POTENTIALS FOR IMPROVING WALL INSULATION IN JAPANESE HOUSING

Thesis presented to the Higher Degree Committee

of Ritsumeikan Asia Pacific University

in partial fulfillment of the requirements for the degree of Masters of Science

in

International Cooperation Policy

by

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JAPAN-GERMANY DUAL MASTER'S DEGREE PROGRAM

INTERNATIONAL MATERIAL FLOW MANAGEMENT

RITSUMEIKAN ASIA PACIFIC UNIVERSITY

2011

Certification Page

In light of academic moral and ethics principles, I hereby declare that this report is my original work and all other sources have been cited thoroughly and referenced in accordance with established research procedures.

Roger M. Soares 30th day of June 2011, Fukuoka, Japan

Acknowledgement

Many of my friends shared their support during the course of my studies, including Keiko and her family.

My sincerest appreciation to APU, UCB, IfaS and the IMAT office for their continued support, direction and encouragement throughout my studies over these past few years.

I am completely indebted to Professor Dr. Peter Heck and Dr. Michael Knaus for their guidance, patience and support. Their encouragement and flexibility have enabled me to continue the pursuit of my degree.

I am additionally grateful for the tremendous knowledge and wisdom shared by my professors over the course of the program. I especially owe my appreciated to Dr. Susanne Hartard and Dr. Christian Synwoldt for their support and guidance throughout my studies and in the development of this research paper.

I am forever thankful for the enormous honor and pleasure to share my studies with my classmates from both groups. Their encouragement and friendship were invaluable and I am honored to be able to claim them as my lifelong friends.

Lastly, I want to thank my family, my father Ed, my brother Richard, whom have shared their guidance and support throughout my studies and a special thank you to my mother Virginia, who has given me her enduring love, patience and support in all my life adventures and pursuits!

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List of Abbreviations

CO_2	Carbon dioxide
ppm	parts per million
mppcf	million particles per cubic foot
db(A)	Decibel; (A) = measurement of the sound pressure
e.g.	For example
i.e.	That is
IAQ	Indoor Air Quality
U Value	A $W/(m^2 \cdot K)$
R Value	$ft^2 \cdot h \cdot °F/Btu$
EIFS	Exterior Insulation and Finishing Systems
VOC	Volatile Organic Compound(s)
CFC	chlorofluorocarbon
HCFC	hydrochlorofluorocarbon
HFC	hydrofluorocarbon
EPS	Expandable polystyrene
UL	Underwriters Laboratories
LEED	Leadership in Energy and Environmental Design
cm	centimeters
mm	millimeters
Btu	British thermal units
PEL	Permissible Exposure Limit
OSHA	Occupational Safety and Health Administration
EPA	Environmental Protection Agency
%	Percent
$	US dollars
ROI	Return On Investment
NPV	Net Present Value
“	inch
Toe	Tonne of oil equivalent
W	Watts
K	Kelvin
m^2	meters squared
pH	measurement of acidity or alkalinity of a aqueous solution
OECD	Organisation for Economic Co-operation Development

Abstract

On average nearly a quarter of primary energy demand worldwide is required for the housing sector. In response to the increasing desire to curb energy demand in housing, many companies have been developing insulation products with improved thermal insulating properties, which allow for structures to resist significant energy losses even as climates and temperatures fluctuate. Many of these products possess a range of attributes that have additional health, environmental and financial implications. Ultimately, the outcome of these will also have significant implications for the holistic view of how they each contribute towards creating sustainability.

On December 11, 1997 the Kyoto Protocol was adopted. The host country, Japan among many other nations had set out to reduce (greenhouse gas) GHG levels by 6% from a benchmark set by 1990 emission levels by the year 2012. The deadline is fast approaching and still many nations are far from reaching their GHG reduction goals. More recently at the 15th United Nations Climate Change Conference (COP 15) in Copenhagen, Japan's Prime Minister Yukio Hatoyama committed the nation to an even more ambitious target of a 25% reduction of GHG from 1990 levels by 2020.[1] For Japan, a substantial amount of energy is not only consumed but is unnecessarily wasted by comparatively inefficient housing. Much of this wasted energy has its origins in fossil fuels sources, thus derailing the country from meeting its Kyoto commitment targets. Unfortunately, while temperatures in Japan are moderate compared many countries located in the northern hemisphere, the country still requires both cooling and heating for houses in most regions.

There are several insulation products currently available for housing projects, however this paper will be examining only three of them, BASF Neopor, Bonded Logic Inc. UltraTouch and HAGA Bio-Korit and comparing them in terms of their energy and cost savings, environmental and health impacts and overall sustainability. The findings revealed that while Bio-Korit and UltraTouch had lower environmental and health risks, only Neopor was a viable option for the Japanese housing market since both BASF and Neopor are already well established. In addition, it was discovered that further analysis, e.g. LCA will be required to acquire a more accurate understanding of the real impact of each product in terms of environmental, health and financial aspects.

Chapter 1: Introduction

Today as pressures build to sustain the world economy, while simultaneously we face a myriad of environmental challenges, including diminishing natural resources, e.g. timber and fossil fuels, developing conservation strategies is critical.

Since a significant amount of both raw materials and energy resources are used for housing, either directly for building or later for heating and cooling, and due to the fact that many in the developing nations seem to have adopted the western philosophy of 'bigger is better' and desire larger homes, coming up with new approaches for limiting the ecological footprint of this sector, will be a major factor towards achieving sustainability. Considering the appropriate or 'best' methods and types of wall insulation for modern houses will play a central role in this process.

According to a recent UN study worldwide housing demand accounts for between 15 and 25% of primary energy consumption in (Organisation for Economic Co-operation and Development) OECD countries, i.e. developed countries.[2] (Dzioubinski & Chipman, 1999) The average per capita household energy consumption in developed countries is nine times higher than in developing countries. Although this gap is astonishing it is likely to narrow in the coming years, as the developed nations further implement energy saving technologies, e.g. improved housing wall insulation, and developing countries such as India and China rapidly grow their economies, which, will likely result in an increase in demand for modern homes including energy consuming appliances. The below figure depicting worldwide energy housing energy consumption from 1970 to 1995 demonstrates this trend.

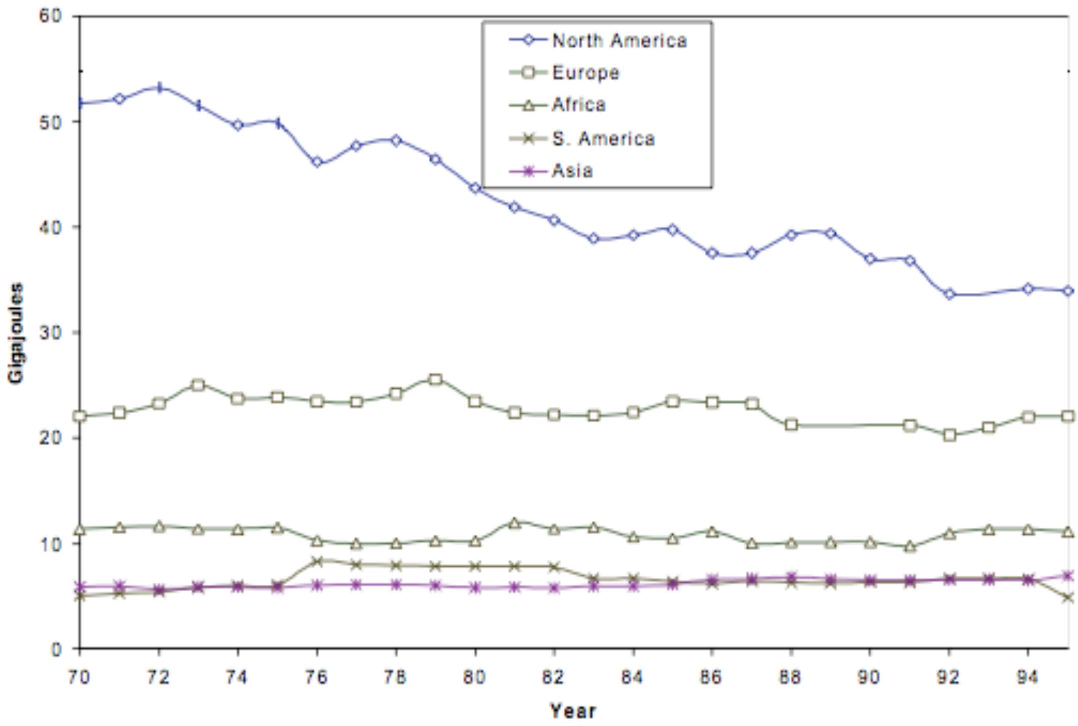

Figure 1.1 Per capita household energy consumption in the world regions
Source: Ref. 2

One of the major environmental challenges directly linked with housing energy consumption is primarily our continued dependence on fossil fuel sources for heating and cooling. The consequences of this dependence have become increasingly apparent in recent decades. The resulting CO_2 emissions into our atmosphere from burning fossil fuels is currently at levels around 380 ppm[3],

which most scientists believe could lead to a number of negative consequences among which are irreversible climate change, greater extremes in weather e.g. flooding and droughts, sea level rise, a potential lower ocean pH, i.e. acidification in the world's oceans, desertification, and so on.

While on one hand the reliance on fossil fuels for heating remains a problem for many of the developed and currently developing nations, many undeveloped nations still rely on more primitive methods for heating their homes, e.g. burning either fuelwood, i.e. firewood or charcoal, which not only directly releases CO_2, but carries the additional side affect of deforestation that has many unpleasant consequences, among which is the loss of forests, a natural carbon sink. The below chart demonstrates the reliance on fuelwood/charcoal in Sub-Saharan Africa and that of fossil fuels for Europe and North America.[2]

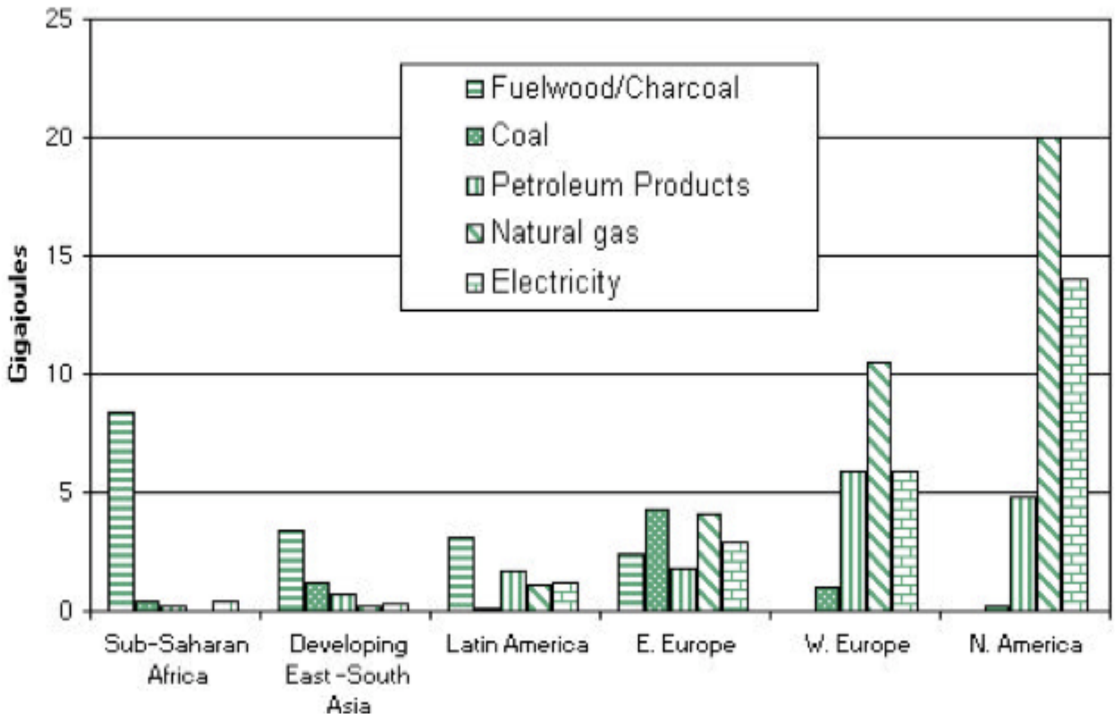

Figure 1.2 Per capita household energy consumption by energy type in 1994
Source: Ref. 2

While decoupling the link between fossil fuels and heating and cooling in houses will remain an obstacle for the unforeseen future, we can begin examining methods to reduce our energy demand by discussing potential ways for improving housing insulation. This paper will be focusing on the situation in Japan, which according to the World Bank is currently the second largest economy and a country[4], which appears to be on the cusp of developing greener, more energy conservative homes, but as of yet still lags behind many other developed nations. While Japan represents just one country, the enormous potential for energy savings was summarized in a paper titled, *Curbing Global Energy, "*The global residential sector is the largest end user of energy worldwide with 25% of global energy demand. It is also the sector with the largest opportunity for improving energy productivity."[5]

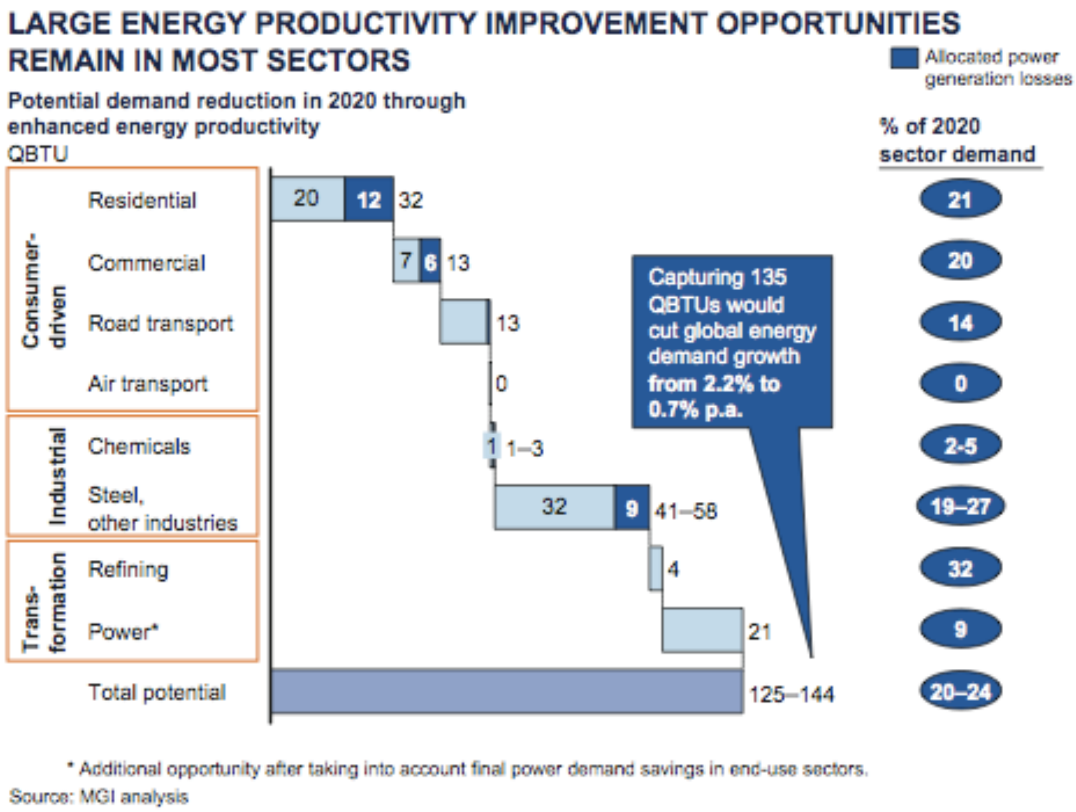

Figure 1.3 Energy productivity improvement opportunities per sector
Source: Ref. 5

Chapter 2: Defining Terms

This section will briefly define some of the key terminology within the paper, in order to provide clearer analysis.

2.1 Explanation of Thermal Indicators (U & R – Values)

2.1.1 U-Value

U-Values essentially measure the rate of heat loss through a given material. In other words, by understanding the U-Value of a material, e.g. a wall, we can understand how much thermal energy is able to escape through that material. Therefore, the lower the U-Value, the less heat is able to penetrate and move through it. The U-Value calculates the amount of heat loss through 1m^2 for every degree difference in temperature on either side of the material. It is given as the following equation **W/(m^2•K)** and is a commonly used indicator for rating the ability of building materials to retain thermal energy, i.e. heat. It should be noted, that U-Values are not as commonly used in North America, where the metric system is less familiar. [6]

2.1.2 R-Value

R-Values similar to U-Values, are used as an indicator to measure the ability of certain materials' insulating characteristics, however unlike U-Values, which measure the flow of heat through a material, R-Values measure a materials insulating power, i.e. its ability to resist the flow of heat. The necessary R-Values for insulation for example, will differ depending on the region's climate and the designated area to be insulated. It is denoted by the equation $\mathbf{ft^2 \cdot h \cdot {}^\circ F/Btu}$. R-Values are the most common indicator for measuring a materials' ability to insulate. [7]

Chapter 3: The Purpose for Examining Japan

3.1 The Energy Situation

As already briefly discussed above, Japan is according to 2009 World Bank GDP statistics the second largest economy in terms of GDP. [4]

(Listed in millions of US dollars)

1. US $14,119,000
2. Japan $5,068,996
3. China $4,985,461

However, these statistics may be misleading since Japan's economy has been negatively impacted by the disastrous events that occurred in March of this year. However, the point still remains that Japan's economy is one of the world's largest and as such it requires enormous amounts of energy.

Table 1. Japanese energy intensity and productivity, including CO_2 emissions per capita, Source: Ref. 8

Japanese energy intensity and productivity *(source IEA)*

2005	Energy consumption per capita (Toe)	CO2 emissions per capita (tonnes)	Energy Productivity (Toe/GDP)
Japan	4.15	9.50	0.15
OECD	4.74	11.02	0.18

Toe = Tonne of Oil Equivalent
Energy Productivity = Consumption of Toe per 000 GDP, 2000 $ at PPP
Energy Intensity per capita = consumption Toe per capita

Similar to OECD countries Japan's per capita energy consumption is at 4.15 Toe, which creates 9.50 tonnes of CO_2 per capita annually. This has tremendous repercussions for the country as it strives to meet its most recent GHG reduction targets. Japan's dependence on mostly fossil fuel sources, which is shown in Figure 4 only intensifies its urgency to reduce its primary energy consumption, especially since over 80% of these energy fuel sources originate overseas[8], which only reinforces the country's dependence on costly imports. Some have suggested that nuclear energy due to its relatively clean air emissions compared to fossil fuels be promoted, however considering the current political climate in regards to nuclear power, this also cannot be a reliable answer to Japan's future energy security.

Table 2. Japanese total energy supply and imports, Source: Ref. 8

Japanese total energy supply and imports (source IEA)

IEA - 2005	TPES (Toe)	Net Imports (Toe)
Japan	530.46	438.98

Toe = Tonne of Oil Equivalent
TPES = Total Primary Energy Supply = Production + imports – exports – marine bunkers +/- stock changes

3.2 A Glimpse at Japan's Housing History

To understand how Japan arrived into this situation, we must peer through the window of history. Japanese culture has long been known to embrace a philosophy of simplicity, which is reflected both in the aesthetics and structure of many of its houses and buildings. The recent pioneer for sustainable design William McDonough (McDonough & Braungart, 2002) reflects on this phenomenon in his book Cradle to Cradle, "I recall a sense of land being scarce but also the beauty of traditional Japanese homes, with their paper walls and dripping gardens, their warm futons and steaming baths. I also remember quilted winter garments and farmhouses with thick walls of clay and straw that kept the interior warm in winter and cool in summer." [9]

The home that is described above is perhaps a decent description of many of the houses build throughout Japanese history. Relying on their openness and natural materials alone for their warmth and cooling, these houses would have a small energy footprint.

The picture below shows precisely how traditional Japanese homes were made from mostly natural materials including, wood, clay or mud, grass or straw and paper and compared to their counterparts constructed in the northern hemisphere, are relatively simple and light in construction. In the second picture, we can clearly see how this construction style has been replicated in more modern housing structures.

Figure 3.1 Interior picture of a traditional Japanese house

Source:

http://img.fotocommunity.com/Architecture/Details/Living-in-old-Japanese-house-3-a17943867.jpg

Figure 3.2 A room in a more modern apartment building

Source:

http://jaredinnakano.files.wordpress.com/2008/09/new_nakano_apt1_t.jpg?w=500&h=375

Since Japan has fairly mild winters, northern Japan being the exception, most of Japanese homes have relied on heating a single room or area for a few months of the year to endure the winters. In the past, the heating source was a small fire fueled by wood or charcoal and in more modern times heated by *"Toyu hitas"*, i.e. kerosene heaters and "*Kotatsu"*, i.e. an electricity heated table covered with a blanket that runs on electricity.

In the summer months, due to their relatively simple construction, thin walls and paper doors, these houses are drafty enough to allow the morning and evening cool breezes to provide relief from the hot mid-day temperatures. However, while Japanese houses may be more suitable for hot and humid climates, most people today rely on electrically operated air-conditioning units to provide additional cooling.

Figure 3.3 A kerosene heater (Japanese: "*Toyu hita*")

Source: http://www.watertubeboiler.org/wp-content/uploads/2011/04/kerosene-heaters.jpg

Figure 3.4 An electrical heated stove covered with blanket (Japanese: *"Kotatsu"*)

Source: http://i-cdn.apartmenttherapy.com/uimages/unplggd/101508Kotatsu-04.jpg

Today this approach towards dealing with seasonal changes in temperature has led to the current situation Japan is now facing with housing. While many houses may still be made of natural materials, most of the "*mansions*", i.e. apartment buildings, are made of steel and concrete, and are cooled and heated with combined heating and air-conditioning units that require large amounts of electricity. This problem is magnified further because many modern houses and apartments have maintained much of the drafty and poorly insulated conditions of their predecessors.

3.3 Background on Housing in Japan

As noted in introduction, residential housing and commercial office buildings consume approximately 25% of primary energy demand worldwide. The situation in Japan is similar with over 30% of primary energy being consumed by commercial buildings and residential housing and the demand for energy in this sector will continue to increase in the future. In addition, space heating and cooling represent 25% of energy use in residential housing and commercial buildings.[8]

While Japan has long recognized the importance of energy efficient technologies in such industries as automobiles, solar power, and household appliances it inconceivably still lacks initiative to set higher standards and regulations that will require builders to construct more energy efficient housing and buildings. [8]

In Europe energy efficient buildings are a critical aspect of the (European Union) EU's strategy to reduce CO_2 emissions that will enable countries to meet their GHG reduction targets. In addition, many European countries view energy efficient building and it's many related industries as new areas for investment and economic development. For example, Germany plans to harness improvements in both heating and insulation of residential and non-residential buildings to reduce CO_2 output by 15% or 41 million tons by the year 2020.[8]

Despite Japan's sense of urgency to reduce its GHG emissions, the absence of stronger governmental regulation seems to suggest that the above view has yet to firmly take hold in the political and business consciousness of the country. Although, certain events including Japan's display of its most innovative energy efficient housing in Hokkaido during last year's G8 conference put on by one of the country's largest residential housing builders *Sekusui House* which seeks to develop more "eco-friendly" housing and a "Futuristic Smart House", which it plans to begin, it still lacks the leadership in the area that has become commonplace among European countries.[10]

The (European Business Council) EBC in Japan recently urged the Japanese government to improve insulation regulations that promote energy efficiency in residential housing and commercial office buildings. Below is a comparison analysis between German and Japanese regulation standards for residential and commercial buildings. It demonstrates that although schemes such as the (Comprehensive Assessment System for Build Environment Efficiency) CASBEE [11], which is similar to (Leadership in Energy and Environmental Design) LEED in the US exist, there still lacks an overall implementation of improved energy efficiency in buildings.[8]

Table 3. Simplified comparison of building regulations in Japan versus Germany

Source: Ref. 8

Simplified comparison of building regulations *(various domestic and international sources)*

U values (W/m2.K)	Germany – required performance of building element		Japan (Region IV of VI, eg Tokyo) – U value of additional applied insulation layer - recommended	
	Residential	Typical Office	Apartment constructed from concrete – insulation material requirement if applied internally	House constructed of timber frame – insulation material requirement for cavity fill
Exterior Walls	0.35	0.35	0.91	0.43
Roof	0.30	0.30	0.40	0.22
Windows	1.9	1.9	4.65	4.65
Exterior doors	2.9	2.9	No requirement	No requirement

Lower values provide more insulation

The EBC perceives that one of the major factors that still hinders the implementation of improved insulation in residential and commercial buildings is the inability of owners to recognize the advantage of lower utility bills, despite higher initial investment for the property, coupled with the belief that the payback period may be too long.[8]

To address the current situation the EBC recommends the following:

- *Establish mandatory U values (heat transmission coefficient – W/m2. C), for windows and of under U 2 and doors of under U 3,in line with many other OECD nations with similar climates. A U value for windows of 2.7 – 4.65 in a city with Tokyo's climate (Zone IV) is well below comparable EU standards, which in many countries are below 2 and also inferior to many building in Seoul, Shanghai and Beijing.*

- *Establish mandatory U = 0.35 values for the completed wall as a systems, in line with many other OECD nations.*

- *Address the ridiculously low insulation standards of commercial buildings, which despite the introduction of the PAL and CEC assessments, continues to allow high-rise office buildings having only single glazed windows and facades, often resulting in a U value of U=6. Even double-glazing with standard, or so called 'low E' grades, achieves only a U value of around 3. Compared with European values typically around or even below U=2, and in some countries with comparable climates to Kyushu and Hokkaido now tending to a U value of 1, the energy inefficiency is appalling.* [8]

3.4 Summary of Japan's Situation

- Japan is one of the largest economies in the world;
- Residential housing and commercial buildings consume over 30% of primary energy;
- Common building insulation levels far below leading European nations, e.g. in practice U = 5.7 in Japan, compared to U = 1.1 for Germany;
- Insulation regulations also far below leading European standards, e.g. exterior wall insulation in Japan U = 0.91 compared to Germany U = 0.35;
- Public perception of long-term payback on initially higher investment for improved building energy efficiency still hindering progress

These figures do not describe a positive scenario for Japan in modern times. As the second largest economy in the world, it is highly dependent of fossil fuels to meet its large energy demand, which is a result of several factors including its enormous industrial development, its considerable use of cement for buildings, roads, etc. and its large population for which housing is essential. However, instead of setting strict building regulations to conserve energy curbing its energy consumption, its regulations are lacks and consequentially do not promote energy conservation strategies, which ultimately sets the country on a course away from meeting its Kyoto and more recently COP 15 targets and positively contributing towards climate change abatement.

Chapter 4: Introduction of Technologies

In this section I will be briefly introducing three wall insulation products that are currently available and being incorporated into housing projects worldwide. Each of the products introduced have their own advantages and disadvantages in terms of insulating ability, soundproofing, impact on (Indoor Air Quality) IAQ, usability, and perceived environmental impact, which will be analyzed in a later section of this paper with the ultimate purpose of identifying some potentially advantageous products that can be introduced into the Japanese housing market.

While there may be conditions including climate conditions, area of application and quality of installation that may alter the insulating properties of the following insulation products we will assume that the figures given by each company are accurate.

4.1 BASF Neopor Insulation Introduction

Figure 4.1 Three views of BASF Neopor insulation being installed
Source: Ref. 12

BASF Neopor is an innovative product from BASF the German chemical company. This particular product has its historical roots dating back to 1930 when the company patented the polymerization of monostyrene, which in 1951 led to the patent of (expandable polystyrene) EPS that was branded as Styropor, an insulation material for buildings and houses. This product is the direct ancestor of Neopor, which was patented in 1995. Neopor is EPS that has been coated with a thin layer of graphite that enhances the products insulating properties by reflecting more radiant heat, while allowing its thickness to be reduced. The company claims that the thickness can be reduced by 15 to 20% compared to Styropor its original EPS product, which allows for up to 50% less raw materials to be used. This is an attractive marketing aspect since it attracts customers whom desire to reduce both their costs and impact on the environment.[12]

4.1.1 BASF Neopor insulation (Exterior insulation EIFS)

As stated above the installation area within the building, e.g. attic, external wall, roof, etc. may alter the insulation performance of the insulation, however we will be considering the Exterior Insulation and Finishing Systems (EIFS)[12] for our analysis, since this is perhaps a “likely” application for the building situation in Japan where many pre-existing concrete building structures will undergo some renovation over their lifetime. In addition, since many residence buildings in large cities, are constructed by a mixture of concrete and steel this application is even more probable.

The below diagrams demonstrate the method of EIFS where the BASF Neopor insulation product is applied to the exterior of the structure. In contrast to interior installation the insulation is applied to external face of the mason/concrete wall. This also contrasts from the other two common installation techniques, cavity insulation “loose beads” and insulation behind a curtain wall, since both of these applications are internal application where the insulation is either sprayed into the interior wall cavity or sandwiched between the internal wall layers.[12]

For existing concrete structures the EIFS installation process should be relatively simple since the BASF Neopor insulation can be fixed directly to the exterior concrete wall with an adhesive once the exterior surface, e.g. stucco, etc. is removed. [12]

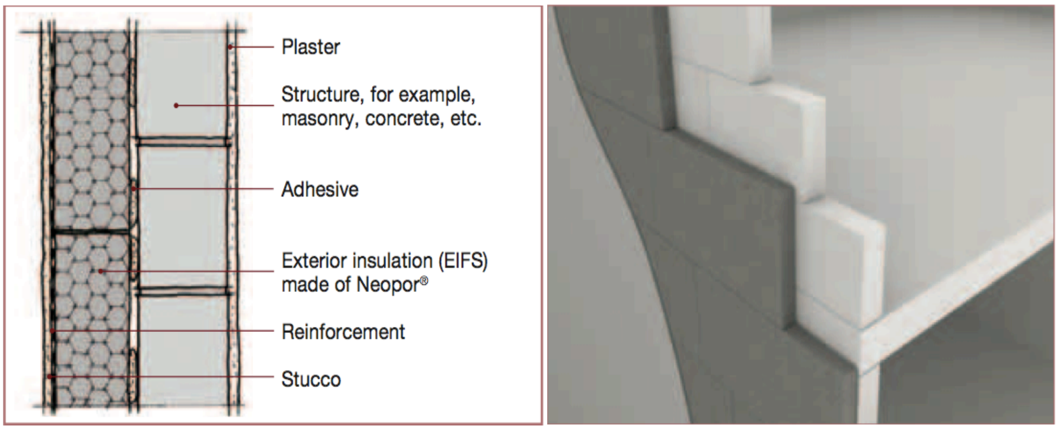

Figure 4.2 Cross-section diagrams of exterior application EIFS of BASF Neopor

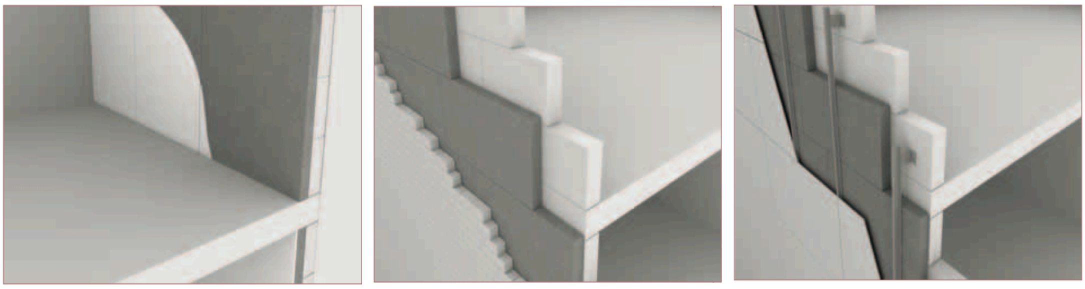

Figure 4.3 Cross-section diagrams of interior, cavity and behind curtain wall applications

Source: Ref. 12

4.1.2 Specific instructions

- Since pentane diffuses out of Neopor raw materials during storage, it is essential that it not be exposed to any ignition agent, e.g. spark, flame, etc.
- Neopor should be stored at a temperature below 20 ° C, in order to "minimize loss of blowing agent.
- It is strongly recommended that Neopor not be packaged in transparent materials, but rather opaque or colored packaging, e.g. white colored plastic
- In addition, company warns against creating thermal bridges, which "entail a higher consumption of heating energy and intensify the risk of condensation."

Adding that, “As a rule, no thermal bridges can occur in well-insulated exterior components that are configured so as to be air-tight.”[13]

4.1.3 BASF Neopor insulating properties

- **U Values**

Considering the application of EIFS the insulation performance of Neopor is U-Value of 0.29 $W/(m^2 \cdot K)$ or a thermal conductivity of $\lambda = 0.029$ W/mK

- **Comparison**

Given a bulk density of $15 kg/m^3$ the thermal conductivity is $\lambda = 0.032$ W/mK, however with the same bulk density standard EPS has a thermal conductivity of $\lambda = 0.037$ W/mK. This increased performance is what allows for the reduction in thickness of 15 to 20% and a potential reduction in material of 50%.[12]

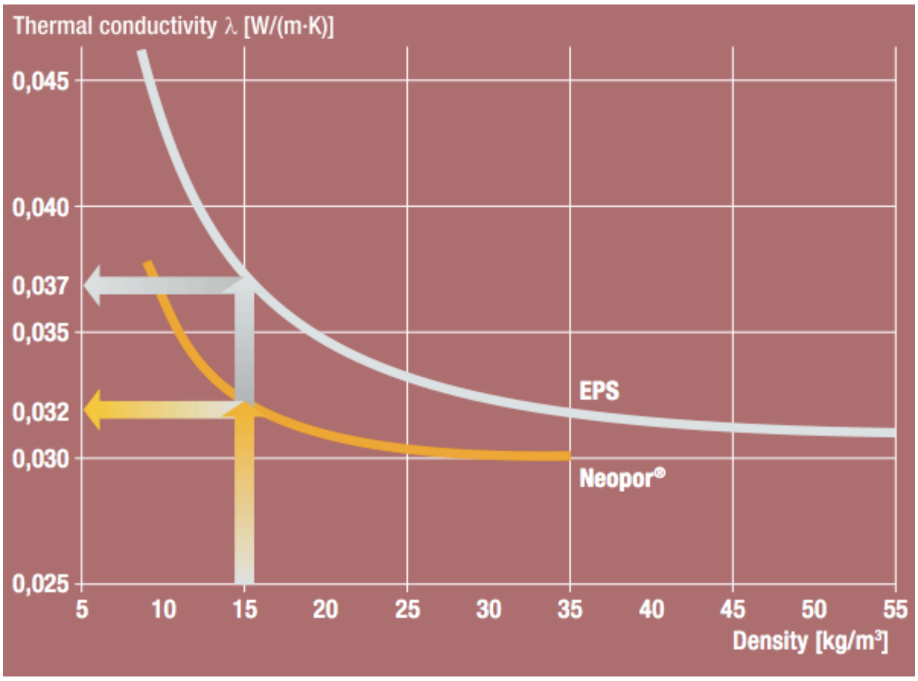

Figure 4.4 Thermal conductivity EPS & Neopor

Source: Ref. 12

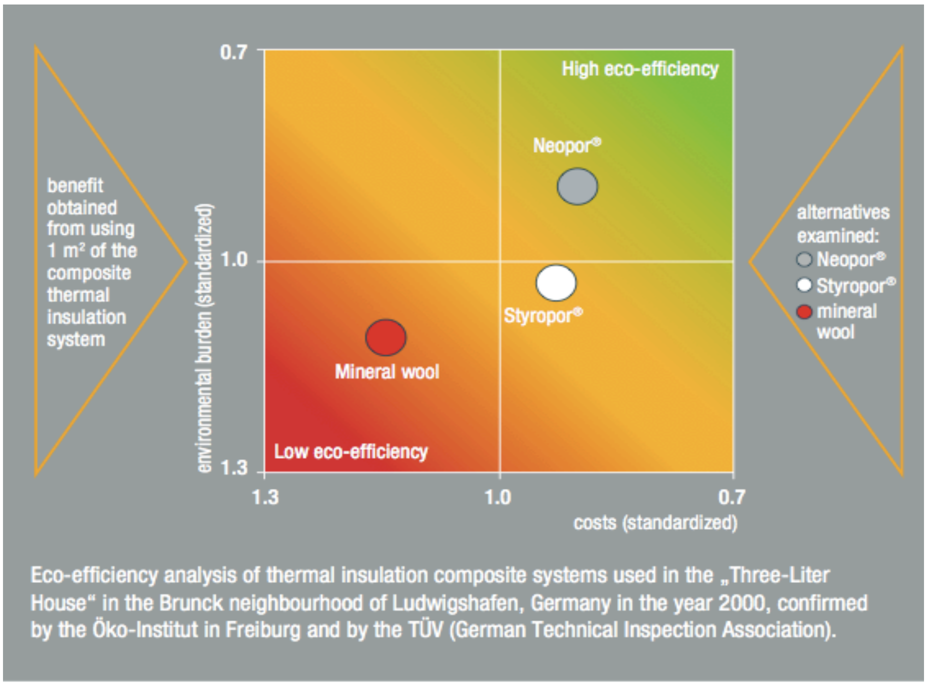

Figure 4.5 Eco-efficiency comparison

Source: Ref. 12

The above figures demonstrate an example of how the company conducted an eco-efficiency analysis on three different materials that were incorporated in the Three-Liter House in Brunck, Germany in the year 2000.

4.1.4 BASF Neopor insulation health & safety aspects

Neopor is essentially manufactured from expandable polystyrene or EPS and graphite. In order to assess the potential health risks of each we must address each of these components individually. Vinyl benzene is the monomer for polystyrene, and is also known by its compound formula $C_6H_5CH{:}CH_2$. [14]

- **Vinyl benzene** – Is an organic compound, which according to the US Environmental Protection Agency (EPA) is a suspected carcinogen and may "also be a suspected toxin to the gastrointestinal, kidney and respiratory systems, among others." This may pose a potential threat to manufactures. [14]

  In addition the US EPA states that styrene can release VOC, which can contribute to the formation of harmful ground-level ozone. This could potentially affect workers with a higher amount of exposure.[14]

  As far as IAQ in houses is concerned, there should not be a problem with mold or mildew as long as proper installation procedures are followed.

- **Graphite** – Is a mineral and is one of the allotropes of the carbon family, is usually benign, however according to the US government agency (Occupational Safety & Health Administration) OSHA the (Permissible Exposure Limit) PEL is [15 million particles per cubic foot or 15 mppcf] averaged over an 8-hour period. However, if inhaled over a long period may cause lesions within the lungs and graphite pneumoconiosis. If natural graphite is the source for BASF's Therefore, the manufacturing of Neopor insulation could potentially be a health risk if proper care is not taken.[15]

4.1.4.1 Soundproofing

BASF claims that Neopor enhances the structures soundproofing qualities.[12]

4.1.4.2 Fireproofing

Neopor insulation is in accordance with the European standard DIN EN 13163. In the classification of 'Euroclass' it is rated as a Euroclass E in accordance with DIN EN 135011, which means that it is "capable of resisting, for a short period, a small flame attack without substantial flame spread". And it is rated as a 'B1' in accordance with DIN 4102, which means that under this classification it satisfies the requirements for a Euroclass D rating, and it can additionally withstand a "thermal attack by a single burning item" with only "limited lateral spread of flame". [16]

Euro-class	contribution to fire / aspired safety level	classification acc. to DIN 4102
F	Products for which no reaction to fire performances are determined or which cannot be classified in one of the classes A1, A2 , B , C , D , E .	B3
E	Products capable of resisting, for a short period, a small flame attack without substantial flame spread.	B2
D	Products satisfying criteria for class E and capable of resisting, for a longer period, a small flame attack without substantial flame spread. In addition, they are also capable of undergoing thermal attack by a single burning item with sufficiently delayed and limited heat release.	
C	As class D but satisfying more stringent requirements. Additionally under the thermal attack by a single burning item they have limited lateral spread of flame.	B1
B	As class C but satisfying more stringent requirements.	
A2	Satisfying the same criteria as class B for the SBI-test according to EN 13823. In addition, under conditions of a fully developed fire these products will not significantly contribute to the fire load and fire growth.	A2
A1	Class A1 products will not contribute in any stage of the fire including the fully developed fire. For that reason they are assumed to be capable of satisfying automatically all requirements of all lower classes.	A1

Figure 4.6 Euroclass fire rating classifications

Source: Ref. 16

4.1.5 BASF Neopor insulation environmental impact assessment

- **Graphite** – Considering graphite is mined in many countries worldwide, with the understanding that mining itself often has negative impacts to the regional environments, including, e.g. producing mining tailings, which can run off into and become hazardous for aquatic life in downstream waterways, it can be concluded that the procurement process of graphite is not completely benign to the environment and may in fact create many unintended negative consequences for local environments.

- **Styrene** – As stated above Styrene may contribute to the formation of ground-level ozone, which is considered a form of pollution. US EPA's Toxic Release Inventory report, which is released by certain industries stated that a "total of 32.8 million pounds of styrene was released to the environment in 1992.[14]

- **Halogenated cell gases** – According to the company Neopor contains no CFCs, HCFCs, HFCs or other halogenated cell gases, which have been known to cause depletion of stratospheric ozone.[17]

4.1.6 BASF Neopor insulation cost & savings aspects

According to a 2010 press release by BASF they claim that Neopor not only meets the standards required in Passive-house construction, but in hotter climates may "save at least 40% of cooling energy in residential buildings." These savings obviously translate into financial savings for residential consumers, as well. [18]

In one particular study BASF examined three different regions within the US to determine the potential cost savings of installing BASF Neopor in houses. The three areas selected were Tucson, Arizona (hot and arid), Tampa, Florida (hot and humid) and Syracuse, New York (cold), which were chosen due to their distinctively different climates. Some basic set factors behind the study were the following:

- **Average house size** – 2028 ft^2, 3 bedrooms, slab on grade, house
- **Annual increase in inflation rates** – 2 to 5%
- **Increase in future energy costs** – 2%, 5% and 10% per year
- **Net Present Value -** $ value of ROI after number of years[18]

The study demonstrated the potential positive impact that Neopor insulation could have on reducing energy costs for homeowners. The largest savings was in Tuscan, Arizona where a total combined savings ($90 heat and $33 cooling) of $123 was saved when 2" Neopor was installed. The ROI showed a payback of 7.7 years with a 2% energy price increase, 7.5 years with a 5% increase in energy prices and 6.5 years with a 10% energy price increase. Considering that installing solar panels on one's roof may require at least a 10-year payback, this seems quite reasonable.[18]

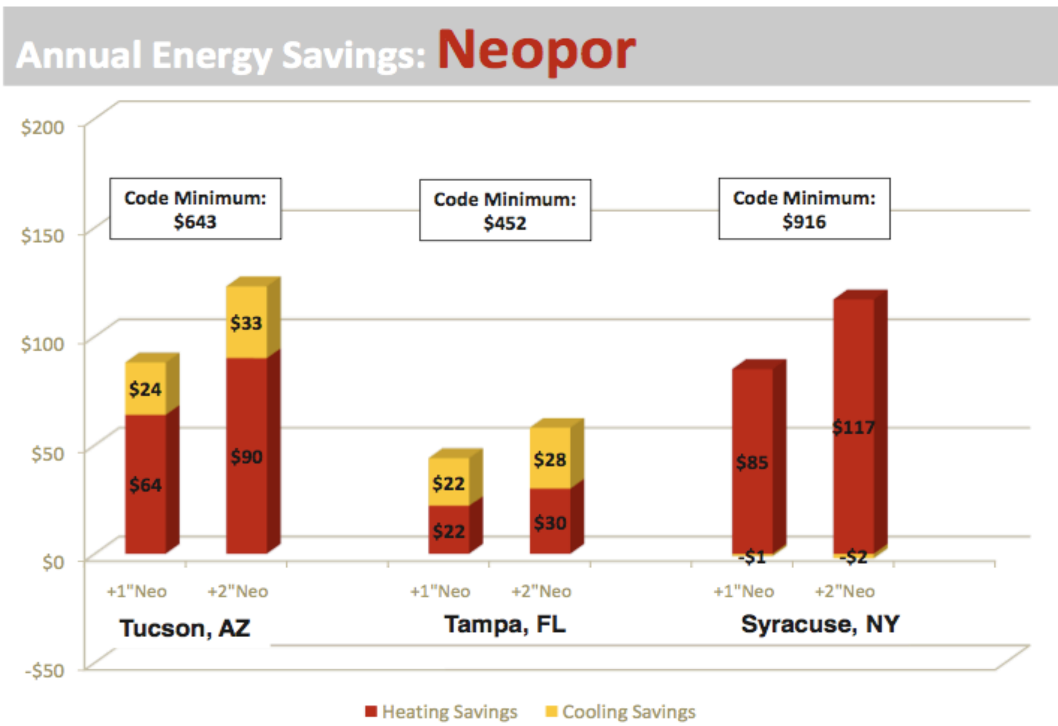

Figure 4.7 Heating and cooling saving in USD for each location

Source: Ref. 18

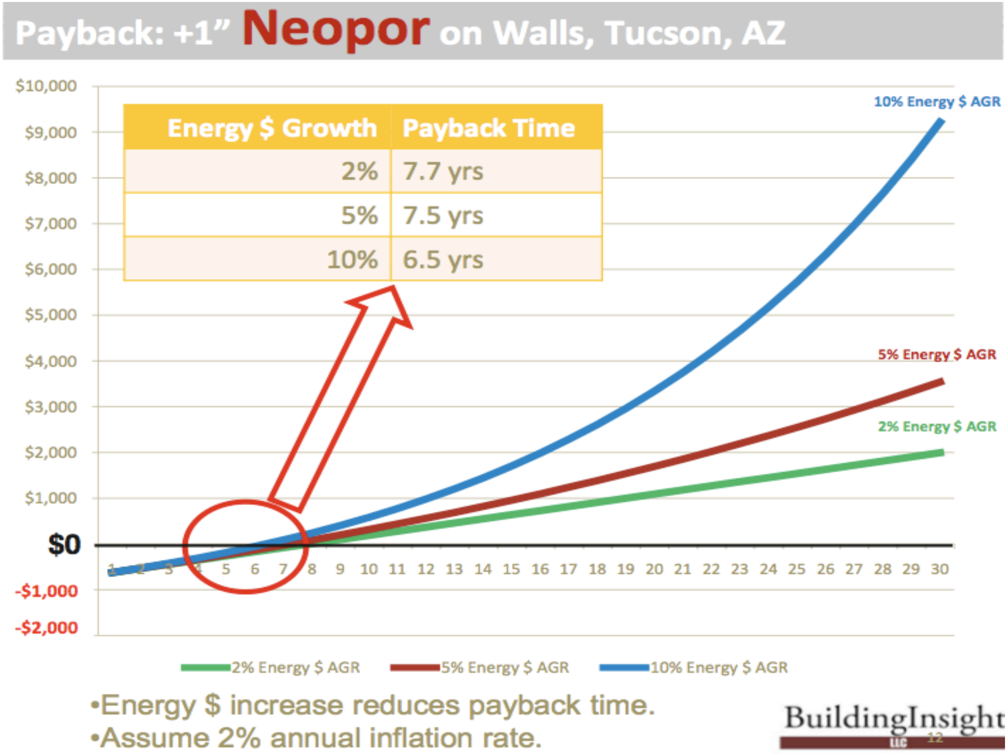

Figure 4.8 Payback for 1” Neopor insulation installed in Tuscan, Arizona house

Source: Ref. 18

4.1.7 BASF Neopor insulation additional information

Researching and hoping to find out more information regarding BASF Neopor’s cost and also its availability, I thoroughly checked the BASF Japan website, but did not see the Neopor insulation product listed in the website. However, after contacting the company’s Tokyo office and being put in contact with a Mr. Makio Saitoh he informed me of the following:

Question: Is BASF Neopor available for purchase in Japan? By whom?

1. BASF Neopor insulation is available and sold in Japan. They “BASF” sell the EPS through their partner to molders, whom then manufacture the Neopor insulation product. Then it is purchased by subcontractors and building companies.

Question: What is the approximate cost/price of BASF Neopor in Japan?

2. While the cost is not fixed, nor listed, it is sold at a premium over standard EPS insulation, because of its higher performance in terms of lower thermal conductivity.

Question: Is BASF Neopor insulation commonly used in Japan? If so, where?

3. Since EPS insulation's share and implementation into the Japanese housing market is low compared to other countries, Neopor insulation is also used on a limited basis by builders. However, he informed me that they are currently in a development stage of this product and should increase its marketing capacity within the near future.

4.2 HAGA Bio-Korit Insulation Introduction

Figure 4.9 Four views of Bio-HAGA Korit insulation installation steps to completion Source: Ref. 19

Bio-Korit is an insulation product produced by the Swiss company HAGA. Bio-Korit is constructed from 100% natural cork[19], which is extracted from the outer bark of an evergreen oak of the genus and species Quercus Suber, i.e. oak cork. The company is marketing Bio-Korit as an all-natural and renewable substitute to conventional insulations, which inherently offers many positive qualities for buildings and houses, including improved insulation, sound proofing, fire-resistance and health and environmental impacts.[19]

4.2.1 Bio-Korit insulation exterior installation

Similar to the BASF Neopor the Bio-Korit is optimal for exterior installation. According to the company it suitable for all masonry, including brick, concrete, limestone, porous concrete or Isolierbackstein, which means it is also suitable for either reforming older concrete buildings or in newer concrete structures, that are common in Japan. Also, similar to BASF Neopor, it manufactured in panels, which can be applied by hand. The specific dimensions are 50 x 100 cm by 4 to 20 thick. [19]

4.2.2 Specific instructions

- Do not apply below 5 ° C
- Cork must be absolutely free of dust or other contaminants when applying glue/adhesive
- Etc.[19]

4.2.3 Insulating properties

- **U Values**

Bio-HAGA Korit has a U-value of 0.40 $W/(m^2 \cdot K)$ or a thermal conductivity of λ = 0.040 W/mK[19]

4.2.4 Bio-Korit specific characteristics

The following specific installations instructions are provided:

- Water vapor resistance (including bio-adhesive, and Einbettmortal Hagasit) μ = 13 – 16
- Specific gravity Koritplatte 100 – 120 kg / m^3
- Pressure + impact resistance system 49 – 53 kg / cm^2
- Suitable for all consumption[19]

4.2.5 Bio-Korit insulation health & safety aspects

According to the company Bio-Korit is "a hundred percent natural thermal insulation system" and is completely without synthetic additives. In addition, the company recommends using a natural mineral adhesive plaster and mortar. [19]

By itself, Cork is a completely natural material which means that it not only does not contain some of the harmful materials, e.g. VOC, found in other insulation products, but it also contains a Suberin, a natural waxy substance that gives cork its resistance to both mould and mildew[20], both of which can lead to IAQ problems. For example, certain mites, e.g. Tyrophagus putrescentiae, often forage on mold and these mites often molt, i.e. shed their skins, several times until they reach maturity, which combined with their fecal matter, creates dust that can exacerbate asthma and allergy conditions for residence within the structure. [21]

4.2.5.1 Soundproofing

The US Green Building Council's LEED standards (Leadership in Energy and Environmental Design) considers cork to be one of the identified sustainable materials that housing builders can use to receive points towards a LEED's certification. There are several areas within the LEED's certification where builders can accrue points towards certification. Under the category "Innovation and Design Process", builders can earn additional points for "exceptional performance beyond the LEED requirements." The soundproofing characteristics of cork are directly identified and described, "cork's natural characteristics such as its cellular structure provides sound proofing properties." Additionally, "The transmission of vibration from mechanical equipment can be reduced using cork flooring and underlayment."[22]

4.2.5.2 Fireproofing

In a study on the fire prevention performance of cork-gypsum it was stated that while cork products often have good sound-proofing and anti-moisture qualities that "without fire retardants are vulnerable in terms of building fire prevention."
A similar product called Suberra, which is an ultra-high density cork claims that its product is heat resistant up to 350 ° F and has a class B fire rating. According to UL (Underwriters Laboratories), which tests building materials for safety, a material with a class B fire rating can withstand moderate exposure to fire.[23] [24]

4.2.6 Bio-Korit environmental impact assessment

- **Cork –** Bio-Korit is made of a hundred percent cork, which is according to the US Green Building Council's LEED standards (Leadership in Energy and Environmental Design), natural, recyclable and biodegradable. LEED also considers the use of cork in both commercial and residential buildings as contributing towards its certification. Cork is a renewable resource because it is can be harvested from the cork oak, "12 to 13 times during its 150-year lifetime…at 9 to 10 year intervals", without harming the tree itself. [25]

  Greg Mella an internationally recognized green architect states that it is, "a natural yet versatile material that can be used alone or combined with other materials in a variety of attractive yet practical applications…no other material provides this level of versatility or sustainability in green building." [26]

4.2.7 Bio-Korit cost and savings aspects

While the price of Bio-Korit is unlisted, we can assume based on Bio-Korit's thermal insulating abilities, its approximate cost savings to consumers. Since Bio-Korit's properties are the following: Bio-Korit has a U-value of 0.40 $W/(m^2 \cdot K)$ or a thermal conductivity of $\lambda = 0.040$ W/mK[19], we can estimate from Table 5 below that the approximate cost for a typical European house with a 100 m^2 wall area would be 172€/a. [27]

In addition, based on the annual heat loss, i.e. kWh/(m^2a) we can see that given the same house with the same wall area of 100m^2, the annual heat loss would be 31 kWh/(m^2a). In Kyushu, Japan the main electric power company is Kyushu Electric Power Co., which currently charges at its lowest rate ¥ 7.90 JPY/kWh for residential homes (see Table 6 below)[27]. Therefore, based on this price we can see that for a U-Value of 0.40 W/(m^2•K), which is the given U-Value for Bio-Korit that the cost for residential consumers in Kyushu would be [31 kWh/(m^2a) × ¥ 7.90 JPY] = ¥ 244.90 JPY/(m^2a) × (100 m^2 wall area) = ¥ 24,490 JPY annual cost to residential consumers. This cost is significant since we can assume that many Japanese houses do not have walls with U-Values even nearly as good as U-Value of 0.40 W/(m^2•K), which means that most Japanese households are paying far more in annual heat losses than they would if they had Bio-Korit insulation applied to their walls.[27]

Table 4. Annual costs per heat loss of typical European house with 100m^2 wall area

Source: Ref. 27

The following table presents the typical heat losses for different external walls based on a typical European single family house with an external wall area of 100 m². Winter temperatures of -12 °C outside and 21 °C at the inside are used as they are typical of Central Europe.

U-value W/m²K	heat loss (load) W	annual heat loss kWh/(m²a)	annual costs (2005) only of the heat loss of external walls €/a
1,00	3300	78	429.-
0,80	2640	62	343.-
0,60	1980	47	257.-
0,40	1320	31	172.-
0,20	660	16	86.-
0,15	495	12	64.-
0,10	330	8	43.-

Table 5. Electricity rates for residential homes in Kyushu, Japan

Source: http://www.kyuden.co.jp/library/pdf/en/rules/rate.pdf

		Summertime	Other seasons
Per kWh	Service at a standard voltage of 6,000 V	¥9.78	¥8.89
	Service at a standard voltage of 20,000 V	¥8.79	¥8.00
	Service at a standard voltage of 60,000 V	¥8.69	¥7.90

4.2.8 Bio-Korit insulation additional information

After thoroughly researching several sites on Bio-Korit insulation and despite attempting to contact the company by email (info@hagannatur.ch), I was unable to and could not identify any companies in Japan that are marketing and selling the Bio-Korit. Therefore, Japanese builders wishing to utilize this product into their housing projects would most likely be forced to order it directly from European dealers.

The price of Bio-Korit is not listed, however it is believed to be competitive with other insulation materials within the regional European market.

4.3 UltraTouch Insulation Introduction

Figure. 4.10 Three views of Bonded Logic Inc. UltraTouch insulation being installed

Source: Ref. 29

UltraTouch insulation is produced in the US by Bonded Logic Inc., which for the purpose of aesthetics and to stay within the set margins all titles in this paper, shall here forth refer to Bonded Logic Inc. UltraTouch as "UltraTouch" insulation. The insulation is made from 100 % recyclable denim and cotton fibers, and 90 % is from post-consumer denim and cotton. The product is marketed as an environmentally friendlier and healthier alternative to traditional fiberglass constructed insulation products. Unlike the previous two products described above, UltraTouch does not come in panels and so it glue or adhesives are not necessary for its installation. Instead, it comes in batts (described below), which can be cut and easily fitted between the wooden studs in the house's frame. [29]

4.3.1 UltraTouch insulation installation

UltraTouch insulation comes in "batts", which are precut panels that are manufactured to fit between the studs (i.e. wooden framing) within the housing structure that are common in homes in the US. The insulation batts come in a wide range of dimensions ranging in thickness (51 to 203 mm), width (413 to 616 mm), and in length (1.22 to 9.75 m). One of the marketing aspects of the product is its ability to be cut to any size, which also enables consumers, the ability to use small scrap pieces to fill gaps that might otherwise be disposed of. [29]

Specific instructions

The following specific installations instructions are provided:

- UltraTouch is compressed for shipping purposes; therefore it must be shaken in order to rebound to its full capacity. It should be noted that this might take several days depending on the local climate.
- Each batt must be cut, so that each fits firmly between each of the housing studs. In order to meet local building codes, builders are recommended to check if a vapor barrier is required. If necessary, than it is advised to apply the vapor barrier towards the living area.
- In case of exterior wall installations, a vapor barrier will most likely be necessary, however builders must check with local municipality in order to ensure that the proper vapor barrier specifications are met. In addition, Bonded Logic, Inc. strongly recommends a single continuous and permeable barrier be used, since this will be the most effective in preventing moisture transfer, while allowing the walls to “breathe”.[29]

4.3.2 UltraTouch insulation properties

Since UltraTouch insulation is a product developed, manufactured and marketed in US primarily its insulation values are given as the "thermal transmission value", which rated by (R-values), instead of (U-values). It has a thermal transmission value (R-value) of 3.94 ft^2 •h•°F/Btu for a 1-inch thickness, which converts to a (U-value) of (0.254 m^2•K/W) at a thickness of 25.4 mm or a thermal conductivity of $\lambda = 0.0254$ W/mK.[29]

Table 6. R-Values for given according to dimensions, i.e. thickness and width

Source: Ref. 29

THERMAL/TECHNICAL INFORMATION

**Tested in accordance with ASTM C -518 at a temperature of 75° F. Higher R-values equal greater insulating power.*

RESIDENTIAL

PRODUCT CODE	R-VALUE*	THICKNESS	(MM)	WIDTH	(MM)	LENGTH	(M)	SQ. FT.
10002-81632	8	2.0"	51	16.25"	413	32'	9.75	129.
10002-82432	8	2.0"	51	24.25"	616	32'	9.75	129.
10002-01316	13	3.5"	89	16.25"	413	94"	2.34	84.
10002-01324	13	3.5"	89	24.25"	616	94"	2.34	126.
10002-01916	19	5.5"	140	16.25"	413	94"	2.34	53.
10002-01924	19	5.5"	140	24.25"	616	94"	2.34	79.
10002-02116	21	5.5"	140	16.25"	413	94"	2.34	53.
10002-02124	21	5.5"	140	24.25"	616	94"	2.34	79.
10002-03016	30	8.0"	203	16.25"	413	48"	1.22	27.
10002-03024	30	8.0"	203	24.25"	616	48"	1.22	40.

4.3.3 UltraTouch insulation health & safety aspects

Material Safety Data Sheet

Section I – Product and Company Information

Manufacturer's Name / Address / Phone Number:
Bonded Logic Inc.24053 S. Arizona Ave. Suite 151 Chandler AZ 85248 Ph.(480)-812-9114

Product Name:
UltraTouch Cotton Fiber Insulation

Composition:
Recycled Fiber Products, Boric , Ammonium Sulfate, Binder fiber.
Contains no fiberglass, asbestos, or formaldehyde.

Chemical Family: Fiber treated with inorganic salts.

Effective:
January, 11, 2010

Section II – Composition and Ingredient Information

recycled fiber, binder fiber, boric CAS NO: 10043-35-3, ammonium Sulfate.
100% boric acid is hazardous under the OHSA Communication Standard base upon animal chronic toxicity studies.

Section III – Physical / Chemical Characteristics

Appearance: Blue
Specific Gravity: n/a
Boiling, Melting, Flash Point: Not Applicable
Vapor Pressure: n/a
Odor: None
pH: n/a
Viscosity: n/a
Solubility: Fiber is not soluble. Chemicals are soluble.

Section IV - Fire and Explosion Hazards:

Extinguishing Media: Water or any standard agent.
Unusual Fire / Explosion Hazards: None.
Special Fire Fighting Procedures: Use standard fire fighting procedures.

Section V - Reactivity Data

Stability: Stable
Hazardous and Byproduct Composition: None
Conditions to Avoid: **Prolonged temperatures exceeding 250 F**

Section VI - Health Hazard Information:

Ingestion: Not intended for ingestion. See physician if ingested.
Skin: Does not normally itch or irritate skin.
Inhalation: Dust may irritate nose or throat. Wear OHSA approved dust mask if irritating. If continued difficulty exists, move to fresh air.

Eyes: Dust may cause eye irritation. Wear goggles if eye irritation. Use fresh water to cleanse eye for several minutes. If irritation persists, seek medical attention.
OHSA Regulated: None known.
Carcinogenicity: None known

Section VII - Personal Protection Information:

Exposure Control: Use a OSHA approved dust mask or respirator if irritating. Wear safety goggles if dust is annoying to eyes.

Section VIII - Handling and Storage Information:

Storage: Dry, indoor storage is recommended at ambient temperatures and atmosphere.
Transportation: UltraTouch Insulation is not a DOT hazardous substance.

Section IX - Waste Disposal:

Dispose in accordance with all applicable federal, state, and local environmental regulations.

Disclaimer: The information presented has been compiled from sources considered to be dependable and is reliable to the best of our knowledge but is not guaranteed to be so. This Material Safety Data Sheet is offered solely for your information, considerations, and investigations. Although the identified product is generally not considered to be toxic, and to the best knowledge of the Manufacturer, there are no known serious health hazards related to its normal and intended use. This product has not been tested as a whole for all potential health affects. It may have other health hazards related to its components. This MSDS is not to be construed as recommending any practice or product in violation of any law or regulation.

Page 1 of 1

Figure 4.11 Materials safety data sheet

Source: Ref. 29

4.3.3.1 Health aspects

- **Non-irritant** – Since the material is 100 % cotton and does not contain fiberglass it is non-abrasive and does not irritate the skin, which is the case with typical fiberglass insulations that require those installing the product to require full protection of face, eyes and body in order to avoid direct contact.
- **Respiratory** – UltraTouch does not contain any materials that would potentially be irritating or harmful for respiration. The following are some common airborne pollutants that negatively impact IAQ:[29]
  1. ***VOCs*** – UltraTouch does not contain any VOCs, which as described in a previous section are according to the US EPA can potentially contribute to the formation of ground-level ozone.[14]
  2. ***Fungus or mold*** – Since UltraTouch is fungi resistant it has a low probability of producing either fungus or mold, which as previously mentioned are primary culprits in contributing to worsening IAQ conditions, since mites feed on mold and leave fecal matter and molted skin that combine with other household dust that exacerbate both asthma and allergy conditions.[21]
  3. ***Fiberglass & asbestos*** – Both fiberglass and asbestos due to their tendency to release microscopic particles that can lodge themselves within the lining of the lungs leading to a number of respiratory illnesses, including the development of lung cancer. Therefore, standard fiberglass insulations come with a warning to take proper steps to prevent inhalation of fiberglass particles, e.g. wearing a mask over the mouth and nose. Fortunately, both of these are absent from the UltraTouch insulation product. [30]

4. ***Boron or Borate*** – UltraTouch insulation is treated with a boron based fire retardant material, which mixed with O_2 forms Borate. This material also gives UltraTouch its moisture resistant properties. Adults can consume as the Longer Term Health Advisory (2.0 mg/L) in drinking water. Symptoms of an overdose of boron can lead to diarrhea and vomiting. Note: The company states that they use an EPA registered fungal inhibitor, but it is unclear whether this is the boron based compound.[31]

As a final comment on UltraTouch insulation's impact on IAQ, it should be noted that it passed the "stringent Environmental Specification 1350 Indoor Air Pollutant testing for the California Public Schools."[29]

FEATURES		ULTRATOUCH	FIBERGLASS
REQUIRES CARCINOGEN WARNING LABEL		NO	YES
NO VOC CONCERNS OR OFF GASSING ISSUES		YES	NO
85% RECYCLED CONTENT		YES	NO
DOES NOT CONTAIN FORMALDEHYDE		YES	NO
REDUCES INDOOR AIR QUALITY ISSUES		YES	NO
ENVIRONMENTALLY FRIENDLY		YES	NO
USES SAFE NATURAL FIBERS		YES	NO
SUPERIOR ACOUSTIC PROPERTIES		YES	NO
REQUIRES LESS ENERGY TO MANUFACTURE		YES	NO
EASY TO HANDLE		YES	NO
NO PROTECTIVE CLOTHING REQUIRED		YES	NO
NO ITCH / SKIN IRRITATION		YES	NO

Figure 4.12 Comparison between standard fiberglass and UltraTouch insulation

Source: Ref. 29

4.3.3.2 Soundproofing

The acoustical performance of UltraTouch is rated in terms of its R-Value, which can be seen in Table 7. The product has been treated with a "patented three dimensional infrastructure that traps, isolates and controls sound waves." This patented process allows the insulation to "reduce airborne sound transmission including traffic, airplanes, radios, televisions, and conversation."[29]

Table 7. Acoustical performance given by R-Values according to thickness
Source: Ref. 29

ACOUSTICAL PERFORMANCE

Sound Absorption was tested in accordance with ASTM E90-02, ASTM C423 (Type A mounting per ASTM E 795)

R-VALUE	THICKNESS	(MM)	ABSORPTION COEFFICIENTS @ OCTAVE BAND FREQUENCIES (Hz)						
			125	250	500	1,000	2,000	4,000	NRC/STC
R-13	3.5"	89	0.95	1.3	1.19	1.08	1.02	1.0	1.15 NRC
R-13	3.5"	89	21	40	48	52	46	48	45 STC
R-19	5.5"	140	0.97	1.37	1.23	1.05	1.0	1.01	1.15 NRC
R-19	5.5"	140	40	53	57	63	53	63	57 STC

4.3.3.3 Fireproofing

UltraTouch has a "patented proprietary process treats each individual fiber with a boron-based fire retardant." According to the company, this treatment not only provides for as a "superior fire retardant", but also "impedes the growth of fungus and mold" while additionally acting as a deterrent for pests. [29]

Building materials require fire resistance testing in two categories: (1) Surface Burning Characteristics (ASTM E-84) and (2) Fire Hazard Classification (UL-723). As seen in Table 8 below, UltraTouch received a Class 1 rating in both categories.[32]

Table 8. Physical properties, e.g. fungi resistance, fire resistance, etc.

Source: Ref. 29

PHYSICAL PROPERTIES	PERFORMANCE	TEST METHOD
Surface Burning Characteristics *(Fire Hazard Classification)*	Flame Spread 5 *(Class 1)* Smoke Developed 35 *(Class 1)*	ASTM E-84 UL-723
Corrosion Resistance	Passed	ASTM C-739
Fungi Resistance	Passed – No Growth	ASTM C-739
Bacteria Resistance	Passed – No Growth	ASTM C-739
Moisture Absorption	Passed – Less Than 15 %	ASTM C-739
Fire Test of Building Material	Passed – 1 Hour Rating	ASTM E-119 / UL-263

4.3.4 UltraTouch insulation environmental impact assessment

As listed below in Figure 4.1.4, UltraTouch insulation provides several environmental benefits including, waste reduction through its 90 % use of post-consumer denim, energy conservation through its high thermal insulating properties, i.e. (R-Values), and a fairly negligible impact on IAQ, while reducing the level of noise pollution and pests for residence within the structure. [29]

In addition, by avoiding using hazardous materials such as fiberglass, asbestos, formaldehyde, etc. they are reducing the flow of these materials into the environment where humans and other living organisms can become exposed to them.

LEED™

LEADERSHIP IN ENERGY AND ENVIRONMENTAL DESIGN

ULTRATOUCH Natural Cotton Fiber Insulation can contribute to earning several LEED program credits. Below are the categories and prerequisites in the Green Building Rating System where UltraTouch may contribute.

		COMMENTS:
ENERGY & ATMOSPHERE:		
Prerequisite 2	Minimum Energy Performance	ULTRATOUCH facilitates compliance with ASHRAE 90.1-1999
Credit 1	Optimize Energy Performance	
Credit 2.1	Construction Waste Management: Divert 50%	Bonded Logic Inc will receive UltraTouch insulation project waste for re-introduction into the manufacturing process.
Credit 2.2	Construction Waste Management: Divert 75%	
MATERIALS & RESOURCES:		
Credit 4.1	Recycled Content: 10%	By weight ULTRATOUCH contains 90% post-consumer recycled content
Credit 4.2	Recycled Content: 20%	
Credit 5.1	Regional Materials: 10%	Project is within a 500 mile radius of manufacture, Chandler, Arizona 85248
Credit 5.2	Regional Materials: 20%	
Credit 6	Rapidly Renewable Resources	ULTRATOUCH utilizes cotton as one of its main material sourcess
INDOOR ENVIRONMENTAL AIR QUALITY:		
Prerequisite 1	Minimum Air-Quality Performance	ULTRATOUCH contains no harmful irritants or chemicals that can pose respiratory health or VOC concerns
Credit 4	Low Emission Materials	
INOVATION IN DESIGN:		
Credit 1	LEED Inovation Credit	ULTRATOUCH contributes to design credits in the useage of innovative materials throughout the project

Figure 4.13 UltraTouch Insulation’s LEED credits

Source: Ref. 29

4.3.5 UltraTouch insulation cost and savings aspects

Since Bonded Logic Inc. UltraTouch insulation is primary sold in the US the prices given are also in US dollars. The prices range depending on the dimensions, from

$57.86 USD for 27.10 ft^2 to $146.53 USD for 126.63 ft^2. Based on a 2,000 ft^2 house the price for the insulation itself, not including tax and labor would be roughly $2,314.[27]

Given the same scenario as we calculated for the Bio-HAGA Korit insulation, whereby we use the information in Tables 4 and 5, we can determine the approximate annual cost to consumers of UltraTouch, in terms of heat losses. The annual heat loss, i.e. kWh/(m^2a) we can see that with the same wall area of 100m^2, the annual heat loss would have been around 16 kWh/(m^2a), since the U-Value for UltraTouch is slightly over the given U-Value of 0.20 W/(m^2•K)[27], Therefore, based on current electricity rates in Kyushu, Japan the cost to consumers in terms of lost energy could be calculated as [16 kWh/(m^2a) × ¥ 7.90 JPY] = ¥ 126.40 JPY/(m^2a) × (100 m^2 wall area) = ¥ 12,640 JPY annual cost to residential consumers. It should be noted that when we compare the cost of energy losses for the Bio-HAGA Korit of 24,490 JPY we have a savings of 12,640 JPY per year in energy costs prevented heat losses through improved insulation.[28]

4.3.6 UltraTouch insulation additional information

After contacting UltraTouch in the US, they informed me that there product was not sold in Japan, however that it could be ordered and purchased directly through them or one of their dealers. Also, Neopor was the only product for which a purchase price was listed.

Chapter 5: Analysis of the Technologies

5.1 Analysis of Usability 'Ease of Installation & Use'

5.1.1 BASF Neopor insulation

Since BASF Neopor comes in panels that can be easily installed either into existing structures or into new houses and apartments it might be an ideal material for the Japanese housing market. In the example above we considered that Neopor would applied as an Exterior Insulation and Finishing Systems (EIFS). In addition, several examples were shown were the insulation could be installed on almost any surface within the structure, e.g. attic, external wall, roof, etc. and applied in a variety of methods including, (1) applied as a panel to the external wall (described above), (2) insertion into the wall cavity by "loose beads", or (3) installed behind a curtain wall. Please see images 4 and 5 under the section *BASF Neopor insulation installation*.[12]

There are several aspects we should detail here for purposes of later analysis.

1. BASF Neopor insulation is sold within Japan
2. Since Neopor's primary input material EPS can be manufactured by BASF on a large scale and is not dependent on either "recycled materials" or "natural raw materials", e.g. trees, it can be manufactured to meet demand.
3. As a "manmade" material EPS is already commonly known and familiar to builders and consumers and therefore would not have to face any stigmas that might arise as barriers while trying to market the product.

Japan is facing a crisis situation in terms of its weak insulation in buildings and if it hopes to meet any future GHG reduction commitments, will have to move forward at a fast pace towards implementing improved insulating materials. Since Neopor comes in panels that can be fairly easily applied to already existing structures as well as new structures, it might be able to be immediately applied to existing housing, e.g. concrete apartment buildings.[12]

5.1.2 Bio-Korit insulation

Bio-Korit similar the BASF Neopor comes in panels with dimensions of 50 x 100 cm by 4 to 20 thick. Also, the installation is similar since it can be applied to almost any masonry surface, including concrete, brick, limetone, and porous concrete or Isolierbackstein. However, HAGA recommends in line with its low environmental impact strategy to use natural mineral based adhesives. In addition, it advises that (1) it should only be applied to clean surfaces, and (2) it should not be applied at temperatures below 5°C.[19]

There are several aspects we should detail here for purposes of later analysis.

1. Bio-Korit is not sold in Japan and would need to be ordered and shipped from European suppliers.
2. Unlike Neopor it is dependent on natural raw materials, e.g. the cork oak, which must be harvested sustainably if they are going to remain for future generations to use and enjoy. Therefore, it is conceivable that there may difficulty to meet large-scale demand. The products heavier weight compared to other products might be a factor in terms of shipping costs.
3. Since cork is considered a sustainable building material with both environmental and health benefits it might be attractive for some consumers,

however since it is not commonly used and still unfamiliar with many builders and consumers it may face some stigmas that would hinder its implementation.

5.1.3 Bonded Logic Inc. UltraTouch insulation

Designed for North American homes, UltraTouch insulation comes in “batts”, which are precut panels that are manufactured to fit between the studs (i.e. wooden framing), which are common. These insulation batts come in a wide range of dimensions ranging in thickness (51 to 203 mm), width (413 to 616 mm), and in length (1.22 to 9.75 m). Even though, it is specifically designed to fit between the studs in North American style homes, there is no reason to believe that it could not also be applied to houses in Japan, although there would need to be some experimentation to see how effectively it could be applied. [29]

There are several aspects we should detail here for purposes of later analysis.

1. Bonded Logic Inc. UltraTouch is not sold in Japan
2. While it is dependent to some extent on recycled waste streams, i.e. post-consumer denim it is conceivable that it could be produced at rates to meet demand. An interesting potentially future idea would be if the company set up a factory in Japan and used domestic sources of post-consumer denim for its input material. This would significantly lower any CO_2 emissions incurred through shipping from the US.
3. As mentioned previously UltraTouch is designed for US and Canadian houses and therefore would have to be proven to be affective and feasible for Japanese housing projects. Contrarily, this could prove to be a marketing advantage for the company since UltraTouch comes in flexible and easily to cut batts, it may

be effective in insulating areas that other insulation materials cannot be used, e.g. around piping or to fill-in gaps in wall spaces.

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5.1.4 Evaluation of results

Considering there is an enormous need for insulation in Japan, despite its current comparatively lower implementation into housing projects, we need to consider the case of optimal demand conditions. If the Japanese government does further promote the utilization of insulation in Japan we can estimate that demand would be quite high. Therefore BASF Neopor insulation may have a significant head start, since it is already available and with minor adjustments could be manufactured to meet the domestic insulation needs within Japan. A word that is key in any business transaction, but particularly applicable in Japan's case is "acceptability". There are many non-Japanese business people that will tell you the tremendous effort necessary to reach a point where Japanese companies will "accept" you and business can begin. Therefore, the fact that BASF as a one of the world's largest chemical companies is already established here gives it and its Neopor product a distinct advantage.

However, having stated this there is no reason that either Bio-Korit or Bonded Logic Inc. UltraTouch could not potentially introduce their products in Japan as well.

Since each has their distinct marketing advantages. For example, since Bio-Korit can be easily be applied to pre-existing concrete structures it could be seen as a 100% natural and environmentally friendlier alternative insulation material. Marketed effectively towards the more eco-conscious it could be very successful. In addition, UltraTouch could also be marketed as a more environmental alternative and perhaps be marketed in a diversified way, as to adapt to Japan's domestic needs.

5.2 Analysis of Insulating Properties (U-Values)

5.2.1 BASF Neopor insulation

Given the application of EIFS the insulation performance of Neopor is U-Value of 0.29 W/(m^2•K) or a thermal conductivity of λ = 0.029 W/mK

It is important to note that by modifying the bulk density of Neopor the thermal conductivity increases to λ = 0.032 W/mK. This is the reason that compared to standard EPS, Neopor has superior thermal insulating properties that allow for a significant reduction in thickness (15 to 20%), which means a reduction in raw materials and therefore less environmental impact.[12]

5.2.2 Bio-Korit insulation

The U-Value for Bio-Korit is 0.40 W/(m^2•K) or a thermal conductivity of λ = 0.040 W/mK.[19]

5.2.3 Bonded Logic Inc. UltraTouch insulation

Since Bonded Logic is a US company the R-Value for UltraTouch insulation is initially given as the "thermal transmission value", which is given a R-value of 3.94 ft^2 •h•°F/Btu for a 1-inch thickness and converts to a U-value of 0.254 (m^2•K/W).[29]

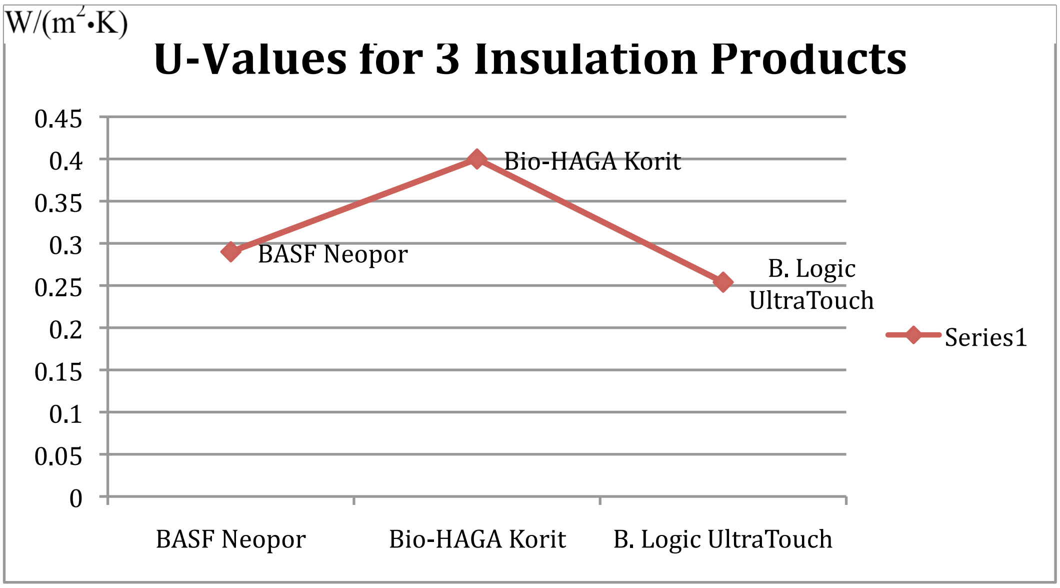

Figure 5.1 U-Values for the 3 insulation products analyzed (Self-generated)

5.2.4 Evaluation of results

In the Figure 5.1 graph we may quickly conclude that Bio-Korit has inferior thermal insulating properties, compared to BASF Neopor with the second lowest U-Value rating and Bonded Logic Inc. UltraTouch with even a slightly lower U-Value rating.

However, while this analysis may lead us to reach some conclusions, we should hesitate to "declare a victor" since each product's ability to create a sufficient thermal barrier to resist heat and cooling losses depends on several factors including the thickness and other dimensions, the quality of manufacturing and handling, the quality of installation, climate and so on.

In order to a more fair analysis we would probably have to set up a proper experiment with some set factors and conditions. Regardless of the accuracy of the outcome of this analysis we can satisfactorily conclude that each of these products if implemented into the Japanese housing sector would significantly improve its current situation.

5.3 Analysis of Health & Safety Aspects

5.3.1 BASF Neopor insulation

Health aspects

BASF Neopor is essentially manufactured from expandable polystyrene or EPS and graphite. In order to properly analyze the potential health risks of these materials we need to examine each separately. The main component used in the manufacturing of EPS is Vinyl benzene which is the monomer for polystyrene or $C_6H_5CH{:}CH_2$. [14]

The US Environmental Protection Agency (EPA) is a suspects Vinyl benzene to be carcinogenic that and may "also be a suspected toxin to the gastrointestinal, kidney and respiratory systems, among others." In addition the US EPA states that styrene can release VOC, which can contribute to the formation of harmful ground-level ozone.[14]

The other primary material used in the manufacturing of Neopor insulation is graphite, which is a mineral and one of the allotropes of the carbon family and is usually benign. While it is difficult to fathom such high rates of direct exposure to the graphite, nevertheless, the US government agency (Occupational Safety & Health Administration) OSHA states that the (Permissible Exposure Limit) PEL is [15 million particles per cubic foot or 15 mppcf] averaged over an 8-hour period. In the most severe case of exposure, if inhaled over a long period it could cause lesions within the lungs and graphite pneumoconiosis.[15]

A health benefit that should not go overlooked is that Neopor has decent soundproofing characteristics, which may have unseen benefits over the long-term for the home's residence.[12]

Safety aspects

In terms of fire safety, the Neopor insulation is accordance with the European standard DIN EN 13163. In the classification of 'Euroclass' it is rated as a Euroclass E in accordance with DIN EN 135011. In other words, it is "capable of resisting, for a short period, a small flame attack without substantial flame spread". In addition, it is rated as a 'B1' in accordance with DIN 4102, which means that under this classification it satisfies the requirements for a Euroclass D rating, and can withstand a "thermal attack by a single burning item" with only "limited lateral spread of flame". [16]

5.3.2 Bio-Korit insulation

Health aspects

Bio-Korit is marketed as "a hundred percent natural thermal insulation system" that is completely free of synthetic additives. To maintain its natural quality the company strongly recommends using natural mineral adhesive plaster and mortar.

Since cork is a completely natural material it does not contain any potentially harmful substances, e.g. VOC. In fact, it contains a natural waxy substance known as Suberin, which gives cork its resistance to both mold and fungus. And as we have discussed prior, preventing both of these is critical in terms of IAQ.[20 21]

Bio-Korit was has received many credits under the US LEED's program for its many environmentally friendly qualities, one of these is its soundproofing characteristics which are directly identified and described, "cork's natural characteristics such as its cellular structure provides sound proofing properties." Adding that, "The transmission of vibration from mechanical equipment can be reduced using cork flooring and underlayment."[22]

Safety aspects

While it seems that cork without fire retardants may be vulnerable in terms of longer exposure to fire, a product called Suberra with a similar cork construction claims that it is heat resistant up to 350 ° F and has a class B fire rating. UL (Underwriters Laboratories), which tests building materials for safety, lists material with a class B fire rating as being able to withstand moderate exposure to fire.[23 24]

5.3.3 Bonded Logic Inc. UltraTouch insulation

Health aspects

Since the material is 100 % cotton and does not contain any of the following substances which either were used in the past or are currently found in similar insulation products:

1. Asbestos and fiberglass, which has been known to contribute to respiratory illnesses, including cancer. Today in the US, the use of asbestos is not permitted by law, so it is quite certain that other comparable products will also not contain asbestos.[30]

2. Formaldehyde, which worsens IAQ conditions and is a known irritant to eyes and throat. In addition, at higher exposure 0.1 ppm may trigger an asthma attack. It is also listed as a carcinogen and has caused cases of cancer in animals and potentially in humans.[33]

3. VOCs, which as described in a previous section are according to the US EPA can potentially contribute to the formation of ground-level ozone.[14]

While UltraTouch insulation is treated with boron based fire retardant material, which mixed with O_2 forms Borate. It is not considered harmful unless exposed over longer periods at higher concentrations. For example, The Longer Term Health Advisory states that humans with of (2.0 mg/L) in their drinking water experience diarrhea and vomiting. The risk therefore to inhabitants is very low.[31]

Safety aspects

In terms of fire resistance, UltraTouch received a Class 1 rating in the two testing categories: (1) Surface Burning Characteristics (ASTM E-84) and (2) Fire Hazard Classification (UL-723).[32]

5.3.4 Evaluation of results

If we consider the exposure to humans over the lifespan of each of these products it is difficult to determine at which point there is any risk to health. For example, while Neopor definitely appears to pose the highest risk between the three products due to its use of Styrene, a "non-natural" material that may have some negative impacts on human health, we cannot be certain to what extent it will impact health and to whom it will impact, the workers at the plant or the inhabitants living within the structure.

Each of these products is treated with some other element for example, Neopor is treated with graphite and UltraTouch is treated with Boron, however here also it is difficult to assess whether there is any real risk to human health.

While both Bio-Korit and UltraTouch clearly identify themselves as "all natural" products, perhaps UltraTouch has the wisest marketing strategy, i.e. to clearly label what potentially harmful substances are not in its product. Because from the consumers point of view, if it is difficult to determine how much exposure to a substance is "too much", then the only real answer is, complete avoidance. Therefore, even though BASF Neopor insulation is probably safe and will likely not pose any harm to human health as long as it is handled properly, it cannot be clearly determined that it will not. In addition, a reasonable homeowner might be hesitant to install it into their home without thoroughly checking out its potential long-term health risks.

All three products seem to be resistant to mold and fungus and therefore should not have any IAQ issues arising from moisture build-up.

Finally, we can say that while these products may not pose any real risk to consumers it is the perceived risk that may really count, when it comes time for a customer to spend several thousands of dollars for a product.

5.4 Analysis of Environmental Impacts

5.4.1 BASF Neopor insulation

The BASF Neopor insulation product is essentially comprised of EPS and graphite. As described above natural graphite requires mining, which definitely has a considerable impact on the local environments in the regions the mining takes place. Several decades of experience has given many experts insight into its harmful effects, which include the production of mining tailings that run off into and become hazardous for aquatic life in downstream waterways. There may also be many other unintended consequences of such actions, including polluting underground water aquifers and even diminishing the chances for tourism in the area. In conclusion, while I was not able to determine whether BASF is using natural graphite for its input material, if this is the case, the negative impact to the environment is substantial regardless whatever restoration efforts may be later occur.

A positive aspect of the BASF Neopor insulation product is that it contains no CFCs, HCFCs, HFCs or other halogenated cell gases, which have been shown to cause depletion of stratospheric ozone. However, the Styrene itself, the primary input material may contribute to the formation of ground-level ozone. An astonishing figure released by the US EPA in its Toxic Release Inventory report, which shows the output of released by certain industries stated that 32.8 million pounds of styrene were released into the environment in 1992.[14]

5.4.2 Bio-Korit insulation

The US Green Building Council's LEED (Leadership in Energy and Environmental Design) considers certain materials such as cork to be a sustainable building material, since it is not only renewable but natural, recyclable and biodegradable. Cork is renewable because it can be sustainably harvested in 9 to 10 year intervals over the lifetime of the cork oak tree, without actually harming the tree itself. There is a tremendously positive aspect that should not be overlooked; trees have the capacity to sequester large volumes of CO_2. In the case of one species of cork oak *montado*, it retains 3.2 tonnes CO_2 per hectare per year. Considering that cork oaks usually have a lifespan of over 150 years, this is a significant contribution towards climate protection. To put this in greater perspective, approximately "1.5 hectares of *montado* with a tree coverage of at least 30 to 40 % are enough to compensate for the annual carbon dioxide emissions of an average vehicle."[34]

5.4.3 Bonded Logic Inc. UltraTouch insulation

As stated by the company UltraTouch offers several aspects which taken on face value are attractive. For example, the usage of 90% postconsumer denim seems very "eco-friendly", but we must take a closer look. According to Figure 12 the product received several points in varying categories towards its LEED certification, for example under the category of Materials and Resources it received credits for its 'recycled content' of 10% and 20% and for its 'regional content' of 10% and 20%. In actuality the product is using 90% postconsumer denim "*by weight*". In addition, the company has limited the project area to within 500 miles of the manufacturing. The company's intention to limit its environmental and carbon footprint is clear, however we cannot be completely certain to the extent their efforts are fulfilling the desired goal.[29]

Other efforts made by Bonded Logic Inc. including the avoidance hazardous materials such as VOC, fiberglass, asbestos, formaldehyde, etc. are to be applauded since each of these may create havoc not only for the consumers of such products and their IAQ but for the manufacturers and those who must handle the later disposal of such materials.[29]

5.4.4 Evaluation of results

In this short summary there are two areas that standout over the others. While we cannot understand from this analysis the complete list of waste and energy streams from the manufacturing of each material, we can get a rough understanding of what waste streams might be included, e.g. waste water.

The first to stand out is the amount of styrene waste that enters the environment each year. The US EPA's Toxic Release Inventory report that showed in 1992 that various industries released 32.8 million pounds of styrene into the environment is something that should get our attention.[14]

The second is the fact that the production input material for one of these products the Bio-Korit actually off-sets its own production emissions through its material source, the cork oak. The fact, that one species of cork oak *montado*, retains 3.2 tonnes CO_2 per hectare per year is a key point in understanding not only how to better manage the material flows, but in essence which products might be more a sustainable option in the future.[34]

5.5 Analysis of Cost & Savings Aspects

5.5.1 BASF Neopor insulation

Using the study from above it was estimated that approximate energy savings for Neopor insulation customers. The largest savings was in Tuscan, Arizona where a total combined savings ($90 heat and $33 cooling) of $123 was saved when 2" Neopor was installed. In addition, the ROI showed a payback of 7.7 years with a 2% energy price increase, 7.5 years with a 5% increase in energy prices and 6.5 years with a 10% energy price increase.[18]

5.5.2 Bio-Korit insulation

Since the price of Bio-Korit was unlisted, the calculated lost annual energy cost by using the figures in Table 4, whereby given Bio-Korit's U-value of 0.40 W/(m^2•K) that the approximate cost for a typical European house in 2005 with a 100 m^2 wall area would have been 172€/a.[27]

However, in order to get a more realistic view of the cost to Japanese consumers the figure given in Table 4 that gives an annual heat loss of 31 kWh/(m^2a) was again used. This figure was calculated to the approximate cost of energy losses based on current energy prices in Kyushu, Japan, which are currently (using the lowest price) ¥ 7.90 JPY/kWh for residential homes (see Table 5).[28] Therefore, based on this price we can see that for a U-Value of 0.40 W/(m^2•K), which is the given U-Value for Bio-Korit that the cost for residential consumers in Kyushu would be [31 kWh/(m^2a) × ¥ 7.90 JPY] = ¥ 244.90 JPY/(m^2a) × (100 m^2 wall area) = ¥ 24,490 JPY annual cost to residential consumers.

5.5.3 Bonded Logic Inc. UltraTouch insulation

Bonded Logic Inc. UltraTouch insulation was the only product for which the listed price was given. The prices in USD were based on the dimensions, ranging from $57.86 USD for 27.10 ft^2 to $146.53 USD for 126.63 ft^2. To get a general idea of how much this would come to, it was estimated for an average size home of 2,000 ft^2. The price for the insulation only would come to $2,314 USD.[29]

However, in order to estimate the approximate annual energy loss to consumers again the same steps were to calculate the energy losses for Bio-HAGA Korit insulation, whereby the information in Tables 4 and 5, was used to determine the approximate annual cost to consumers of UltraTouch, in terms of heat loss, i.e. kWh/(m^2a). Again based on the same scenario with a same wall area of $100m^2$, the annual heat loss would have been around 16 kWh/(m^2a), since the U-Value for UltraTouch is slightly over the given U-Value of 0.20 W/(m^2•K). Using the current electricity rates in Kyushu, Japan I calculated the following [16 kWh/(m^2a) × ¥ 7.90 JPY] = ¥ 126.40 JPY/(m^2a) × (100 m^2 wall area) = ¥ 12,640 JPY annual cost to residential consumers.[27 28]

5.4.4 Evaluation of results

The evaluation of either annual saved energy costs in the case of BASF Neopor and approximate lost annual energy costs in the case of Bio-Korit and UltraTouch was helpful in gaining a perspective into just how much money can be saved through improved wall insulation.

As the world's economic situation becomes more serious this must also be a consideration for homebuilders now and into the future. The concept that proper insulation does not matter and that energy is cheap is a one that if not already discredited, should be abandoned forever.

5.6 Contribution Towards Sustainability

This section will examine the degree of sustainability for each product.

For this purpose, several concepts will be introduced which are identified in the work of William McDonough and Michael Braungart in their book *Cradle to Cradle* (McDonough & Braungart, 2002).[9] Essentially there work is primarily concerned with how to deal with industrial material flows.

The concepts can be summarized briefly into three categories:

1) Eco-effectiveness[9] over eco-efficiency – this concept's philosophy is that if we continue to pollute the environment with questionable substances, i.e. chemicals and elements, but do so in just smaller quantities then we may end up destroying the planet's ecosystems more completely, without a chance to recover.
2) Design mimic's nature – this second concept, essentially is what it sounds like. It's based on the idea that if we are going to design and engineer products, houses, water treatment plants, we should do so that they adopt nature's ingenuity into them. The desired result of such a practice that we could gain nature's wisdom, while producing products that would have virtually have zero or little negative impact on the environment.
3) Utilization of service over ownership – this last concept, argues that it is not necessary for people to own everything for which they actually only require the service or use of for a limited amount of time. For example, you do not need to own your cell phone and all the valuable materials within it forever, but in actuality only need the service or use of the phone, until you wish to acquire a new one. Therefore, we companies should be encouraged to offer their services and not their products for sale to customers. (p. 111)

5.6.1 BASF Neopor Insulation

If we consider the first concept of *Cradle to Cradle* eco-effectiveness[9], then it can be quickly identified that the manufacturing of EPS from Styrene is perhaps outside of this concepts boundaries. They would argue that a more eco-effective material should be considered, in order to avoid introducing toxins into the environment. In fact, they have developed an extensive database that is available to companies that lists which materials are safe and can be used in manufacturing and which ones cannot.

5.6.2 Bio-Korit Insulation

The idea of using the tree bark and not destroying the tree to produce the insulation for Bio-Korit is in line with the cradle-to-cradle principle. In addition, this would follow their second principle of mimicking nature's design. Just as the cork oak utilizes its own bark to protect itself from extreme conditions in the environment, so can we humans protect our homes and their occupants from the external extreme changes in our environment.

5.6.3 Bonded Logic Inc. UltraTouch Insulation

Since UltraTouch is made from 90% post-consumer denim and cotton, we can see that it has been recycled. At this point, we must introduce the concepts of downcycling and upcycling, which are also introduced in their work. Site (p. 110) In the process of downcycling a material upon disposal is mixed with other materials to form an inferior product that will eventually be "thrown-away", however the process of upcycling requires that "technical nutrients" and "biological nutrients" be protected within their respective nutrient cycles, therefore materials remain uncontaminated and can (at least in theory) be endlessly recycled.[9]

With this in mind, we can approach UltraTouch with the view that if it is designed in a way that its material contents can be feasibly upcycled after it is no-longer housing insulation, then it would be fully compliant with the *Cradle to Cradle* concepts.

Chapter 6: Conclusions and Recommendations

6.1 Conclusions

6.1.1 Options Available

As we can see from the table below there are many options available to both homeowners and builders when it comes time to choose wall insulation for housing. Each option comes with its own set of characteristics, e.g. density, thermal insulating capacity, etc., however the choice of which to use will have to be carefully balanced considering all of the following:

1) The initial cost of the insulation, including tax and installation fees;
2) The insulation's ability to insulate against losses in thermal energy, i.e. its U-Value or R-Value;
3) The insulation products overall impact on the environment in terms of energy expended, emissions created, and which and what amount of harmful substances will be introduced into the environment during the product's full lifetime;
4) The potential risk to health. This is another area where consumers of the insulation will need to do a certain amount of research into the products development prior to purchase;
5) The ease or feasibility of acquiring the product, e.g. either from overseas or from domestic dealers;

6) The ease of (a) installation, (b) care or upkeep needed during its use, and (c) its disposal.

Besides demonstrating the numerous choices available to consumers, we can also see by the below graph that “more natural” materials, e.g. cork, clay, etc., seem to use far less primary energy compared to materials that have more manmade sources and also likely require more technical processes during their production.[35]

In order to find the most sustainable solutions for the future of Japanese housing there are many factors that will need to be considered besides those that may be obvious or easily recognizable.

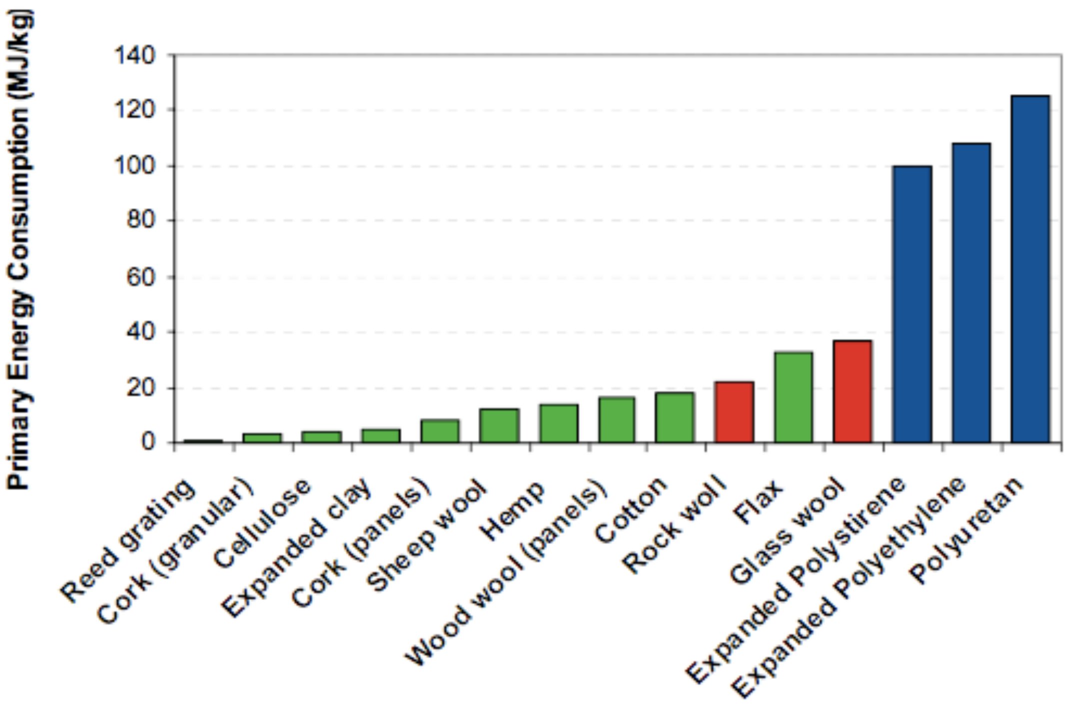

Figure 6.1 Estimation of primary energy consumption of some insulation materials' life cycles

Source: Ref. 35

6.1.2 The Carbon Factor

As has been discussed previously in this paper, Japan is facing a critical situation to reduce its carbon footprint. Whether the target is 6% or 20% from 1990 levels is irrelevant unless there are individuals who are willing to lead. While Prime Minister Hatoyama will not be in office when 2020 arrives, and therefore does not have to take responsibility for his "political rhetoric", at some point, whether from within or external, the political pressure to change, will come.

The technical answers to address this crisis will have to be considered carefully. Below is a graph that shows the global warming potential of several insulation materials, similar to the graph above we can see that the more natural materials, e.g. flax and sheep wool, had comparably smaller footprints in terms of both their primary energy consumption and global warming potential.

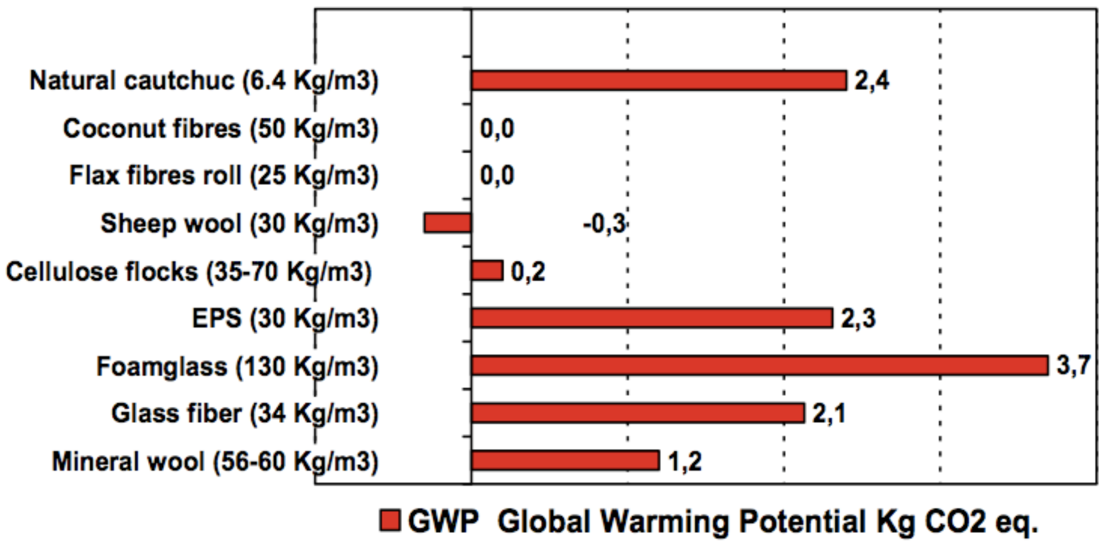

Figure 6.2 GWP Global Warming Potential of various insulation materials
Source: Ref. 35

6.2 Recommendations

Based on the findings in this paper we can conclude and suggest the following:

1. While both Bio-Korit and Bonded Logic Inc. UltraTouch insulation products are attractive from both environmental and health aspects, the fact that they are not yet manufactured and sold in Japan gives them a distinct disadvantage for the Japanese house market. However, as the 'political atmosphere' in Japan changes and there is even more pressure for government involvement and support, I think both products might find a place in the market and success.
2. The Japanese government must do more to support the push towards improved housing energy efficiency, either through programs such as CASBEE[11] or through financial subsidies. As the 'home' to the Kyoto Protocol and the world's second largest economy, the world is watching Japan with high hopes that it will become a leader in the effort in GHG abatement and sustainable climate protection.
3. In regards to future research it is recommended that a Life Cycle Analysis (LCA) be conducted, since as it was discovered, it is quite difficult to gage which products actually have a lower impact on the environment, human health, etc. without an actual experiment or case study, whereby all factors are set for each product and the results can be better determined.

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