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An Investigation into the use of Linoleum and Hemp in the New SUB: A Triple Bottom Line Assessment

Kevin Bergen

Keenan Moe

Lekuku Lets

Lucy Li

University of British Columbia

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An Investigation Into The Use Of Linoleum and Hemp In The New SUB:

A Triple Bottom Line Assessment

Submitted to: **Carla Paterson**
Date: **March 31,2011**

Completed By:
Kevin Bergen
Keenan Moe
Lekuku Lets
Lucy Li

ABSTRACT

As the campaign for sustainable housing increases globally and across UBC, the demand for rapidly renewable resources rises. There is a swift increase in the number of new buildings, including the new Student Union Building's Platinum+ goal, that are aiming to achieve various Canada Green Building Council's LEED certifications(Canadian Green Building Council). The purpose of this study is to conduct a triple-bottom line analysis on linoleum and hemp, with specific focus on hempcrete, to determine whether these constituents are viable rapidly renewable building materials suitable for use in the new SUB. This paper includes extensive journal research, primary data collection in the forms of surveys and interviews, and secondary data compilation such as government videos, blogs, and various other sources.

From an environmental perspective, both linoleum and hemp can be harvested with relative ease, and are greenhouse gas emissions neutral and negative, respectively. There are minimal usage of pesticides and toxic chemicals during the production and maintenance phase. Each material is biodegradable so waste sent to landfills does not negatively impact the environment. Moreover, from an economic standpoint, linoleum is one of the cheapest rapidly renewable materials available, while hemp despite its initial high production price is highly subsidized, thereby driving the domestic prices down. The low operation and maintenance cost of each material makes them great economic solutions for extended lifetimes. Lastly, the social impacts of choosing linoleum and hempcrete are notable. Not only do linoleum and hemp encourage the growth of local producers, leading to a rise in local employment, but they also create a comfortable and aesthetically pleasing environment for the occupants. Linoleum and hemp are both very durable and therefore, resistant to demanding conditions over a long time period. This radically reduces the required maintenance work, and lends these materials to be very effective in high traffic locations.

Based on the findings from the triple-bottom line analysis, it is determined that linoleum and hemp are both exceptional materials that exceed the LEED's rapidly renewable material requirement. However, because neither material can be obtained locally within the 500 mile radius, the local criteria cannot be met.

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LIST OF ILLISTRATIONS

GLOSSARY

Embodied energy - Energy required to make, transport, and dispose of material.

Fiber - the outermost, durable, part of the hemp plants' stalk.

GHG negative – pulls more CO2 from the atmosphere than it produces

Hempcrete - a mixture of hurds, a lime-based binder, water, and pozzolan.

Hurds (shives) - The inner, wood-like, part of the hemp plants stalks providing strength.

Indica - Cannabis genus grown for recreational and medicinal drug purposes

Layout Waste – Waste produced from installation, left overs that were not used.

Net Present Value – the evaluation of a product over its useful life, calculated seen from the value today.

Pozzolan - a material that acts like cement when combined with calcium hydroxide

Sativa (hemp) - Cannabis genus grown for industrial use.

Turnover rate - Total time it takes to grow and harvest and replant.

Yield – An amount of product grown.

LIST OF ABBREVIATIONS

CO_2 - Carbon Dioxide

LCA - Life Cycle Analysis

LCC – Life Cycle Cost

LEED - Leadership in Energy and Environmental Design (LEED) Green Building Rating System

NPV – Net Present Value

RRM - Rapidly Renewable Materials

SO_2 – Sulfur Dioxide

SUB - Student Union Building

VOC - Volatile Organic Compounds

1.0 INTRODUCTION

The new Student Union Building is trying to acquire Canada Green Building Council's LEED Platinum+ certification (Canadian Green Building Council). LEED platinum is achieved by acquiring 80 points out of the possible 100, with additional 6 points for innovation in design and 4 points for regional priority. The use of rapidly renewable materials can help attain the MR Credit 6. This requires that that 2.5% of the total value of all building materials and products used in the project based on cost must consist of one or a combination of rapidly renewable materials (Canadian Green Building Council). Rapidly renewable materials by definition must be plant based and have a regeneration and growth cycle of less than 10 years.

This report will present an evaluation of linoleum and hemp, with specific focus on hempcrete. Conclusions will be drawn upon whether linoleum and hemp are optimal RRMs that will aid the overall qualifications for the MR Credit 6, especially the local contents requirement. Our team has conducted the research and assessment of linoleum and hemp usages in the new SUB based on the triple-bottom line analysis by specifically investigating the environmental, economic and social impacts.

2.0 BACKGROUND

Detailed below are brief descriptions of linoleum and hemp.

2.1. LINOLEUM

Linoleum, invented in 1863, is a biodegradable material that can be used for material will crack (Wikipedia, 2011). Linoleum, when installed and maintained properly, has a life expectancy of roughly 40 years due to its exceptional durability (Contempo Floor Coverings, (a)). It is also extremely versatile, and can therefore be used in a multitude of areas, such as flooring, decorations, and even counter tops.

Linoleum consists mainly of linseed oil (27%); colophonim (8%); limestone(10%); ground wood (10%); ground cork (10%); and pigment (5%), which is usually titanium dioxide. (Potting, & Blok, 1995, and Jonsson, Tillman, & Svensson, 1997, pp. 3). The main ingredient, linseed oil, is extracted from flax, which is an annual crop grown mostly in western Canadian prairies and Argentina. The extraction process can be completed in two ways: through hydraulic pressure or using heat and pressure (Knudsen, 2007, pp. 4059-4067). Despite the fact that flax is mostly grown in Canada, linoleum's main producers are located in either United States or Europe, with the largest manufacturer situated in Kirkacldy, UK, owned by Switzerland-based Forbo Group (Wikipedia, 2011).

2.2. HEMP

Hemp, a plant from the Cannabis genus, Sativa, is grown for industrial purposes. It is, however, commonly mistaken for the Cannabis genus, Indica, a strain that produces psychological effects due to its THC content (5 up to 20%). Nevertheless, studies have shown that negative side effects from Sativa are negligible (West, 1998). Sativa is chosen industrial use due to its long, soft, durable, fibrous properties that provide immense amounts of strength (International Year of Natural Fibers, 2009). The plant's fiber (the outer layer of the stalk) constitutes 25% of its mass, while the remaining 75% attributes to the hurds (the wood-like material in the center of the stalk), also known as shives. The principal producers of hemp are located in China, Canada, France, Germany, Chile, and Korea (International Year of Natural Fibers, 2009), with British Columbia producing 158 acres out of the total 26,815 acres from Canada in 2010 (Government of Alberta, 2011). Due to hemps strength and durability, it can be used as different types of fabrics, biofuel, plastics, and hempcrete.

Hempcrete is a hemp-lime composite material similar to concrete most commonly used for wall insulation. It is a mixture of hurds and a lime-based binder, typically with small amounts of water and pozzolan (sand or cement). Its primary producers are located in United States, England, France, and Ireland.

3.0 POSSIBLE USES IN NEW STUDENT UNION BUILDING

Detailed below are potential uses of linoleum and hemp in the new SUB at the University of British Columbia.

3.1. LINOLEUM

Linoleum can be used in three main capacities for the new Student Union Building: flooring, furniture, and decoration.

Linoleum, due to its resilient and enduring properties, is an ideal flooring material. It can be used for high traffic hallways, entrances, dance studios, and club rooms where a significant influx of students is expected (Wikipedia, 2011). It can also be installed in the potential new daycare center and numerous kitchen areas because of its ample cushioning.This will reduce the number of accidents for the children and kitchen staff, as well as breakage of dropped kitchenware. Moreover, linoleum is substantially water resistant, making it another great candidate for bathroom and kitchen flooring, where occasional water accumulation may occur. Even if impromptu water damage does occur, linoleum can be renovated by painting over the top coat without stripping off the entire floor (Contempo Floor Coverings, (b)). However, for areas where water might come up from the sub-floor, particularly in the basement, linoleum should not be considered (Salgado, 2011).

Furthermore, linoleum can be manufactured in an assortment of colors and designs, which allows for different arrays of wall coverings to be constructed, including artistic murals, or even 3D wall coverings. In addition, because of its malleable property, linoleum can be used to create defining sculptures inside the new SUB. Another possible application of linoleum is for counter tops in kitchens, bathrooms, and daycare centers, where excessive amounts of scratches are expected to incur (Potting, & Blok, 1995).

3.2. HEMP

The different parts of hemp can be incorporated into distinctive parts of the new Student Union Building, including fabrics, paper, fuel, plastic, and building materials.

The fibrous strands of hemp are ideal for fabrics due to their increased durability over cotton. They can be used as rugs, carpets, as well as various couches and chair coverings (The Information Distillery). Hemp hurds, naturally acid-free and unlikely to deteriorate over time, are alternatives that can be incorporated in paper production. This will lead to a reduction of overall waste produced by the SUB. Nonetheless, hemp hurds, because of their resilience, can also be used during the building construction phase in the form of hempcrete. Possible applications include foundations, walls, roofs, floors, shingles, paneling, and pipes, with the exception of load bearings supports. Furthermore, biofuel can be extracted from hemp to fuel diesel generators that produce electricity to power building appliances, thereby decreasing total external energy consumption (Whitis). Lastly, plastic can be created from hemp – a more environmentally friendly alternative to petroleum-based plastics due to hemp's improved strength and freedom from toxic chemicals (The Information Distillery).

4.0 TRIPLE BOTTOM LINE ANALYSIS

For the remainder of this report, the Triple Bottom Line analysis will focus on hempcrete, a specific use of hemp, as well as linoleum.

4.1. ENVIRONMENTAL ANALYSIS

4.1.1. Linoleum

Through the primary use of LCA the advantages and disadvantages will be discussed below. Although linoleum can be used for more then flooring applications, this analysis will look at the comparison and effects of linoleum as a flooring solution due to the content of research material.

Advantages

Linoleum presents the majority of its advantages when compared to similar resilient floor finishes like vinyl. Comparing the LCA flow charts in Appendix A the apparent advantage linoleum has is its use of natural ingredients. The use of these natural ingredients is biodegradable can in fact offset a lot of the GHG emissions produced during its manufacturing (Lozada-Figueroa, 2004, pp 1-3). For example, "In the waste handling of the old linoleum GHG emissions are avoided because the energy from incineration substitutes energy from coal. Since these avoided emissions are larger than the emissions from manufacturing of the new linoleum we end up with a negative net emission" (Petersen, & Solberg, 2004, pp. 143-167).

Analyzing the graphs in Appendix B we can see that linoleum does uses a lower amount of scarce renewable materials, most likely due to the regrowth of flux crops annually. We can also see that linoleum has slightly lower net energy consumption over vinyl, however as mentioned before if we include the offset to coal use this consumption is further reduced. Lastly, looking at the major emissions linoleum generates less CO_2 gas due to its CO_2 neutral harvesting of linseed oil and little to no dust particles (Petersen, & Solberg, 2004, pp. 143-167). In full environmental analysis, "The difference between linoleum and vinyl flooring is less clear, and depends on what environmental parameters are considered most important" (Moussatche, & Languell, 2001, pp. 1-4).

Disadvantages

When comparing to other resilient flooring solutions linoleum has apparent advantages regarding many environmental aspects. However, when we extend our environmental analysis to include more flooring options the advantages begin to reduce.

When comparing to the next commonly compared hardwood flooring option linoleum has a reduced incentive for usage. Using the tables from Appendix B again for the analysis we can see that linoleum consumes more net energy then hardwood. Both of these flooring options do provide energy offsets to coal burning however the potential offset for hardwood is still much greater. Continuing the comparison, linoleum produces greater SO_2 and VOC, as well as overall material waste including 6% layout waste (Jonsson et al., 1997, pp.).

4.1.2. Hempcrete

Advantages

Due to the fact that hempcrete is extracted from hemp hurds, the following analysis of hempcrete will first describe the environmental advantages of hemp, then narrow down to the growth, transportation, materials and processing, and energy aspects of hempcrete.

Hemp has a short turnover rate. It takes approximately 90 to 120 days (3 to 4 months) for hemp to grow 10 to 20 feet tall and be ready for harvesting.

Consequently, it can produce four times the yield of trees and eight times that of cotton. Hemp, impervious to diseases, requires minimal agrochemicals during the growth cycle, thus lowering the amount of chemical contamination of soil. Moreover, as an adaptable plant, hemp grows in most climates and enriches poor soils after every crop (American Lime Technology, 2008).

Hempcrete, unlike concrete, produces no toxic by-products, off gases, and high embodied energy, and creates less site waste due to increased efficiency in the building process (Watson, 2010). It is also much less energy intensive because of its high thermal mass and insulating properties, therefore lowering the heating and cooling emissions necessary to maintain a comfortable room temperature. At the end of hemp's lifecycle, it can be reused as building material or even broken up to fertilize gardens, as it is biodegradable (American Lime Technology, 2008, and Goran Homes).

Another significant advantage of hempcrete is that its greenhouse gas negative. Hempcrete absorbs more carbon dioxide from the atmosphere than it produces in its lifecycle, thereby reversing the effects of global warming. Throughout the process of manufacturing from crop to building the material sequesters, hempcrete stores approximately 108 kg of CO2 per m3 of wall (Watson, 2010). This value is greater for roofing material with a theoretical maximum is 165 kg. For each acre of hemp, approximately 4.6 tonnes of carbon dioxide are emitted from manufacturing and processing, while approximately 8.9 tonnes of carbon dioxide are absorbed during its useful lifetime (Watson, 2010). This is based on the Manitoba average of 2.5 dry-tonnes of hemp yielded per acre (Manitoba Agriculture, Food and Rural Initiatives). Refer to Appendix B for calculations. Moreover, hempcrete continues to sequester "carbon as lime" as "the hempcrete calcifies over time," effectively reducing the amount of greenhouse gases in the atmosphere (Hemp News, 2011).

Hempcrete Natural Building Ltd., the local manufacturer of hempcrete (Allin, 2011), purchases hemp hurds from a processing facility in Manitoba (Hendyrson, 2011). With the remainder of the essential materials obtained locally and the mixing of hempcrete done on site, their product is produced with minimal transportation emissions. Implementing this RRM material into the SUB would decrease the buildings ecological footprint, bringing it closer to the LEED platinum+ requirement.

Disadvantages

Despite the fact that hempcrete is greenhouse gas emission negative, it does however emit some GHG in its production period since lime and hurds are required during processing. Nevertheless, as discussed above, the amount of GHG absorbed in hempcrete's lifetime will exceed the GHG generated; hence, this caveat can be overlooked. Moreover, from the lack of projects in BC, there are currently no local hemp producers, effectively leading to a subsequent lack of local processing facilities. Currently, hempcrete projects must purchase hurds from Manitoba. This contributes to an additional transportation distance of approximately 1,870 km from Winnipeg, Manitoba to Vancouver, BC, causing increased emissions during shipping phase (Travel Math).

4.2. ECONOMIC ANALYSIS

4.2.1. Linoleum

The economic analysis of linoleum is best compared through a life cycle analysis of NPV per square foot for a given lifetime. The chart in Appendix C estimates the life cycle NPV of a variety of flooring solutions. The figure is calculated in US dollars, and based off US wages and standards (Moussatche, & Languell, 2001, pp. 1-4). Keep in mind, that "Life cycle costing should not be confused with Life Cycle Assessment which includes the whole life of the material including environmental accounting; life cycle cost includes only the economic values used to compare the cost of different material alternatives over the serviceable or useful life span" (Moussatche et al., 2001, pp. 1-4).

Advantages

The clear advantages of linoleum from an economic point are its long useful lifetime, and its relatively inexpensive O&M costs. These factors play a large role in reducing the lifetime cost of linoleum per. square foot. The O&M is 73% of that associated with vinyl floors (Moussatche et al., 2001, pp. 1-4). Directly comparing the LCC of all the flooring options linoleum is the most cost effective resilient flooring solution at approximately $117 per square foot. It provides a more expensive but still competitive LCC to alternative soft flooring solutions like carpet. Linoleum is even cheaper then a few of the hard flooring systems. When we directly compare the LCC of the other RRM flooring systems like, cork, rubber and bamboo linoleum is $72.68 cheaper then the second lest expensive rubber, and $177.46 cheaper then bamboo the most expensive alternative.

Disadvantages

The only major economic disadvantage behind linoleum flooring is its increased capital cost over non-rapidly renewable materials. The LCC of linoleum is also much large then hard flooring solutions with a comparable life span. With an initial capital cost 5 times higher then exposed concrete it is much more expensive to buy, install and maintain. The best flooring solution for The SUB should be based on the quality and necessary functions of the flooring, using his economic analysis as a guide to the best financial solution to meet those needs (Moussatche et al., 2001, pp. 1-4). How, ever linoleum may be too high of a cost to justify its use over less expensive floorings.

4.2.2. Hempcrete

This economic impact analysis will be discussed relative to Industrial Hemp production as it is the main source of Hempcrete.

Advantages

Hemp is resistant to rodents, fungus, and many weeds, which makes it easy to maintain because there will be limited or no use of pesticides, herbicides and insecticides (Rodie, 2009, pp. 1). This leads to a major reduction of maintenance cost. Despite the fact that hemp is cheap to maintain, the costs of production vary. In fact, the average budgeted cost of starting hemp production is based on a minimum of 10 acres, and is quite expensive. See Appendix D for budget costs but overall hemp production is viable.

Furthermore, hempcrete houses are highly insulated, making the building easier to heat in the winter and easier to keep cool in the summer. This effectively reduced the heating and cooling costs of the building. “In many tests...when installed, the energy efficiency of hemp a building and insulating materials surpasses expectations” (ULC). As a matter of fact, present hempcrete houses serve as an extremely cost effective alternative to reduce operating costs.

Moreover, the Canadian government provides subsidies and has invested in hemp production since hemp was legalized in Canada (Government of Alberta, 2011). These benefits encourage potential farmers to farm hemp as the revenue margin increases annually. The investment and subsidies have also reduced hemp price. In a CNN video it is reported that the government is planning to remove taxes on hemp trades .

Furthermore, hempcrete buildings have a very long life. This is attributed to the material properties of hemp being fibrous and durable. Although building with hempcrete is initially expensive compared to other materials, it will likely outlast the lifetime of its competitors. This is due to the lime content in the hempcrete mixture constantly calcifying, turning to stone-like material consequently making the material more durable and stronger. Studies in Europe have estimated 600-800 year life span for the wall system (Department of Agricultural Economics, 1998). Implementing hempcrete in the SUB would significantly reduce operating costs and provide a long lasting building which reduces the total cost over the lifetime of the building.

Disadvantages

Hemp is a tall, densely branched plant with a strong fiber core that is difficult to harvest. This forces farmers to resort to traditional hand cutting methods in most places. The Germans, however, have introduced an alternative harvesting method for fiber separation by using steam and ultrasonic waves. Consequently, the cost of such a machine is not feasible with the current market demand. Implementing such a system would surely increase the import cost of hemp products (Government of Alberta, 2011). In addition, the past hemp restriction is preventing further innovations in the hemp manufacturing sector as some manufactures believe that the market may still be volatile; therefore, the risk outweighs the benefits. This is illustrated by the decrease in Canadian hemp production by 68% in 2007 (Government of Alberta, 2011). Refer to Appendix E for Canadian hemp production details.

Finally, storage and transportation costs are higher than average for to two reasons. One, in order to maintain exceptional quality, hemp requires special protection from microbial breakdown; especially in humid areas like Vancouver. Two, the estimated storage costs of hemp range from $13.22 to

$14.23 per ton based on a six month storage period--this cost includes repairs, insurance, and losses (Ehrensing, 1998). Furthermore, the vast majority of hemp is exported, further increasing the shipping costs.

4.3. SOCIAL IMPACT

Detailed below are the social advantages and disadvantages of linoleum and hempcrete.

4.3.1. Linoleum

Despite the fact that linoleum serves only as a building material, it contributes considerably to the social welfare of those who produce and use it. The benefits of using linoleum are illustrated by evaluating how the structure, design, amount of maintenance work, and the potential emerging domestic producers affect the users, while the disadvantages are described by the mainstream misconception, release of VOCs and its accompanying odor when treated improperly.

Advantages

Linoleum flooring, manufactured in a myriad of colors, can be installed in prominent areas of the new SUB as powerful media that illustrate a general message to students, staff, faculty and visitors through means of wall coverings, murals or even sculptures. These compositions will help strengthen the UBC spirit. Linoleum can also be used to decorate certain club or lounge rooms to acquire the precise environment as linoleum can be pieced together in striking patterns (Contempo Floor Coverings, (b)). The themed lounges that are being built can be achieved effortlessly in order to convey the ambiance suitable for any occasion.

Moreover, linoleum requires minimal maintenance to preserve its immaculate condition; only regular mopping and an annual polish are necessary for an optimal finish (Contempo Floor Coverings, (a)). This will drastically decrease the level of work needed from the maintenance workers, and thereby increase their overall level of welfare. As previously mentioned, linoleum also has a relatively supple surface (Jonsson et al., 1997, pp.). This crucial property will aid the reduction of the severity of accidents in kitchens, bathrooms and daycare centers if they do arise. Furthermore, Canada currently does not have any large linoleum manufacturers despite its extensive comparative advantage in the production of flax (Flax Council of Canada). If LEED specified buildings, such as the new SUB, become more prevalent, there can potentially be an influx of demand that can stimulate the emergence of domestic producers. This will raise the overall employment level in neighboring linoleum industries and in the long run, the welfare of those related to the linoleum production lines.

Disadvantages

The mainstream society has been influenced to desire mass amounts of high-end marble and hardwood, as they are the symbols of status. Despite its renowned title as the one of the greenest and most affordable materials, linoleum is often misunderstood and interpreted as a cheap and classless material (Contempo Floor Coverings, (a)). Many only consider linoleum as an economical alternative as opposed to the greener choice. To some viewers, the use of linoleum may mislead them to infer the SUB as an unrefined piece of architecture due to the lack of expensive materials. In addition, linoleum releases low levels of VOCs as mentioned in the environmental analysis during its lifecycle; however, the VOC levels detected are harmless to human health (Knudsen, 2007, pp. 4059-4067). Needless to say, despite being accepted by the Canadian Health Agency, the public generally does not want to use any type of material that releases any amount of unsafe chemicals. Moreover, linoleum when treated improperly may have an unpleasant smell that may require extended periods of ventilation (Knudsen, 2007, pp. 4059-4067). This can cause tremendous inconveniences to users during its life period and the discomfort may hurt the reputation of linoleum.

4.3.2. Hempcrete

There are significant social advantages of using hempcrete as it benefits both the society and individuals. Detailed below are effects of hempcrete on the community, how it creates a healthy and comfortable living environment, as well as a public survey regarding hempcrete awareness and potential use.

Advantages

The social benefits of hempcrete can affect the community in a variety of ways. The cultivation of the plant "supports biodiversity" and provides a "transition to organic farming" (Hemp News, 2011). Hempcrete also "supports local and regional sustainable development, employment creation, and eco-innovations" that aid present and future generations by encouraging the expansions of sustainable housing (Hemp News, 2011). In addition, Jayeson Hendyrsan, owner of Hemp Natural Building Ltd., stated that if there were more hempcrete projects in BC, a BC processing facility would likely be constructed to complement the existing BC hemp farms. The increase of demand will likely stimulate a growth of employment, leading to an eventual rise of overall societal welfare.

Hempcrete is more lightweight, safer, and easier to work with than concrete, resulting in a less labour intensive manufacturing and installation process (American Lime Technology, 2008). Houses built with hempcrete are also "healthier than conventional houses," and by adapting such material into our new SUB, a more comfortable, aesthetically pleasing living environment can be created (Pawlik-Kienlen, 2008). Hempcrete has all of these beneficial aesthetic qualities for the following reasons: it is non-toxic and mould resistant resulting in better air quality (important as North Americans typically spend 90% of the day indoors (Hemp News, 2011)); it also exhibits high vapour permeability that allows the walls to reduce condensation and moisture in the building and self-regulate the moisture content (American Lime Technology, 2008); furthermore, it has the ability to store heat due to a U-value of 0.040 KW/m; last but not least, it is fire resistant (American Lime Technology, 2008); and have the ability to absorb approximately 90% of airborne sound. Consequently, it is not surprising that "hemp buildings and insulation products have won numerous awards and commendations from technical and health experts" in Germany, the UK and elsewhere (Hemp News, 2011).

During the course of this research, 20 members of society were randomly selected and surveyed (10 UBC students, 10 middle aged adults). The participants were asked if they were aware of hempcrete, and then informed of the aforementioned social benefits. They were also asked if they will consider hempcrete when building a house, commercial building or the like. See Table 1 below for the results. The people who replied no or were hesitant generally felt they require more information or were happy with the current technology of traditional houses.

Table 4.1 Hempcrete Survey Results

	Is aware of hempcrete as a building material	Would potentially use hempcrete as a building material	
		yes or likely	no or hesitant
UBC Students, Undergrad (Randomly selected)	0	8	2
Adults, 30+ yrs old (Randomly selected)	1	6	4

Disadvantages

The disadvantages of hempcrete are not plentiful in nature, but they do have a significant effect on the industry. Foremost, hempcrete is not ULC (Underwriters Laboratories of Canada) rated. ULC is "a key architect of the Canadian National Safety System, administered by the Standards Council of Canada (SCC)" (ULC). Without testing and certification by the ULC, the government will not take responsibility in the event of a failure (Hendyrsan, 2011). As a result, architects are not able to design buildings using hemp that meet building standards, for example, fire rating.

The implementation of hempcrete in commercial and residential industries is further limited through US politics that prohibit the manufacturing and processing of hemp. This effect is then rippled through the global market due to the dominant role United States plays on the global market. This ban is attributed to the negatively portrayed image of hemp associated with cannabis (West, 1998). As a result, some farmers view the market as volatile and are hesitant to invest in furthering the industry through larger crops and processing plants (West, 1998). Consequently, due to the latter reason, the public must be well informed of the difference between hemp and cannabis before any misinterpretations form and cast a negative veil onto the sustainable new SUB.

5.0 CONCLUSION & RECOMMENDATION

In conclusion to the environmental, economic, and social analysis' we have conducted on two rapidly renewable materials for use in the construction of the new Student Union Building:

- Linoleum consisting of flax seed oil
- Hemp for the use in hempcrete

We have evaluated each material on its advantages and disadvantages in each of the criteria and have developed strong understanding and recommendations regarding the materials.

Linoleum

Using the triple bottom analysis technique, it was concluded that although linoleum is not manufactured within 500 miles of UBC, its strong social befits, relatively neutral carbon footprint, its biodegradable properties and low economic LCC make it a viable solution for a green surface covering. It's wide range of color and patterns, and versatility make it very appealing for a wide rang of uses. Linoleum also meets all of the MR Credit 6 criteria for rapidly renewable materials in the LEED scoring platform. All of these unique qualities make linoleum a low maintenance, user friendly solution for the new student union building while helping to achieve LEED Platinum+.

Hemp

Through the triple bottom line analysis of hemp, it is determined that there are many advantages of hemp; in particular, hempcrete. The advantages are numerous and outweigh the disadvantages in each assessment. The material is environmentally friendly, is high yielding, grows rapidly, fully recyclable, provides a healthy living environment, and is durable and strong. Regarding the new SUB project, walls, floors, and roofs could be constructed from hempcrete, supported by a structural framework made from concrete, steel, or timber. The material provides a comfortable living space, and the operating costs of the building would be effectively reduced through decreased heating and cooling costs. Although the material (hurds) are currently expensive, a project such as the SUB could be the driving force behind British Columbia constructing a processing facility for BC grown hemp, reducing the material costs and increasing the sustainable factor as transportation could be less than 500 miles from Vancouver, BC.

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APPENDIX A

Shown below are the flow charts for the three major flooring options compared in the environmental analysis of linoleum flooring. These flow charts show the complete environmental life cycle of linoleum, vinyl, and hard wood flooring.

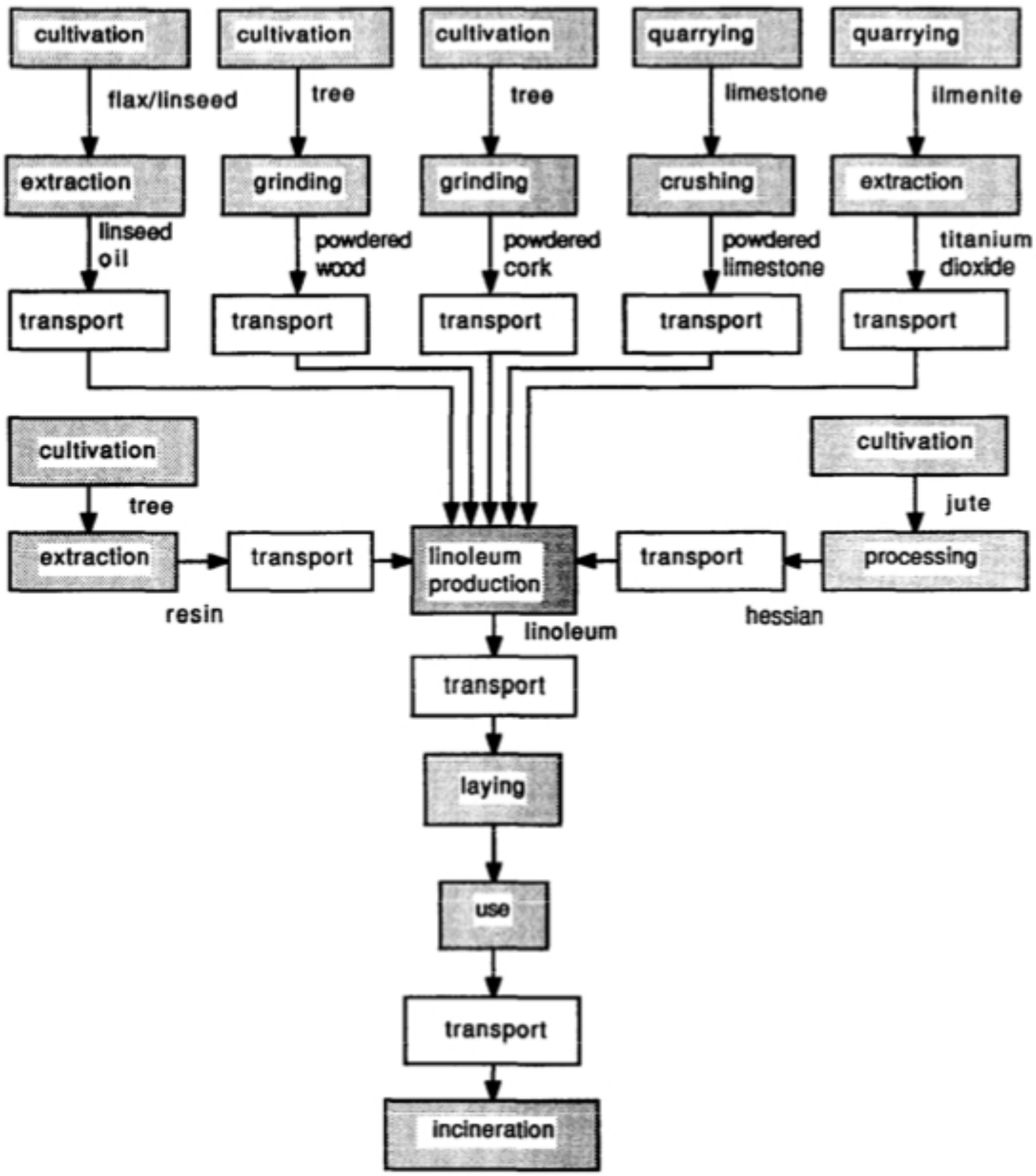

Fig. 1. Flow chart for linoleum.

Jonsson, A., Tillman, A.M., & Svensson, T. (1997, May). Life Cycle Assessment of Flooring Materials: Case Study. *Technical Environmental Planning.* doi:10.1016/S0360-1323(96)00052-2

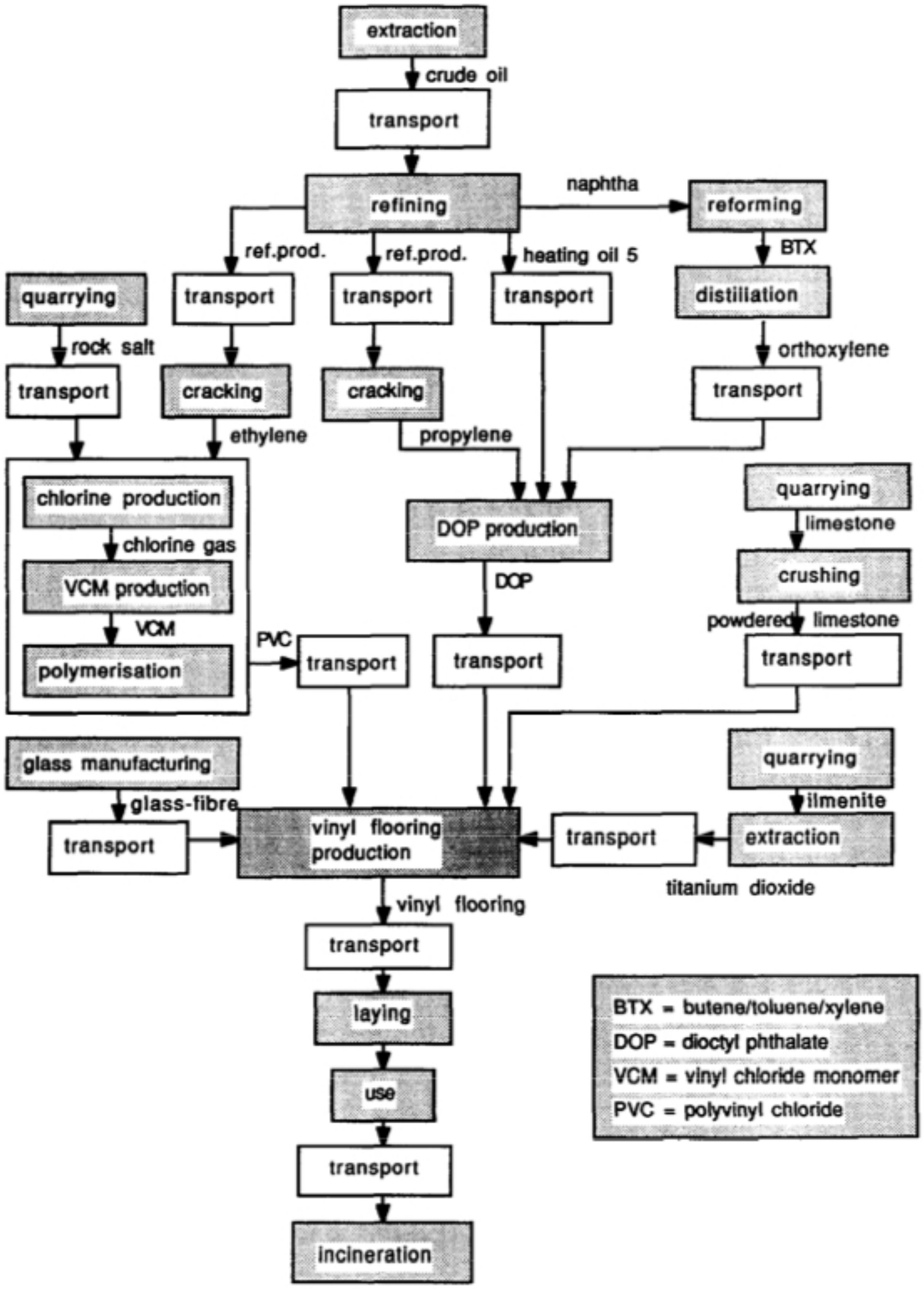

Fig. 2. Flow chart for vinyl flooring.

Jonsson, A., Tillman, A.M., & Svensson, T. (1997, May). Life Cycle Assessment of Flooring Materials: Case Study. *Technical Environmental Planning*. doi:10.1016/S0360-1323(96)00052-2

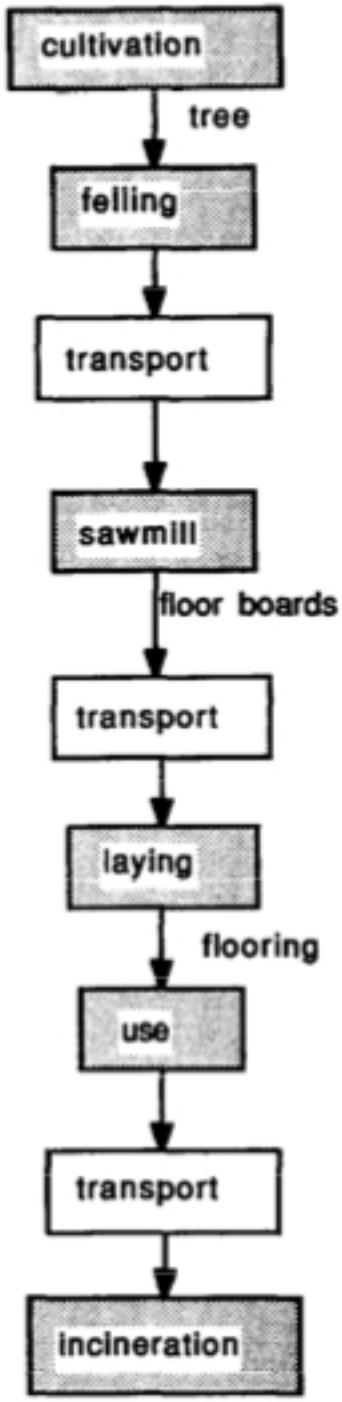

Fig. 3. Flow chart for solid wood flooring.

Jonsson, A., Tillman, A.M., & Svensson, T. (1997, May). Life Cycle Assessment of Flooring Materials: Case Study. *Technical Environmental Planning*. doi:10.1016/S0360-1323(96)00052-2

The bar graphs pictured below directly compare linoleum, vinyl flooring and solid wood flowing against the four major contributions to GHG emissions:

- Resource use
- Energy use
- Emissions
- Waste generation

Using these graphs we can directly compare the environmental impact of each flooring solution in the several components that contribute to the overall GHG emssions on a yearly basis.

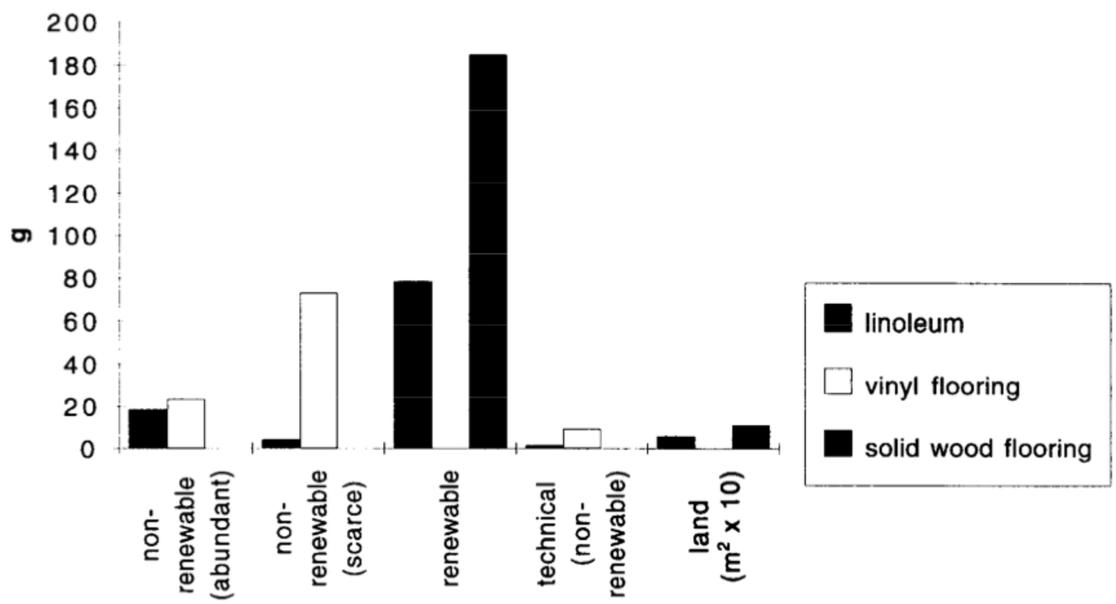

Fig. 4. Resource use per functional unit (year and m^2) flooring material.

Jonsson, A., Tillman, A.M., & Svensson, T. (1997, May). Life Cycle Assessment of Flooring Materials: Case Study. *Technical Environmental Planning.* doi:10.1016/S0360-1323(96)00052-2

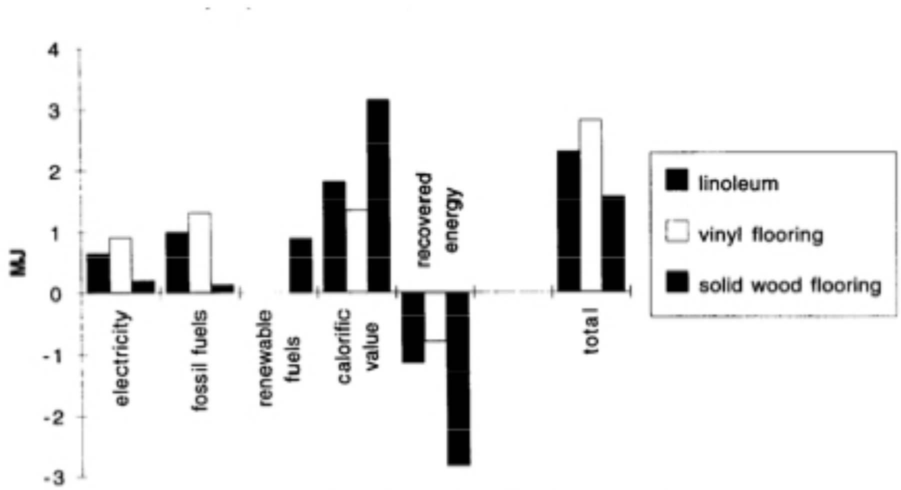

Fig. 5. Energy use per functional unit (year and m²) flooring material.

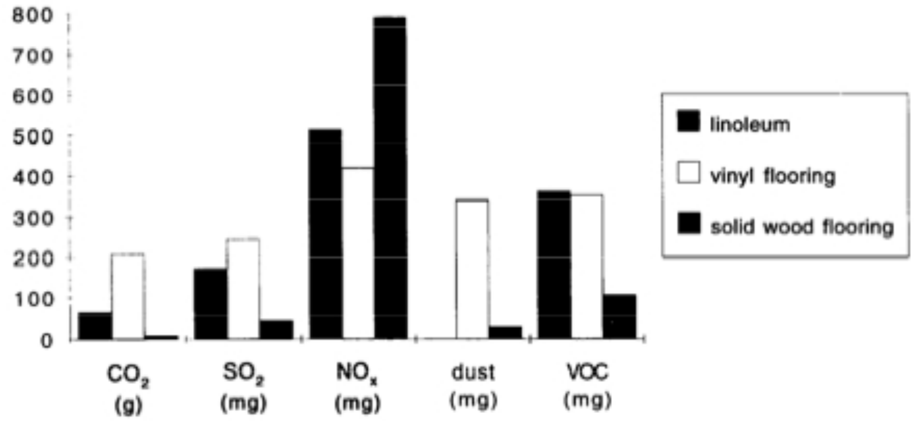

Fig. 6. Emissions to air per functional unit (year and m²) flooring material.

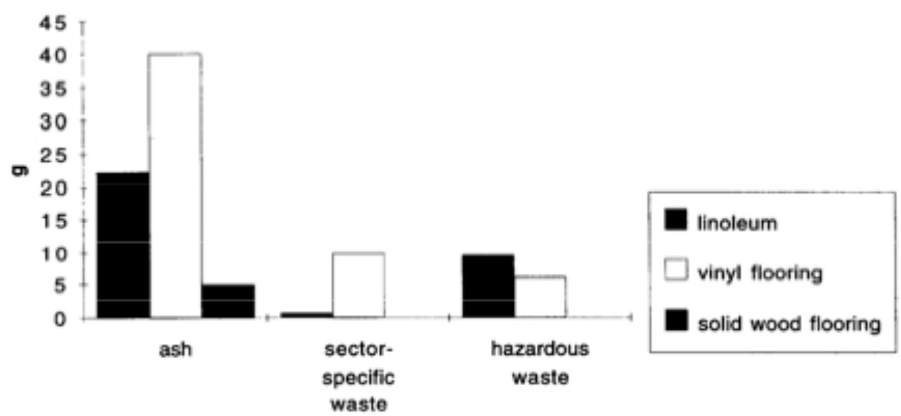

Fig. 7. Waste generation per functional unit (year and m²) flooring material.

Jonsson, A., Tillman, A.M., & Svensson, T. (1997, May). Life Cycle Assessment of Flooring Materials: Case Study. *Technical Environmental Planning.* doi:10.1016/S0360-1323(96)00052-2

APPENDIX B

CO2 produced during manufacturing and processing of hemp, annually:
1.84 tonnes CO_2/tonne hemp produced
2.5 tonnes hemp produced/acre (Manitoba)
1.84 tonne CO_2/tonne hemp * 2.5 tonne hemp/acre = 4.6 tonne CO_2 produced/acre

CO2 absorbed during growth of hemp, annually:
22 tonnes CO_2 absorbed/hectare = 8.9 tonnes CO_2 absorbed/acre

Conclsuion:
Hemp absorbs nearly twice the amount of CO_2 than it produces.

APPENDIX C

HARD FLOORING SYSTEMS

IDENTIFICATION NUMBER & RANKING	FLOORING SYSTEMS	CAPITAL COST	SYSTEM SERVICE LIFE	NUMBER OF REPLACEMENT SYSTEMS	NPW OF REPLACEMENT SYSTEMS	MAINTENANCE AS A PERCENTAGE OF CAPITAL COST	MAINTENANCE COST	TOTAL NPW OF O&M	TOTAL COST OF SYSTEM IN NPW
1	Ceramic Tile (6"x6"x1/2") Mortar & Grout	$7.31	50	0	$0.00	1.00%	$0.07	$8.25	**$15.56**
2	Ceramic Tile (6"x6"x1/2") Mastic & Grout	$6.69	30	1	$16.24	2.00%	$0.13	$15.09	**$38.02**
3	Quarry Tile Mortar & Grout	$6.70	35	1	$18.85	2.00%	$0.13	$15.11	**$40.67**
4	Exposed Concrete Sealant (2 coats)	$0.79	50	0	$0.00	76.00%	$0.60	$67.72	**$68.51**
5	Terrazzo (1 3/4") Cast in place	$7.10	50	0	$0.00	8.00%	$0.57	$64.07	**$71.17**
6	Epoxy resin	$1.60	12	4	$2.28	37.00%	$0.59	$66.78	**$85.16**
7	Laminated wood (synthetic core) vapor barrier & adhesive	$12.00	20	2	$21.67	5.00%	$0.60	$67.68	**$140.50**
8	Wood plank (2 1/4") vapor barrier & urethane	$9.31	30	1	$22.60	24.00%	$2.23	$252.03	**$283.94**
9	Bamboo flooring vapor barrier & adhesive	$13.22	25	1	$27.68	17.00%	$2.24	$253.50	**$294.40**

RESILIENT FLOORING SYSTEMS

IDENTIFICATION NUMBER & RANKING	FLOORING SYSTEM	CAPITAL COST	SYSTEM SERVICE LIFE	NUMBER OF REPLACEMENT SYSTEMS	NPW OF REPLACEMENT SYSTEMS	MAINTENANCE AS A PERCENTAGE OF CAPITAL COST	MAINTENANCE COST	TOTAL NPW OF O&M	TOTAL COST OF SYSTEM IN NPW
1	Linoleum (.125") Adhesive	$4.50	30	1	$10.92	20.00%	$0.90	$101.52	$116.94
2	Vinyl Composition Tile (VCT) Adhesive	$1.43	15	3	$11.11	86.00%	$1.23	$138.72	$151.25
3	Vinyl Sheet Adhesive	$2.05	15	3	$15.92	60.00%	$1.23	$138.74	$156.71
4	Rubber Sheet (1/8") Adhesive	$5.30	10	4	$46.85	23.00%	$1.22	$137.50	$189.65
5	Cork (1/8") Adhesive	$3.43	6	8	$66.11	36.00%	$1.23	$139.28	$208.82

SOFT FLOORING SYSTEMS

IDENTIFICATION NUMBER & RANKING	FLOORING SYSTEM	CAPITAL COST	SYSTEM SERVICE LIFE	NUMBER OF REPLACEMENT SYSTEMS	NPW OF REPLACEMENT SYSTEMS	MAINTENANCE AS A PERCENTAGE OF CAPITAL COST	MAINTENANCE COST	TOTAL NPW OF O&M	TOTAL COST OF SYSTEM IN NPW
1	Carpet tile (18"x 18", 20oz/syd) Hard back	$2.21	10	4	$19.53	29.00%	$0.64	$72.29	$94.04
2	Carpet tile (18"x 18", 2o oz/syd) Cushion back	$2.51	12	4	$26.33	25.00%	$0.63	$70.78	$99.62
3	Carpet (Nylon loop pile 40oz/syd) Adhesive	$3.61	11	4	$34.74	18.00%	$0.65	$73.30	$111.65

Moussatche, H., & Languell, J. (2001). Flooring materials-life cycle costing for educational facilities. *University of Florida.* 19, 10, 333-343. Retrieved from http://www.kntiledesign.com/Upload/File /lifeCyclesCostStudy1.0.pdf

Table I LCC asumptions

Inflation rate	3 per cent (Energy, 1997). This rate was used to inflate the capital cost of each flooring alternative to determine the replacement cost and to inflate the operation and maintenance costs associated with any given flooring system
Discount rate	None (0 per cent as required by the FDOE)
Operation and maintenance	Derived from equipment and supplies used, the time consumed for each procedure, the required frequency of performance, the number of people involved, and the average wages and labor fees in Florida
Building service life	50 years
Capital cost	Derived from manufacturer's data and appropriate installation costs
System service life	Derived from information provided by the product manufacturer and observations. Service life assumes manufacturer recommended cleaning and maintenance is preformed
Number of replacements	The appropriate number of replacements for each system was assumed to support the educational institution for a 50-year service life
Salvage value	The LCC assumes no salvage value of system at time of replacement

Moussatche, H., & Languell, J. (2001). Flooring materials-life cycle costing for educational facilities. *University of Florida.* 19, 10, 333-343. Retrieved from http://www.kntiledesign.com/Upload/File /lifeCyclesCostStudy1.0.pdf

APPENDIX D

Table 2. Industrial Hemp - Costs and Returns per Acre

Land Rent				
Operating Expenses	**Fibre Only**	**Grain Only**	**Grain & Fibre**	**Budget**
Seed $9.90/kg. 40 & 20lb./ac	180	90	90	
Fertilizer 11-52-0 @ 70 kg/ha Urea @200 kg/ha 0-0-50 @ 100 kg/ha	106	106	106	
Fertilizer Application (Custom)	7	7	7	
Herbicide				
Pesticide				
Fuel 29L at $0.55	16	16	16	
Repairs, Maintenance and Depreciation	20	20	20	
Crops Insurance Premiums	20	12	14	
Police Security Check	5	5	5	
Global Positioning	10	10	10	
THC Sampling and Testing	40	40	40	
Harvesting	15 Swather and Mowing	60 Combining	15 Swather and Mowing	
Raking/tedding: 2 passes @ $10	20		20	
Baling (Custom)	53		27	
Trucking (Grain = $12/t, Straw = $17/t)	51	4	30	
Straw Storage 7 sq. feet per bale	45		23	
Grain Drying $0.30 per lb.		24	24	
Grain Storage				
Stalk Shredding		10		
Consulting/Labour				
Interest in Operating: *10% for 6 months*	29	20	25	
Total Operating Expenses	**617**	**424**	**532**	

Table 3. Revenue

Operating Expenses	**Fibre Only**	**Grain Only**	**Grain & Fibre**	**Budget**
Expected Yield, Fibre___t. @ $___				
Expected Yield, Grain___Lbs. @ $___				
Yield per Acre: Fibre 3.0 t @ $17	510			
Fibre: 1.5t @ $120			180	
Grain: 800 lbs. @ $0.50		400	400	
Total Revenue	**510**	**400**	**580**	

http://www.omafra.gov.on.ca/english/crops/facts/00-067.htm#harvesting retrieved: 22/03/2011

APPENDIX E

Table 4. Hemp Production by Province (Canada), 1998 - 2010 (Acres)

Year	BC	Alberta	Sask.	Man.	Ontario	Quebec	NB	NS	PEI	Yukon	Canada
1998	178	94	650	1,497	2,873	59	529	47	0	0	**5,927**
1999	556	1,862	7,640	21,950	2,523	212	10	312	10	0	**35,075**
2000	719	756	3,522	7,179	535	590	2	252	4	0	**13,559**
2001	237	279	968	1,165	516	74	0	0	0	10	**3,239**
2002	495	304	1,110	1,474	351	47	0	0	0	0	**3,781**
2003	18	379	1,661	3,625	981	32	10	44	0	0	**6,750**
2004	44	1,577	2,480	4,089	451	26	10	44	0	0	**8,721**
2005	0	2,263	8,469	12,395	620	182	47	44	0	0	**24,021**
2006	273	5,194	14,882	26,442	982	224	20	44	0	0	**48,060**
2007	173	3,593	5,663	5,157	99	450	10	0	0	0	**15,145**
2008	12	1,437	3,798	2,453	20	331	0	0	0	0	**8,050**
2009	207	1,932	5,090	6,015	325	228	0	0	39	0	**13,837**
2010	158	5,152	10,409	9,384	919	793	0	0	0	0	**26,815**

http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/econ9631 retrieved: 23/03/2011