UBC Social Ecological Economic Development Studies (SEEDS) Student Report

An Investigation into the Life Cycle of PVC and its Alternatives using Three-Bottom-Line Assessment

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Group G: Red-Listed Materials

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ABSTRACT

The University of British Columbia (UBC) is well-known for striving to implant environmental sustainability in every inch on its ground. One of the most outstanding strategies was to establish the University Sustainability Initiative (USI) as a leading society to sustainability, incorporating sustainability learning and research opportunities. To further integrate the students and the faculties to the UBC sustainability programs, UBC SEEDS (Social, Ecological, Economic, and Development Studies) was established as the first sustainability integration academic program in Western Canada.

At the same time, the new SUB construction project was launched, and it is expected to be completed in 2014. In parallel to the objective of UBC sustainability policies, the new SUB design team is now striving for the Leadership in Energy and Environmental Design (LEED) Platinum Certificate. In order to obtain LEED Platinum, red-listed materials are to be avoided in the design as much as possible. One of the most common red-listed materials is polyvinyl chlorine, generally known as PVC.

The three-bottom-line assessment is done on PVC, in order to evaluate how the life cycle of PVC affects the environment, the society and the economy. The assessment shows that the life cycle of PVC largely contributes to negative environmental impacts, such as green house gas emission, global warming, energy consumption and waste construction. Although PVC costs low, it is potentially hazardous to human health.

Possible alternatives to PVC are examined, in order to eliminate the negative impacts of PVC as much as possible. In this matter, the assessment shows that wood is the most environmental-friendly alternative. Other building materials such as aluminium, ethylene propylene (EPDM) and polyethylene (PE) are proven to be a better alternative to PVC building components. In terms of the social impact of PVC, the history of PVC antagonism, due to the health hazard caused, is presented in the assessment.

In conclusion, PVC is indeed one of the largest contributors to negative environmental impacts, as well as a socially-undesirable and economically-inefficient product. Moreover, it is possible to be substituted with environmentally, economically and socially-better materials. Therefore alternatives presented in the assessment should be implemented into the new SUB Building, in order to achieve LEED Platinum.

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GLOSSARY

Abiotic Depletion:	Reduction in the number or quantity of nonliving components of the biosphere, such as rocks and minerals
Acro-osteolysis	A disease resulted in destruction of bones, characterized by clubbed fingers, bone deterioration, heart and metabolic problems, skin changes, and muscle anomalies
Angiosarcoma	A type of cancer characterized by rapidly duplicating and extensively penetrating cells derived from blood vessels, causing loss of structural differentiation within a cell or group of cells
Chlorinated PVC	A modified form of PVC used for hot water pipes
Cross-linked polyethylene	A modified form of polyethylene used for hot water pipes
Ethylene Propylene	A type of rubber that is used as insulation of high voltage cables
Elastomer Polyolefin	A class of polymers that can be used to substitute PVC for a better performance for all aspects and situations
Kyoto Protocol:	An International agreement, binding 37 countries and the European Community to reduce green house gas emission
Raynaud's Syndrome	A disease resulted in constriction of blood vessel, characterized by highly sensitive, cold and prickling fingers
Reburning:	A process whereby a hydrocarbon fuel is injected immediately downstream of the combustion zone to establish a fuel-rich zone in order to convert nitric oxide to HCN

Plasticizers:	A chemical substance added to plastics or other materials to make them more flexible
Phthalates:	A group of man-made chemicals as plasticizers in PVC
Polyethylene	A plastic material used for piping

LIST OF ABBREVIATIONS

CO_2	Carbon Dioxide
CH_4	Methane
CPVC	Chlorinated PVC
EPDM	Ethylene Propylene
NO_x	Nitrogen Oxides
HCl	Hydrogen Chloride
PE	Polyethylene
PEX	Cross-linked polyethylene
PVC	Polyvinyl Chloride
TPO	Elastomer Polyolefin

1.0 INTRODUCTION

Polyvinyl chloride (PVC) is one of the most mass produced materials with a long controversial history, low economic cost, extensive physical properties and it is largest client of the chlorine industry. On the way to reach the LEED certificate for new SUB, there were a number of complexities. Additionally, partial or full elimination of PVC is one of the predominating factors. In order to fulfil requirements and show plausibility of environmental construction, undertaking examination of the current market for possible alternatives was an indispensible start.

The uniqueness of PVC is attributable to the polar molecular structure of vinyl chloride due to the presence of chlorine atoms that inexplicably were a triggering cause for early examination of polymer’s toxicity and continuous supervision of the industry. The continuous battle for more than 60 years between PVC and environmental organizations demonstrates the towering vigour of corporations for defending and dominating on the current market despite numerous environmental and health care problems associated with the plastic [11].

This report demonstrates the availability and possible utilization of alternative materials with equivalent economical and environmental assets that are fundamental components of a sustainable development. Understanding the full broadness of PVC applications, this report provides comparative examination on the window frame, piping, roofing and flooring alternatives with a particular focus on wood which is the most valuable material, widely used for its remarkable properties, i.e. high strength, low specific weight, good insulation properties and availability [6]. The ultimate and focal idea of the report is a disclosure and a demonstration of misperception of PVC as the only solution for affordable and dependable construction.

2.0 ENVIRONMENTAL IMPACTS OF PVC AND WOOD

In this report, a life cycle analysis (LCA) is performed that compares PVC to wood in terms of impact onthe environment during their entire life cycles. This life cycle includes the resource acquirement phase, the production phase, the use phase and the recycling/disposal phase [2]. More specifically, the following environmental comparison is narrowed down into three main environmental aspects: green house gas emission and global warming, energy consumption and waste construction.

2.1 GREEN HOUSE GAS EMISSION AND GLOBAL WARMING

The green house gases are defined as, according to the Intergovernmental Panel on Climate Change (IPCC) assessment report user guide, natural and synthetic gases that "absorb and emit radiation at specific wavelengths within the spectrum of thermal infrared radiation emitted by the Earth's surface, the atmosphere itself, and by clouds" [8]. Examples of green house gases are carbon dioxide (CO_2), nitrogen oxides (NO_x), methane (CH_4), hydrogen chloride (HCl) and dust [8].

2.1.1 PVC

Figure 1 (below) shows the amount of green house gases emitted during the life cycle of PVC. This section of the report focuses specifically on the manufacturing process, incineration and landfill disposal. As observed from Figure 1, the largest contribution to green house gas emissions occurs during the production phase [10]. The second largest contribution to green house gas emissions occurs during the disposal phase [10], primarily from incinerating PVC waste.

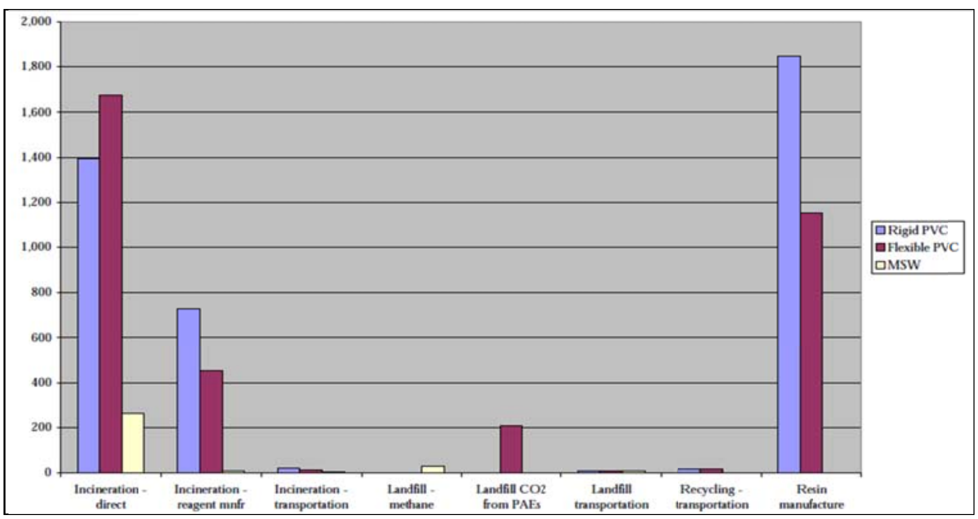

Figure 1. Greenhouse gas emissions from PVC waste management and resin manufacture (kg/tonne)

Source: Brown et al., 2000, p.55

Table 1 below shows the amount of specific green house gases produced while manufacturing PVC.

Table 1. Green house gas emitted from PVC manufacture, kg/tonnes of compound.

Burden	Rigid PVC	Flexible PVC
CO_2	1,846	1,152
Dust	3.70	2.31
SO_2	12.34	7.71
NO_x	15.19	9.48
HCl	0.22	0.14

Adapted: Brown et al., 2000, p.52

Table 2 below shows the amount of green house gases emitted during PVC waste incineration. According to [3], landfill disposal contributes the least CO_2 emission; the net environmental burden of producing 1 kg of PVC is much larger than that of disposing of 1 kg of PVC in landfills.

Table 2. Green house gas emitted from PVC incineration.

Incineration burdens	Units	Rigid PVC	Flexible PVC	MSW
Direct emissions to air				
CO_2	kg / tonne of waste	1393	1673	264
NO_x	kg / tonne of waste	1.01	1.01	1.01
SO_2	kg / tonne of waste			0.25
HCl	kg / tonne of waste	0.051	0.051	0.051

Adapted: Brown et al., 2000, p.53

In addition, although recycling PVC is possible, only 30% of PVC waste is recycled [10]. This is because it is much cheaper to produce PVC products with primary resources, than it is to recycle used PVC [6]. In other words, the manufacturing factories see no reason to spend money on recycling.

2.1.2 Wood

The amount of the green house gases emitted is shown in Table 3 below. The largest contributions come from the resource acquirement phase, such as sawmill, and transportation. From our calculation based on Table 2 and Table 3, wood contributes about 86% less green house gases compared to the amount of green house gases emitted by PVC.

Table 3. Total green house gases emission per 7.4kg wood.

Emissions to air		
CO_2	424 g	transports (74%)
CO	36.8 mg	sawmill (96%)
SO_2	1.89 g	sawmill (56%) transports (24%)
NO_x	31.6 g	incineration (64%)
HC	0.98 g	transports (85%)
dust	1.24 g	transports (48%) sawmill (36%)

Adapted: Å. Jösson et al., 1996, p.252

According to Figure 2 (below), wood contributes negatively towards global warming, provided it is not land-filled during disposal [2]. This is because during the life cycle, the CO_2 contained in the wood itself is deducted from the amount of CO_2 emitted during the disposal phase [6], specifically from the wood waste incineration. In addition, land-filling wood waste should be avoided, because of toxin CH_4 leakage from the wood waste to the landfill [2].

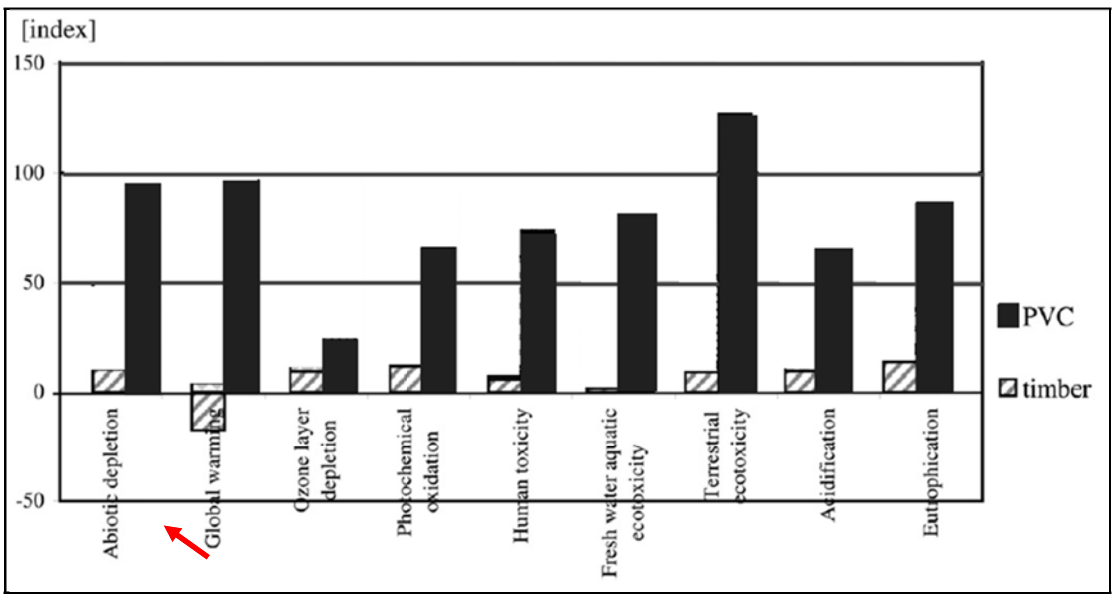

Figure 2. Contribution to the environmental impact categories by PVC and timber wood. (Arrow points at global warming contribution of timber wood.)

Adapted: I. Blom et al., 2010, p.2536

Figure 3 below compares the green house gas emissions due to wood and vinyl flooring material, with PVC being the main constituents of vinyl flooring. From the figure, it is observed that wooden flooring in fact generates far less green house gases than PVC flooring, except in the case of NO_x. However, up to 90% of NO_x can be eliminated using the technique of reburning [12].

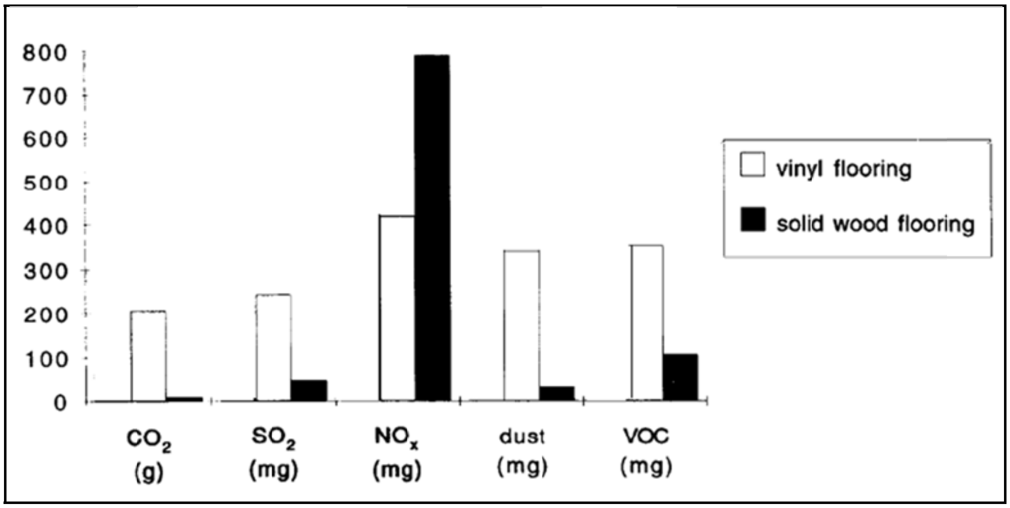

Figure 3. Emissions to air per functional unit (year and m’) vinyl and wood flooring material.
Adapted: Å. Jösson et al., 1996, p.253

2.2 ENERGY CONSUMPTION

The section below compares the energy consumptions of PVC and wood, starting with a description of the energy consumption during the life cycle of PVC, followed by analysis of the energy consumption during the life cycle of wood.

2.2.1 PVC

Table 4 below shows the total energy consumption of PVC manufacture per unit kg.

Table 4. Total resource of energy consumed from PVC manufacture (per kg production).

Fuel	Coal	MJ	6.96
	Oil	MJ	6.04
	Gas	MJ	15.41
	Hydro	MJ	0.84
	Nuclear	MJ	7.87
	Other	MJ	0.13
	Total fuels	MJ	37.25

Adapted: Brown et al., 2000, p.A4-2

Table 5 below shows the total energy consumed during PVC incineration. In comparing Table 4 and Table 5, it is seen that incineration makes up over 90% of the energy consumption in the life cycle of PVC.

Table 5. Total energy and resources consumed from PVC incineration.

Incineration burdens	Units	Rigid PVC	Flexible PVC	MSW
Electricity generated	MWh / tonne of waste	0.81	1.00	0.50
Heat generated	MWh / tonne of waste	0.81	1.00	0.50
Fuels & feedstock (a)	GJ / tonne of waste	4.73	2.96	0.05
Water use	kg / tonne of waste	1208	757	12.10
Other raw materials	kg / tonne of waste	134	84.4	1.35

Adapted: Brown et al., 2000, p.53

Our research showed insignificant amount of energy consumption due to PVC land-filling. Therefore, most energy consumption occurs during PVC manufacturing and PVC incineration. Although possible solutions such as mechanical recycling are available to eliminate incineration, they are too expensive to be implemented [10]. Instead, over 70% of PVC waste is discarded with cheap disposal methods [14], such as incinerated and land-filling [10]. Also, incineration is needed to destroy the plasticizers in PVC [10].

2.2.2 Wood

On the other hand, research shows that wood production consumes 52% less electricity and 79% less fossil fuels than PVC production [2]. However, this is only credible if wood waste is incinerated after use [10]. This is because by incineration, heat generated can be reused in wood production [5]. When energy is reused throughout the life cycle, amounts of green house gas emissions and waste are reduced. According to [5], emission of CO_2, NO and SO_2 are reduced to below the limit of the Kyoto Protocol. In addition, concentrations of all heavy metals were reduced to lower than the Kyoto Protocol's limits, which is 0.5 mg/g. Toxic gas emission levels were also below the legislative limit value, which is 100 pg/N.m^3. Table 6 below shows the energy consumption during the life cycle of wood flooring. The result from this table also shows energy recovery from incineration.

Table 6. Total energy consumption of the life cycle of wood flooring (per 7.4kg).

Parameter	Amount	Dominant activity
Use of energy		
electricity	8.37 MJ	sawmill
fossil fuels	5.39 MJ	transports (74%)
		tree felling etc. (26%)
renewable fuels	35.4 MJ	sawmill (drying process)
recovered energy	−113 MJ	incineration

Adapted: Å. Jösson et al., 1996, p.252

Figure 4 below compares the unit energy consumptions during the life cycles of wood and PVC flooring. From the figure, it is observed that almost 80% of energy consumption of wood flooring is recovered, whereas only about 40% energy consumption of vinyl flooring is recovered.

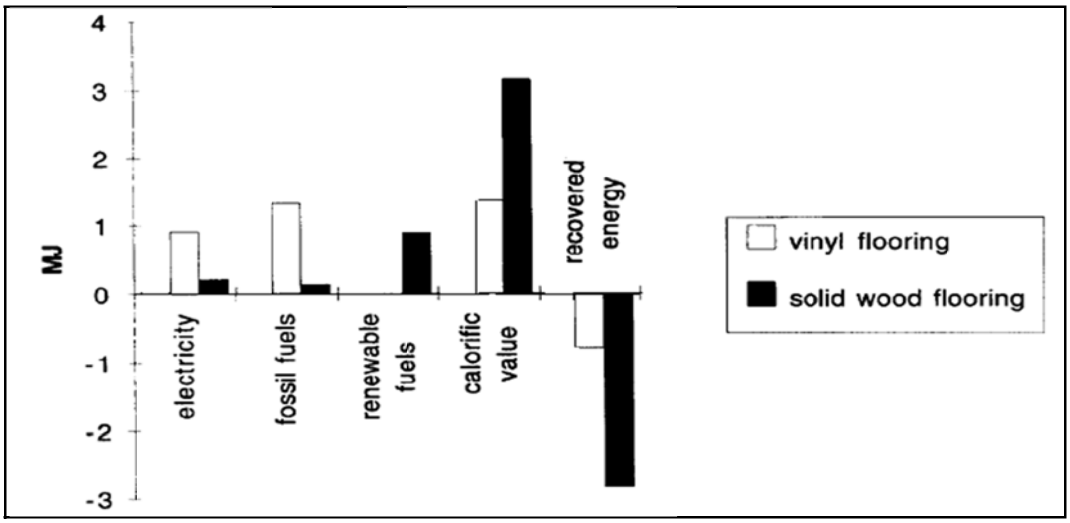

Figure 4. Energy use per functional unit (year and m’) vinyl and wood flooring material.
Adapted: Å. Jösson et al., 1996, p.253

2.3 WASTE CONTRUCTION

The section below compares the energy consumptions of PVC and wood, starting with a description of the energy consumption during the life cycle of PVC, followed by an analysis of the energy consumption during the life cycle of wood.

2.3.1 PVC

Land-filling is the least preferred way to manage PVC waste, because of its long term uncertainties, such as political situations and legal norms [7]. However, this method is still used to dispose of over 80% of PVC waste, as shown in Table 7 below, because it is the easiest and cheapest demolition method.

Table 7. Fractions of PVC waste in different type of solid waste and landfilled portion.

Type of waste[a]	PVC waste (tonnes/a)	Landfilled portion (%)	Landfilled PVC waste (tonnes/a)
construction and demoliton waste	442,000	95	419,900
electrics and electronics waste	110,000	90	99,000
Packaging	796,000	70	557,200
automotive waste	120,000	80	96,000
Other waste	406,000	n/a	n/a
Total	1,874,000	65	1,218,100
MSW	1,147,000	70	802,900
Future MSW[b]	2,600,000	45	1,170,000

Adapted: I. Mersiowsky, 2002, p. 2237

Because a large portion of PVC waste is land-filled, it is subject to bio-corrosion and decomposition due to high temperature and biodegradation [3]. At high temperatures over 70°C, plasticizers in the PVC waste are released, causing the leachate of phthalates, as well as tiny pieces of brittle PVC [3]. Phthalates released then emit green house gases. The toxins released into the landfill then cause abiotic depletion.

2.3.2 Wood

Figure 5 below compares the waste generated during the life cycles of wood and vinyl flooring. From the figure, it is observed that wood creates almost 90% less waste than PVC. There are some that would argue that the paint on wood might corrode the environment However, according to [6], the paint does not affect the environment significantly. Moreover, “low-solvent paint” is recommended due to the health aspects of workers.

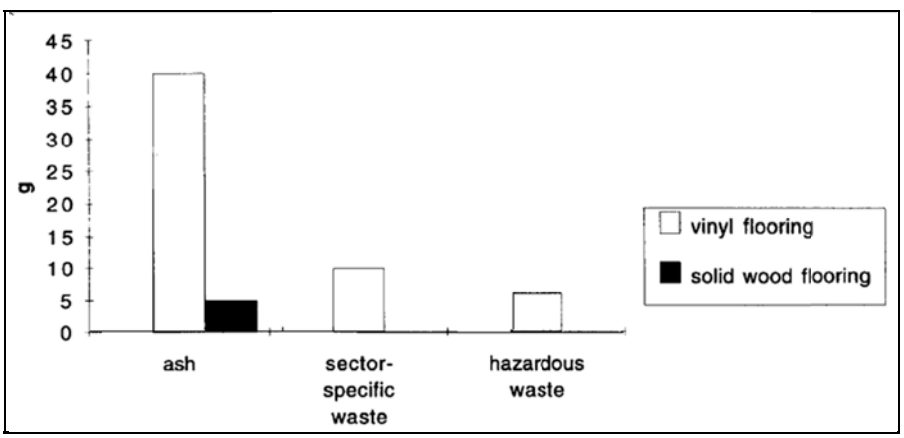

Figure 5. Waste generation per functional unit (year and m’) vinyl and wood flooring material.
Adapted: Å. Jösson et al., 1996, p.253

In conclusion, wood generates less green house gases and waste, in addition to consuming less energy than PVC. Therefore wood is shown to be a more environmentally-friendly material for buildings, when compared to PVC. The following section talks about the economic impacts of PVC.

3.0 ECONOMIC IMPACTS OF PVC AND WOOD

One of the main reasons PVC is used in buildings is because it is cheap. However, maintenance and replacement costs, which are overlooked many times, may actually cause PVC to be more expensive than other materials. Also, PVC is cheap compared to some newer, better materials since it has the advantage of mass production, but this may change. PVC has a number of uses in construction. In this section, evaluations of PVC and alternatives are made for windows, roofing, piping, and flooring.

3.1 PVC IN WINDOWS

Window frames and shutters can be made out of PVC, but some alternatives are wood, aluminum, and fiberglass. Windows may degrade due to environmental conditions such as temperature, sun exposure, and humidity.

A survey estimating the average lifetime of some different window types [13] showed PVC to last 24.1 years, timber 39.6 years, aluminum 43.6 years, and aluminum clad timber 46.7 years. Wood is the most expensive in terms of maintenance, since it requires painting every few years, and may rot. PVC windows require cleaning with alkaline detergents every six months. Aluminum requires little maintenance; for example, it may only need to be painted 20 years after first installed. Wood is easy to install and repair, while PVC windows are difficult to repair when damaged and may need to be replaced entirely. PVC is also sensitive to hot and cold temperatures, as well as UV rays from the sun. Aluminum clad timber is easy to repair, and requires little maintenance since the wood is protected from environmental degradation. Fiberglass windows also require little maintenance, but may pose some health issues.

3.2 PVC IN ROOFING

Single-ply roofing systems have lower cost and are easier to install than other roofing systems. In single-ply low-slope roofing, PVC is one of the three cheapest and most common materials used, along with Elastomer Polyolefin (TPO) and Ethylene Propylene (EPDM).

PVC has been promoted because of its reflectivity; it is able to reflect sunlight which will lowers building temperatures, reducing the cost of air conditioning. However, TPO and EPDM can also be white, and share this advantage. There are also studies speculating that roof color may have little effect on energy costs for buildings in northern climates, since absorbing the sunlight may be more efficient than reflecting it, and roofs covered in snow can already reflect sunlight. Even if reflection does make a difference, PVC has no real advantage.

PVC also has the shortest average lifetime compared to other roofing materials. PVC contains plasticizers which help make it flexible, but these plasticizers separate over time and the PVC becomes brittle, causing seams in the roof to fail. It also becomes brittle in cold temperatures. TPO is flexible, even in cold weather. EPDM is resistant to UV rays and weathering, unlike PVC.

Even worse, Figure 6 below showed that PVC roofs also cost more to install than TPO or EPDM roofs. PVC roofing is more expensive and has no advantage over other materials, so there is no good reason to use it.

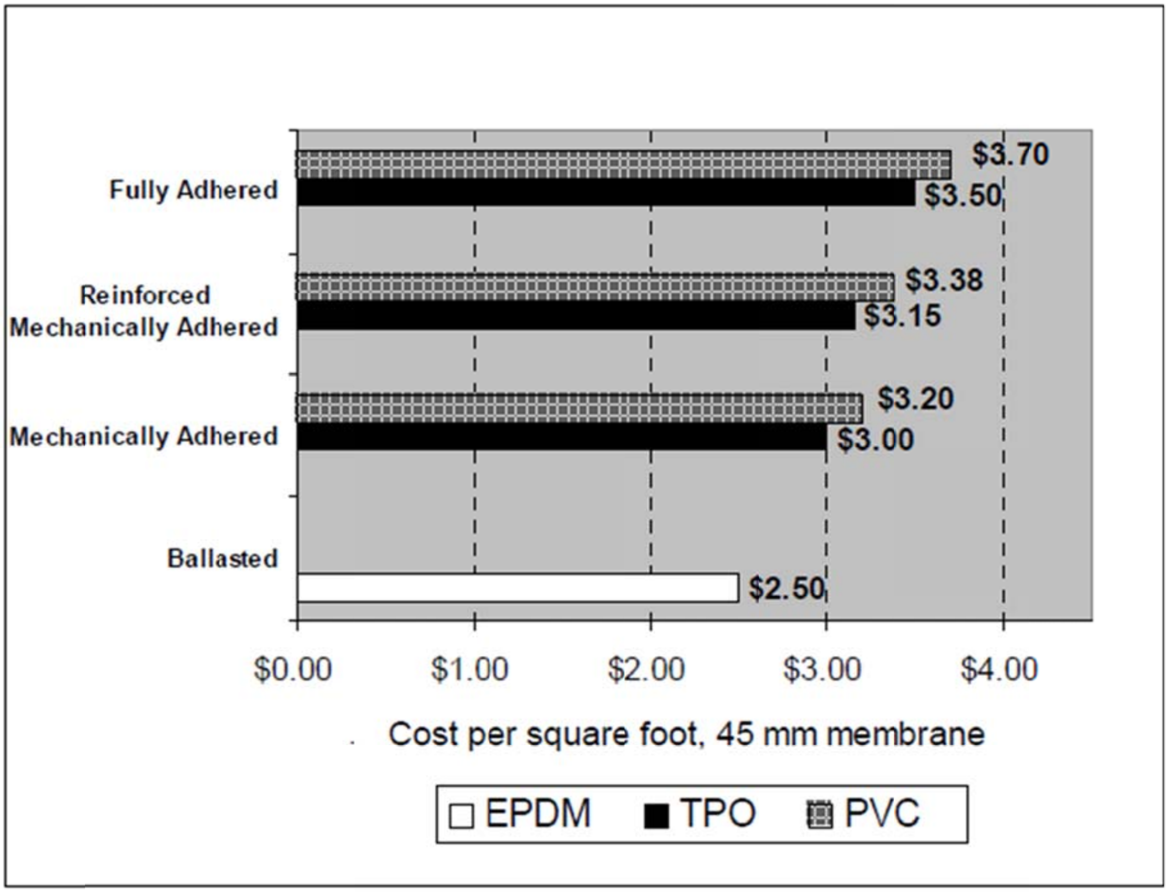

Figure 6. Roofing Installation Costs in Austin
Adapted: Ackerman et al., 2003, p.21

3.3 PVC IN PIPING

Pipes in buildings make up almost half of all PVC use. PVC is usually the cheapest piping material, but the most cost-effective solution depends on the specific situation. For example, the material cost of underground pipes may be insignificant compared to the cost of digging, so PVC would have little advantage. PVC is generally weaker than other materials under high pressure and below-freezing temperatures, resulting in more breaks and leaks. PVC is often compared to traditional materials and plastics such as Polyethylene (PE).

Traditional piping materials include copper, iron, concrete, and vitrified clay. Copper is a standard for hot and cold water pipes, and iron or concrete may be used for sewer pipes.

Compared to PVC, traditional materials are stronger under extreme temperature and pressure. However, for large diameter pipes, they are heavier and more difficult to install and repair.

PE is one of the most important piping alternatives to PVC. PE pipes have the benefit of being stronger under high pressure and below-freezing temperatures, and are far less toxic than PVC. For hot water pipes, one would use modified plastics: Chlorinated PVC (CPVC) instead of PVC or Cross-linked polyethylene (PEX). PE pipes require more labor to install than PVC since it is a newer material. However, the material cost of PE pipes is nearly the same as that of PVC pipes. PEX costs slightly more than CPVC, but its installation cost is far less.

PVC piping is usually cheaper than alternatives, but PVC-free piping is affordable and more effective. It is clear that PVC can be avoided in this case.

3.4 PVC IN FLOORING

PVC flooring is a type of resilient flooring, meaning it is stain- and water-resistant. Other types of resilient flooring are linoleum, cork, rubber, and other polymers, each with individual advantages. Linoleum is anti-static and anti-bacterial. Cork tiles which are waxed with every few years can last for a long time. Rubber sheets or tiles can affect indoor air quality, but requires little maintenance. Stratica, a non-vinyl polymer flooring, is non-allergenic, and mildew- and odor-resistant. It is also easily recyclable.

PVC is chosen for its initial low cost even though its maintenance costs usually make it the most expensive choice. Table 8 below shows that vinyl flooring (which contains PVC), has both the shortest life spans and highest overall maintenance cost when compared to the alternatives. In the case that a building requires resilient flooring, PVC can be avoided.

Table 8. Life cycle costs of flooring (per square foot)

Material	Brand - type	Initial cost: material and installation	Expected life span (years)	Initial cost per year of life span	Maintenance cost per year	Total cost over 20 years
		A	*B*	*C = A / B*	*D*	*E = (C + D) * 20*
Vinyl	Armstrong - Solid Vinyl	$9.70	25	$0.39	$52.00	$1,048
	Armstrong - VCT	$2.65	15	$0.18	$52.00	$1,044
Cork	Dodge - Regupol	$7.25	40	$0.18	$25.70	$518
	Expanko	$10.30	30	$0.34	$25.70	$521
Linoleum	Armstrong	$6.30	25	$0.25	$40.00	$805
	Forbo - Sheet	$5.50	35	$0.16	$33.30	$669
	Forbo - Tile	$6.42	25	$0.26	$33.30	$671
Non-chlorinated polymer	Amtico - Stratica	$6.75	40	$0.17	$32.00	$643
Rubber	Dodge - Regupol-Econights	$6.50	30	$0.22	$40.00	$804
	Dodge - Regupol-Ecostone	$7.75	30	$0.26	$40.00	$805
	Expanko - Treadmaster	$7.50	30	$0.25	$32.00	$645
	Flexco - Radial I, II	$11.70	35	$0.33	$24.00	$487

Adapted: Ackerman et al., 2003, p.24

In conclusion, PVC is the worst choice for all building components, including windows, roofing, piping, and flooring. In particularly, PVC windows are sensitive to temperature, yet hard to repair. PVC roofs and floors also cost much higher though they have the shortest life time, compared to other roofing and flooring materials. In addition, PVC piping is more expensive and less effective, compared to PVC-free piping. Furthermore, the following section talks about the social impacts of PVC.

4.0 SOCIAL IMPACTS OF PVC

This section describes the social impacts of PVC. It focuses on the historical development of the PVC industry, followed by health care hazards due to the use of PVC. This section also further explains the multiple solutions created by PVC manufacturers to confront the opposition by society due to the PVC-induced health hazards.

4.1 HISTORICAL IMPLICATIONS AND ANTAGONISM TOWARDS PVC INDUSTRY

In order to see difficulties associated with the situation of PVC elimination, understanding historical development of PVC, one of the most criticized plastics on the planet, is essential. Today, the term PVC is widely used in public. However, the majority of people do not see the big picture behind this acronym. In fact, PVC is one of the celebrities of the plastic family due to its cheapness and extensive attributes. According to [11], PVC is one of the most mass produced and used plastic materials with a long and intricate history.

The beginning of the twentieth century was signified with a noticeable surplus of chemicals from acetylene and chlorine industries [11]. This excess resulted in the search of ways to utilize chemicals for more functional and practical compounds, and hence PVC was born.

According to [11], at the first stages, PVC was a brittle and unstable material that had particular potential in exploiting chlorine. The industry was facing numerous complications with demonstrating better functionality. “The material was difficult to process, and even when it was, consumers judged the product to be inferior” [11]. The popularity and acceptance of the new material with better flexibility and thermal resistivity came after the introduction of highly toxic plasticizers and fire redundant additives. During this period of time, multiple environmental organizations appeared on the horizon of the rising industry. PVC’s inseparable connection with the chlorine industry and numerous diseases raised consciousness and directed antagonism that had historically unsustainable momentum that has been proved by scientific experiments [9]. As the name implies, eliminating chlorine from PVC is impossible “since polar nature of polymer which enables PVC accept very wide range of additives that all other plastics on the market is due to the presence of chlorine atoms” [9].

4.2 HEALTH CARE PROBLEMS

Availability of PVC as the best material on the emerging market of polymers was the leading factor of the intense spread of factories all around the world. In 1960, in Miamata Bay in Japan, people started showing symptoms of “nervous disease” which resulted from consuming seafood with the presence of mercury that was the post product of a neighbouring vinyl chloride (VC) factory [11]. Even long before these incidents, there were clear indications of possible harmful effects associated with VC. The first publication confirming high toxicity and multiple disorders in screening animals appeared in 1938 [11]. By the middle of the twentieth century, acro-osteolysis and Raynaud’s Syndrome were ailments common to workers of vinyl industry [11].

In the next twenty years, an investigation on PVC, by a physicist and employee of the PVC industry, published the verdict that “VC caused angiosarcoma in the liver, kidneys, and ears of test animals” [11]. By 1995, 175 incidents of atypical liver cancer and higher rates of miscarriages in workers’ families were recorded [11]. These and many other circumstances triggered immediate reaction within the industry on “reducing exposure, concentrations and emission” [11] and saving the product from further accusations.

4.3 SUCCESSFUL ELIMINATION OF PVC FROM FOOD PACKAGING IN NETHERLANDS

When the PVC industry expanded to the food market by taking part in food packaging, a series of consequences were observed. Incineration of PVC slowly started to disrupt ecosystems of neighboring grasslands. There werenumerous detections of highly hazardous toxins, for example, dioxin in the milk of cows [11]. This incident raised a massive anti-PVC campaign with the collaboration of 8 environmental and consumer organizations. While establishing serious policies on food, national retailers of food took immediate actions on replacing and banning PVC. According to [11], the PVC industry convinced the government that all problems had a direct relation to the chlorine waste. It was a close and dangerous call for the enterprise where an accelerated action on foregoing the use of PVC in packaging was the only chance of surviving and safeguarding the heart of the industry [11]. It took less than a year to remove and replace PVC packaging [11]; therefore, successful elimination of PVC in the food system shows us the potential power behind consumers and officially organized masses.

4.4 HOW INDUSTRY DEALS WITH CONFRONTATIONS

Having more than 50 years of continuous engagement with various environmental and health problems, [11] points out different managing strategies successfully implemented by the PVC industry. Continuous attempts of moderating, redefining and translating critical problems of smaller notability and “quick surrender for the sake of system [11]” for serious drawbacks are conventional ways of dealing with obstacles.

In conclusion, unambiguous understanding of consumer’s power must be present in the mindset of every global citizen because dealing with corporations of high authority results in small changes. Living in purchasing and dumping lifecycle will only empower industry for further development and indestructibility. Small and unorganized actions will simply strengthen and prepare industry for further defence; therefore, the simple and effective solution will be to avoid PVC usage and to promote alternative materials to public by showing possibility of building and living without endangering the ecosystem. Meanwhile recycling has been pushed to the back and as a result we are observing huge landfills and oceans full of unnatural waste nowadays. It is time to take actions to alter our perception of PVC as the only solution for cheap and reliable construction.

5.0 CONCLUSION

The second section of the report showed that wood is a more environmentally friendly building material than PVC since the production of wood requires less energy and produces less greenhouse gases than the production of PVC. The majority of PVC waste ends up in landfills, while wood is biodegradable and creates significantly lower amounts of waste.

The third section of the report demonstrated that for any specific use for PVC in a building, there are usually better alternatives. PVC may initially be cheaper than alternative materials, but in many cases PVC ends up costing more due to maintenance and replacement.

The fourth section of the report referred to the history of PVC to lay out the antagonism of PVC that leads health problems such as cancer.

Therefore in overall, PVC is harmful to the environment and health of individuals. Hence use of PVC in the new SUB can be avoided in place of more efficient building materials which are still affordable.

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APPENDIX

Paradox behind human creations for "better life"

For the last few centuries human kind was eager to design, generate and fabricate new technologies putting down time, money, energy and even lives; however, there is no exceptional achievement without drawbacks. Around a century ago was the birth of PVC, material without foreseeable future, people believed in superior qualities of polymer. Paradoxically even the temporary pause after the World War ||, when most of the projects on PVC development around the globe were seized, did not terminate polymer's sensational history regardless of plastic's inferior qualities. With the introduction of plasticizers and fire retardant additives PVC was under continuous pressure from environmental organizations but apparently plastic finds in niche in our lives.

Interesting collaboration between corporations without habitual competition probably due to the PVC's tendency to decomposition:

Entering the market: 1920 Du Pont, 1926 ICI (Imperial Chemical Industry, a subsidiary of AkzoNobel), 1928 Rhône – Poulenc.

Functionality of primary products created opportunity for business: Shock absorber seals, tank linings, coated textile (raincoats and shower curtains). Expansibility of PVC followed to flooring, roofing and electrical cable industry almost simultaneously.

"Products smell, sweat, the print comes off and they become brittle" however people was still purchasing different merchandise due to the visible physical difference, people most probably were driven by attractiveness of material. (Getting bored with common goodsç èneed for new products)

Going beyond your limits

When the PVC industry entered the food packaging market, industry did a big mistake by crossing personal values of humanity (health). Going beyond your limits and securing almost 100% of your market after multiple addressed attacks shows that PVC might not be the best example of plastic family but industry represents successful strategies, incredible improvements and continuous development.

Finding the balance between scarce resources and growing population

Having many opinions regarding "human nature equilibrium", stating the truth and predicting the outcome is always difficult and often inaccurate activity that needs justification and realization of many factors, but right now there is only one concern – there is too much plastic in our world!