in today's world has had a major impact on the environment. Cellulose and fibreglass insulation packaging should be accounted for when looking at the environmental

concerns. Packaging varies with each company from organic to inorganic packaging. The largest difference between the two insulations would be the amount of packaging needed. An example of this is: insulating 500 sq. ft. of space requires 30 packages of fibre glass which is approximately equal to 100 packages of cellulose fibre insulation (NAIMA, 2009). The chart down bellow illustrates this.

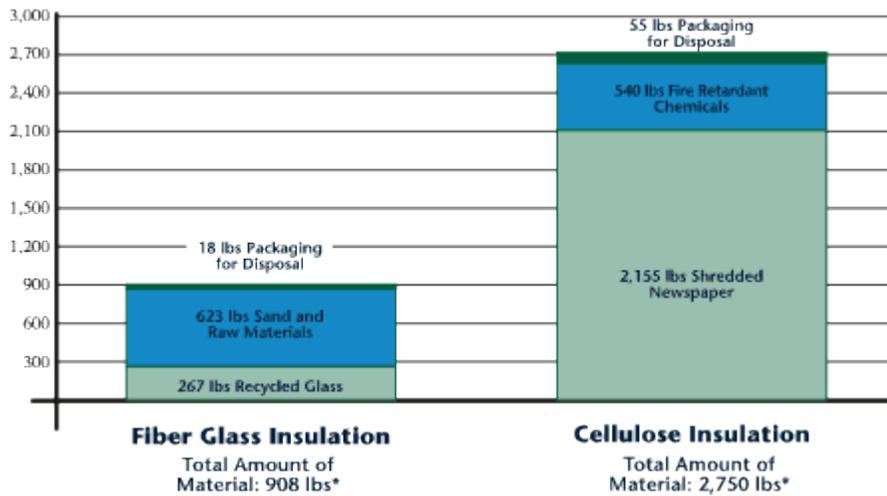


Figure 1 - Waste content of packaging cellulose fibres vs. fibreglass insulation, Source: NAIMA (2009)

4.6 HOME ENERGY SAVINGS IMPACTS

Once these two insulations are ready to install, they can provide insulation to buildings. Cellulose insulation is generally the better insulation to use for home energy savings. Cellulose fibres insulation can be blown into odd shaped cavities resulting from wires, electrical boxes and pipes (Superseal, 2003). Fibreglass insulation is cut to fit into spaces between/around wires, electrical boxes and pipes; however air voids still exist in far greater quantities than when cellulose insulation is used (Superseal, 2003). Cellulose insulation is shown to be 38% tighter than fibreglass insulation and requires 26% less energy to install (Superseal, 2003). A Princeton University study has shown that homes containing cellulose insulation have a 24.5% reduction in air infiltration compared to homes containing fibreglass insulation (Superseal, 2003). These numbers clearly explain that homes containing cellulose insulation results in reduced energy consumption. Reduced energy consumption is proportional to a reduced environmental impact (lower fossil fuel consumption).

4.7 CONCLUSION

When considering different environmental impacts of cellulose insulation against fibreglass insulation it may not be a clear cut solution to pick the more environment friendly solution. Cellulose insulation supports the forest industry's negative environmental impact. Cellulose and fibreglass insulation both support the fossil fuel industry's negative environmental impacts; however, cellulose insulation has the lesser impact in this case. Future home energy savings is favoured by cellulose insulation and this is proportional to the lesser environmental impact. Cellulose insulation may be recommended to have a lesser environmental impact.

5.0 ECONOMIC COMPARISON

The comparison of economic aspects between fibreglass and cellulose insulation is made up of insulation efficiency, material costs, and installation process comparisons.

5.1 INSULATION EFFICIENCY

R-value is the ability of a material to resist heat flow. The higher the value the more effective the material is as an insulator. When comparing fibreglass insulation as opposed to cellulose, their R-values are very similar. Loose fill cellulose insulation has an R-value is approximately R-3.5 per inch of thickness (Fisette, 2005). On the other hand, Fibreglass insulation has an R-value of R-3.2 per inch of thickness. This number varies from R-3 to R-4 depending on the quality of the installation of the material. When cellulose insulation is densely packed, its R-value can increase from R-3.5 to R-4.0 per inch of thickness (Fisette, 2005). However, this is not what makes cellulose unique.

The ability for cellulose to resist air leakage more than fibreglass is what puts cellulose over the top in terms of insulation materials. While both fibreglass and cellulose depend on trapped air for its insulation, cellulose is more naturally resistant to the conduction of heat due to the wood fibre and the cellulose structure of the wood (Fisette, 2005). When searching for a great insulating material this is an area of concern as many materials will have approximately the same R-value depending on how densely it is packed. The greater the insulation efficiency, the less money a building operator will have to spend on heating and cooling. In terms of building operating costs, fibreglass is more expensive than cellulose insulation.

5.2 MATERIAL COSTS

Currently, there are only about 10% of houses using cellulose as a form of insulation, leaving a lot of room for growth for this product (Fisette, 2005). Cellulose uses about 200 times less petro-energy and also manufacturers receive “green” points because it requires less energy to produce than fibreglass. However, when looking at the energy cost per installed R-value; fibreglass takes about 8 times more energy to produce than cellulose insulation. Even though more cellulose is needed to receive the same R value, the amount, and therefore cost, of production energy required is much lower. Even though the production energy required is lower,

the lesser use of cellulose insulation results in a higher material cost to the consumer than fiberglass insulation. Therefore, if cellulose insulation was more widely used the consumer's price for material should drop below fiberglass insulation.

5.3 INSTALLATION PROCESSES AND COST

The different installation methods and associated costs of cellulose and fiberglass will be discussed.

5.3.1 CELLULOSE BLOWN-IN

This type of insulation is a great option for attics and retrofits but can also be used for new structures (Cellulose Insulation vs. Fiberglass). The great part about this form of installations is that there is no need to remove any existing wall fixtures. However, special equipment is needed in order to maximize cellulose's insulating ability, see figure 2. At least two people are required to complete the job and they should preferably be trained professionals. As a bonus, trained professionals can insert cellulose into walls where there is already some fiberglass.



Figure 2 - Blown in Cellulose Insulation (Green Solutions Magazine, 2008)

5.3.2 CELLULOSE SPRAYED

This method is very effective for open wall cavities in new construction as you can spray dampened cellulose directly into the opening in the wall, see figure 3. It uses the same material as the blown-in process which is recycled newspaper with some chemical additives. This method involves the use of a hose with a high-pressured nozzle, resembling a pressure washer, attached (Fisette, 2005). After it has been installed, there is a 2-day drying period where the moisture content of the fibre is to drop below 25%. The time may vary depending on the temperature of the environment. The complete coverage of this installation is very eco-friendly as it is densely packed therefore taking up less space leaving no voids in the walls.

The spraying method is very messy though. Windows, doors, and electrical boxes must be protected prior to installation (Fisette, 2005). Also, the fibre that's wasted needs to be cleaned up as the installation process goes along.



Figure 3 - Sprayed Cellulose Insulation
(Celebar International Cellulose, 2010)

5.3.3 FIBREGLASS

When installing fibreglass, protective equipment is needed just as when installing cellulose. The difficulty with fibreglass is making sure it is cut so that it can fit around wires,

electrical boxes, and pipes (Superseal, 2003), see figure 4. This can be very time consuming. In addition, unlike cellulose professional installation is not required but, as with cellulose, the R-value is very dependent on the quality of installation (Fiberglass and mineral wool insulation). Fibreglass comes in two forms: loose-fill and batts. Loose-fill can seal air spaces best since it is blown in, preventing air movement and heat loss. On the other hand, batts installed at low-density are common but can lose up to 50% of its R-value in cold climates, while high-density batts cost more but will have a higher R-value even in cold climates (Green Home Guide, 2009). However installation is less expensive than that of cellulose as the materials are much more common and are used in majority of buildings today.

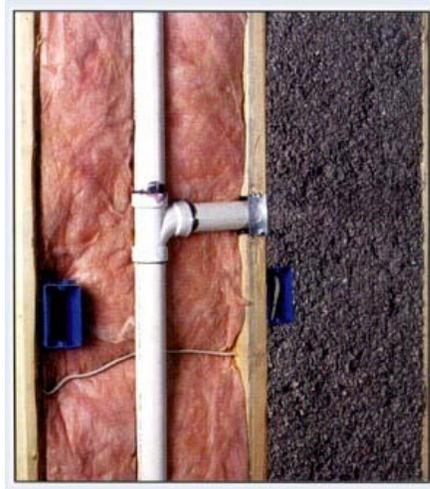


Figure 4 - Fibreglass (L) and Cellulose (R) Insulation
(Houle Insulation Inc., 2009)

5.4 CONCLUSION

We can confidently say that when it comes to the economic aspect of this comparison cellulose is the better option. Even though the costs for installation and material are a bit higher than fiberglass, in the long run the cost of the structure's heating is much less. This creates a quieter indoor environment as the densely packed cellulose creates an airtight, more comfortable living and working area.

6.0 CONCLUSION AND RECOMMENDATIONS

The research to find a sustainable alternative to a particular building component consisted of analysing social, environmental, and economic aspects, and compared fibreglass insulation to cellulose insulation. This analysis showed that cellulose insulation outperformed fibreglass insulation in each category.

Cellulose insulation outperforms fibreglass insulation in the social analysis due to the lesser risk of exposure to toxic chemicals during installation and during a buildings lifetime. These chemicals are not from the main insulation material, but from the glue and chemical additives used to prevent mould and fire. Cellulose is favoured in the environmental comparison due to the large amount of recycled material incorporated into the product, and due to the lesser amount of embodied energy used in its production. Cellulose insulation also can provide better insulation than fibreglass and therefore reduce energy use in buildings. This is an environmental and economic advantage of cellulose insulation compared to fibreglass. Currently the upfront cost of cellulose insulation is higher than fibreglass, as are the installation costs, due to its lesser use in the construction industry.

Currently the use of fibreglass insulation is the most popular insulation choice due to its low cost, ease of installation, and, most importantly, the widespread knowledge of its installation. This report has shown that cellulose insulation is recommended over fibreglass when examining social, environmental, and economic aspects. With the greater focus on sustainability, healthier and greener products in today's society, the use of cellulose insulation should increase. This would lead to more certified installers and further increase the use and decrease the cost. With the construction of the new SUB, UBC has an opportunity to support a more sustainable product and lifestyle, and could increase the use and awareness of cellulose insulation, and prove that it could be a viable alternative to fibreglass insulation.

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