

Wood Pellets as a Biofuel:  
Current Status and their Market Potential

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## Abstract

Awareness of climate change and the likelihood that we will run out of fossil fuels is encouraging the development and use of renewable energy. As wood pellets are a sustainable and renewable energy source, the production of wood pellets is developing and growing rapidly worldwide. Guo, Song, and Buhain (2015) reported that renewable energy currently accounts for only 8% of total global energy consumption, but estimated that it will reach 30% by 2050 if renewable energy is continuously researched and developed. European countries, the US and Canada lead wood pellet production, accounting for over 90% of the global volume. Asia and South America have enormous potential to contribute to global production and consumption of wood pellets, yet they have produce very small quantities and lack coherent strategies and policies to increase capacity. Experts encouraged the use of wood pellets, because they are easy to handle and use and are generally very safe, cost efficient and environmentally friendly. However, by 2011, only 22 million tonnes of pellets were used for fuel (0.38 EJ), about 1% of the global biomass consumption (55EJ) (WBA, 2014). Therefore, to increase their use and to become a significant global energy source, more study is needed, including how to address environmental and health concerns culminating in global policies, standards and strategies. This essay addresses the current global status and situation of wood pellet markets and analyzes the potential for a global wood pellet market and finds that the market for wood pellet has grown rapidly in the last few decades and will develop significantly with better policies and strategies.

*Keywords: biofuel, bioenergy, wood pellets, pellets, renewable energy, fossil fuel, domestic heating.*

## **Introduction and Background**

Our world is highly dependent on fossil fuels. We use them to warm our homes, operate vehicles, run factories and industries and produce electricity. Fossil fuels currently play a significant role in the global energy market, which is forecast to continue; Shafiee & Topal (2009) predicted that the energy generated from fossil fuels will consume as much as 84% of the global energy market in 2030. Unfortunately, we will run out of this source of energy. These researchers reported that if we consume oil, coal and gas, three types of fossil fuels, at the current rate, reserves of oil, coal and gas will last 40, 200 and 70 years respectively (2009). Therefore, we need a renewable and sustainable energy source to substitute for fossil fuels and other hydrocarbon-based energy resources.

Bioenergy and biofuels are considered as alternatives to fossil fuels and the development of bioenergy and biofuels is growing fast. Pellets are a type of biofuel made by compressing organic matter or biomass, usually sourced from industrial or food waste, agricultural residues and lumber industries (Karkania, Fanara, & Zabaniotou, 2012). Interest in their use as a competitive substitute for fossil fuels is growing because they are easy to use and store and they are inexpensive, renewable and sustainable. Currently, the most common type of pellets are made from sawdust or from industrial waste from milling or wood product manufacturing.

This essay investigates worldwide wood pellet markets, presents the results of recent studies about wood pellets, analyzes environmental concerns and the economic value of pellets, addresses the possibility and potential of marketing wood pellets and discusses opposing viewpoints and possible difficulties to using wood pellets.

## History and Development of Wood Pellets

**Worldwide energy consumption.** The world energy market is highly dependent on fossil fuels. However, fossil fuels are limited and non-renewable energy sources. As shown in figure 1, since the early 1900s, world consumption of fossil fuels has gradually increased, and by 2030, consumption of all types of fossil fuels is expected to hit over 150 quadrillion Btu.

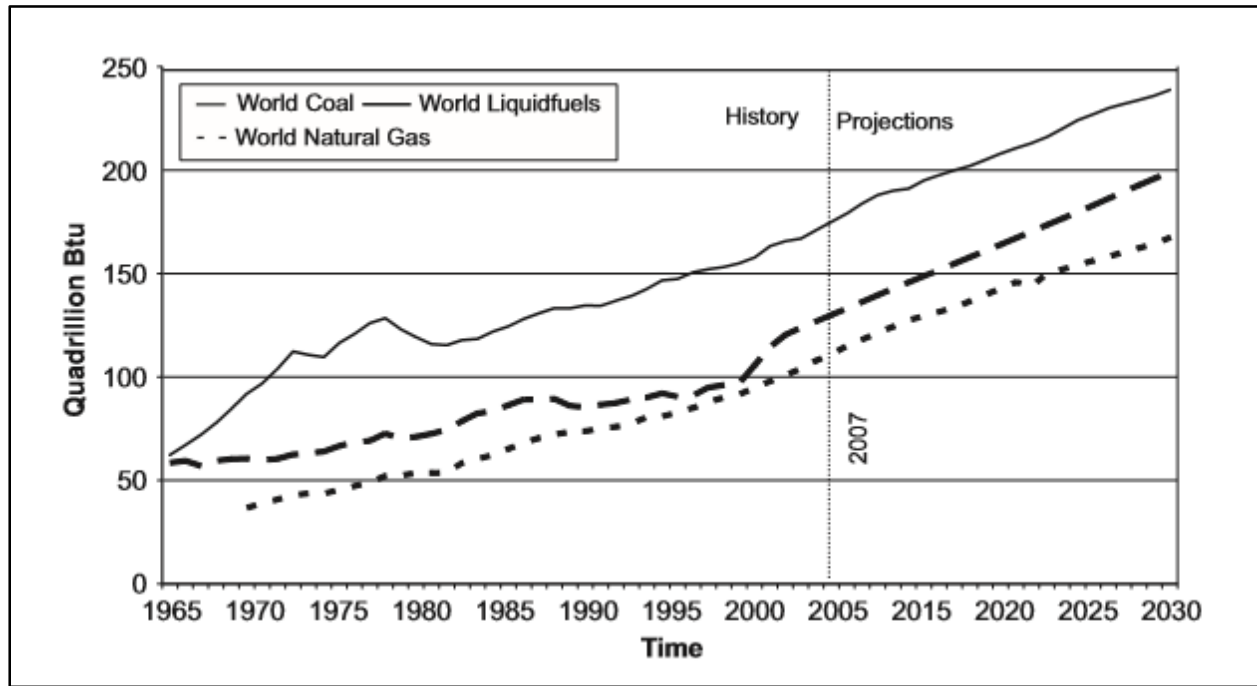


Figure 1: Consumption of fossil fuel worldwide from 1965 to 2030.

Adapted from Shafiee & Topal, (2009). When will fossil fuel reserves be diminished? Energy Policy, 181-189.

Lincoln (2005) estimated that of the total energy consumed, approximately 85.1% was derived from fossil fuels, of which approximately 52.3% was used by commerce and industry, 25.8% by transportation and 21.1% for residential use. Lincoln also estimated that in 2010, US sources of energy from renewable sources were only 8% of its total energy use compared to 83% from fossil fuels. Figure 2 shows that among renewable sources, about 25% came from wood.

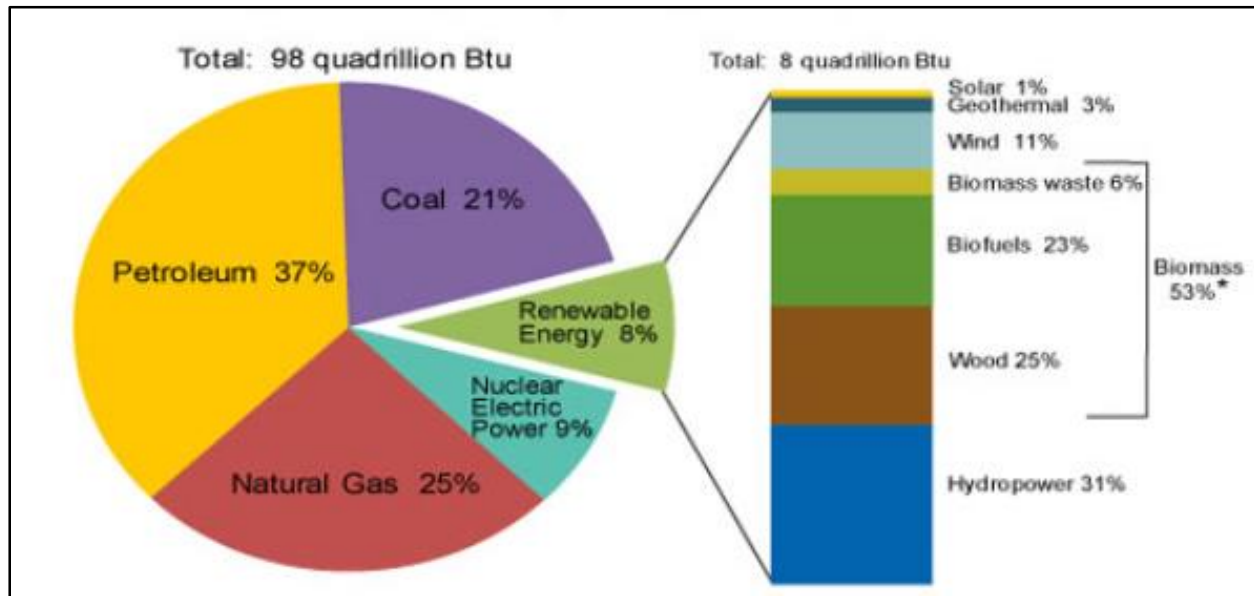


Figure 2: U.S. energy consumption by energy source in 2010.

Adapted from McLamb (2010). The secret world of energy. Retrieved from Ecology Webinar Series: <http://www.ecology.com/2010/09/15/secret-world-energy/>

Regarding bioenergy, Guo, Song and Buhain explained in their study (2015) that human beings have always used bioenergy and in the last 15 years, those fuels have been “...intensively researched, produced, and used”, but fossil fuels are still the dominant energy source today, meeting over 80% of the world’s energy consumption and demand. However, global consumption of bioenergy has been steadily increasing and the use of wood chips and wood pellets for domestic purposes has doubled in the past decade and is expected to grow steadily (2015).

### Development of Wood Pellets

Before the 19<sup>th</sup> century, wood products were the predominant source of fuel for domestic purposes and in some countries, people still use wood as a fuel. Lu and Rice (2010) reported that approximately 2.2 million households, accounting for 2% of total thermal energy use for household heating, used wood as a primary heating source. These authors also stated that the use of wood pellets and other forms of compressed wood residues has been investigated for many years and that in the early 1930s, compressed sawdust in the shape of logs was marketed and

sold for fuel (2010). However, the development and methods of production of modern wood pellets was introduced surprisingly late. The first wood pellet patent was registered in 1976 in the US during the global oil crisis; wood pellets from bark and sawdust were first used for small-scale local applications (Kuokkanen, Kuokkanen, Stoor, Niinimäki, & Pohjonen, 2009). Until the 1980s, worldwide interest in producing pellet was low, despite vast sources of wood residue. However, with awareness about exhausting supplies of fossil fuels, fossil fuel-based pollution discussed in the Kyoto Protocol and rising global oil prices, interest in replacing fossil fuels with renewable sources increased (2009).

Beginning in the 1990s, many countries looked at producing renewable energy, including developing wood pellets. The first large-scale wood pellet production started in Sweden in 1992 (2009). Guo, Song and Buhain (2015) estimated that global production of wood pellets reached about 19.1 million tons in 2012 and expected it to reach 45.2 million tons by 2020. According to Lu and Rice (2010), the countries of the European Union are the largest wood pellet producers in the world and wood pellet production in Europe alone accounted for over 9 million tons in 2007. On the other hand, in 2006, only 1.2 million tons were produced in Canada and 0.8 million tons in the US, but the wood pellet industries in both countries are growing rapidly every year (Heinimo & Junginger, 2009).

Many scientists and organizations believe if efforts to develop renewable energy continue, by 2050 renewable energy will provide about 30% of the world's demanded energy and a significant amount of this energy could come from wood pellets (Guo, Song, & Buhain, 2015).



## Study of Wood Pellets

### Characteristics

Wood pellets, an alternative to oil, particularly for heating purpose, are cylindrically shape and generally 2-3 cm in length (Figure 3). Pellets are produced by grinding wood residues under high pressure through a hammer mill and then compressing the sawdust through 6 to 8 mm holes in a pelletizer die (Guo, Song, & Buhain, 2015). Wood pellets have relatively low moisture content, 7-12%, high density, 1100-1500 kgm<sup>3</sup> and an energy content of 4.7-5.0 kWh kg<sup>-1</sup> (Table 1). Just over 2 tons of pellets is equivalent to 1000 L of fuel oil.



Figure 3: General appearance of wood pellets.

Adapted from Environmental Benefits of Wood Pellets (2016). Retrieved from Wood Pellet Association of Canada: <http://www.pellet.org/>

**Table 1: Properties of wood pellets and some comparison data.**

Property or comparison	Value
Size	Diameter usually 6–10 mm and length 10–20 mm
Energy content	4.7–5.0 kWh kg <sup>-1</sup> , circa 3 MWh bulk-m <sup>-3</sup>
Moisture content	7–12% for pellet, 12–40% for wood chips
Ash content	~ 0.5%
Density	1100–1500 kg m <sup>-3</sup> , 600–750 kg bulk-m <sup>-3</sup>
Compared to light fuel oil equal as	1000 L oil = 2.1 t pellets, 1 m <sup>3</sup> oil = 3.3 bulk-m <sup>3</sup> pellets, 1 t oil = 2.5 t pellets
Compared to wood chips equal as	1 bulk-m <sup>3</sup> chips = 0.28 bulk-m <sup>3</sup> pellets, 1 bulk-m <sup>3</sup> chips = 0.18 t pellets

Note: Adapted from Kuokkanen, Kuokkanen, Stoor, Niinimäki, & Pohjonen (2009). Chemical methods in the development of eco-efficient wood-based pellet production and technology. *Waste Management & Research*, 561-571.

### **Advantages**

High quality wood pellets are mechanically durable and generally contain less than 0.7% ash (Guo, Song, & Buhain, 2015), are easy to store, process, transport over long distances, and are relatively safe (Patzek & Pimentel, 2007). They are also cheap, easy and safe to use, renewable and sustainable.

**Environmental benefits.** Wood pellets are an efficient source of biomass energy, which is important, as fossil fuels contribute dramatically to CO<sub>2</sub> emissions (Thomson & Liddell, 2015). As they are made from wood waste materials, such as wood residues and sawdust, pellets burn cleanly and thus create less air polluting emissions compared to other combustion heating energy sources. Thomson & Liddell (2015) reported that wood fuel can be neutral in CO<sub>2</sub> emissions if the harvest rate is equal to the re-growth rate, meaning that the amount of CO<sub>2</sub> produced by consuming biomass fuel can be equal to the amount taken from the atmosphere during the growing stage. This would result in a zero net addition of CO<sub>2</sub> to the atmosphere.

Furthermore, wood pellets can be produced locally, alleviating the need to transport the energy source over long distances, thus reducing the transport source of CO<sub>2</sub> emissions related to fossil fuels. For those who use wood burning stoves for heating, replacing those systems with

modern wood pellet heating systems such as boilers, burners, or stoves can reduce emissions by 95% (Mahapatra, Gustavsson, & Madl, 2007).

**Economic Considerations.** Wood pellets are less expensive than fossil fuels, such as oil, liquefied petroleum gas, and electric powered systems, particularly as wood pellets have higher energy content than oil (Thomson & Liddell, 2015). The domestic heating cost of wood pellets is also generally cheaper than any other fossil fuel. According to the Biomass Energy Resource Center (2007) one ton of wood pellets equals 120 gallons of heating oil, 170 gallons of propane, 16,000 ft<sup>2</sup> of natural gas and 4,775 kilowatt hours (kWh) electricity. It calculated that paying \$200/ton for pellets equals \$1.67 per gallon for heating oil, \$1.18 per gallon for propane, \$12.50 per (1,000 ft<sup>3</sup>) for natural gas and \$0.04 per kWh for electricity. Thus, at \$2.40 per gallon of heating oil, a wood pellet user would save \$.63 per gallon or 27%, with total yearly savings of \$2,700 on a \$10,000 annual fuel bill (2007).

In addition, wood pellets' high availability and low price of raw materials make the cost of pellets more stable. This is especially positive as prices of fossil fuels fluctuate widely. Also, producing wood pellets locally supports local economies with infrastructure and jobs. Producing wood pellets is very cost-effective since the raw materials are relatively cheap and mills can operate automatically needing only a few employees (Lu & Rice, 2010).

Another benefit of wood pellet is global trade and rapid development and expansion of wood industries. This is likely as wood pellet production is projected to increase from the reported global production of 19.1 million tons in 2012 to 45.2 million tons in 2020 (Guo, Song, & Buhain, 2015).

**Accessibility and transportation.** Wood pellets are small, typically with a diameter of 6-10mm and a length of 10-20 mm. Their uniform and compact size makes them easy to handle,

use and transport over long distances without changing their energy efficiency. They are similarly easy to store as they do not freeze or mold and are not prone to bridging. Fifty 40 lb bags can be stored neatly with a high packing density of around  $650 \text{ kgm}^{-3}$  (2015).

Another significant advantage of wood pellets is accessibility. As wood pellets break up easily and the dust produced during combustion process is very fine, combustible, and explosive, they are very suitable for small stoves to big power plants. Since, wood pellets do not depend on a fixed physical distribution network, wood pellets are very suited for domestic use. For instance, in Northern Ireland, where around 68% of households rely on oil for heating, rural areas have a poor natural gas network and depend on a fixed physical distribution network (Thomson & Liddell, 2015). There, using wood pellet heating systems can be a good option, especially as domestic pellet boilers can fit through a standard house door (2015).

## **Wood Pellet Markets**

### **Overview**

The global market for wood pellets as an international commodity is developing rapidly. In last few decades, many countries have shown interest in renewable energy, especially to lower their greenhouse gas emissions. As a result, the wood pellet industry is becoming prosperous (Goh, et al., 2013). In the EU, home to the majority of global pellet production and consumption, countries have been trying to increase their shares of renewable energy. Goh et al. (2013) estimated that in 2010, the trade volume of wood pellets between EU and non-EU countries was about 45 PJ compared to 75 PJ and 16-22 PJ for biodiesel and bioethanol respectively.

Estimating the global pellet trade accurately is hard because there are no official statistics for wood pellets and the market of wood pellet is not mature enough and is developing rapidly every year (Heinimo & Junginger, 2009). However, the World Bioenergy Association (WBA) an

association that reports annual world bioenergy statistics, reported that 27 million tonnes of pellets were produced in 2014 and 97% of the global production of pellets were from the Americas and Europe in 2013. (Kummamuru, 2015). In addition, worldwide production capacity and the average size of pellet plants are increasing, showing a 22% trend increase from 2009 (Goh, et al., 2013).

Figure 4, global production and consumption in 2010 by country, shows that EU countries were dominant while in Asia, South Korea and Japan produced and consumed very little. Table 2, global production of wood pellets 2012-2014, shows that America and European countries were dominant, accounting almost over 90% of the global production of wood pellets (Kummamuru, 2015). The wood pellet industries in Canada and United States have grown rapidly since 2005, and Canada is now the most important wood pellet exporting country in the world. Specifically, Canadian wood pellets, primarily from BC, are mainly exported to Europe. For instance, exports were about 400 kilotonnes in 2004 and about 625 kilotonnes in 2006, making Canada the largest wood pellet exporter in the world (Heinimo & Junginger, 2009).

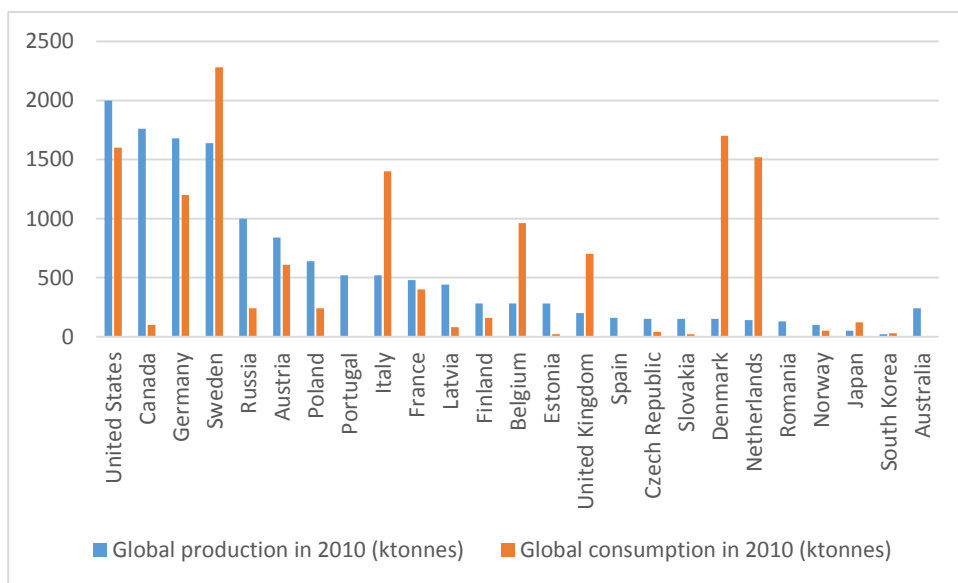


Figure 4: Wood pellet production and consumption in 2010 by countries. Adapted from Goh, et al. (2013), Wood Pellet market and trade: A global perspective. Biofuels, Bioprod. Bioref, 24-42

**Table 1:** Global production of wood pellets 2012-2014

	World	Africa	Americas	Asia	Europe	Oceania
2012	19.5	0.09	6.71	0.30	12.4	0.00
2013	22.1	0.10	7.62	0.62	13.8	0.00
2014	27.0	-	-	-	-	-

Note: Adapted from Kummamuru (2015)

### European Countries

The European Union has been interested in renewable energy for last few decades as part of an EU objective is to increase the use of bioenergy and develop environmentally friendly and cost efficient bioenergy under international and national environmental rules. The EU is the primary wood pellet market and will remain the leading wood pellet producer for the next several years. In 2010, it produced about 61% of global totals and consumed nearly 85% of the global wood supply (Goh, et al., 2013). In Germany, Austria, France, Italy, Finland and Norway, wood pellets are mostly used domestically for household heating. Germany and Austria have high feedstock availability, which allows them to export their excess production (Goh, et al., 2013). Germany has the largest production capacity, produces the most in Europe and is increasing the number of pellet production plants dramatically; Saracoglu and Gunduz (2009) reported that 290,000 tons of wood pellets were produced in 28 pellet plants in 2005 and 32 more companies at 35 sites had been built in 2006. 75% of Germany's total production volume is used for residential heating and the remainder for generating electricity in its power plants. In the past several years, Germany has increased production.

In Austria, wood pellet production covers its national demand, which is mostly for residential heating (Goh, et al., 2013). Unlike Germany and Austria, in the Netherlands, Belgium and the United Kingdom, wood pellets are mostly used to operate power plants. Wood pellets are

relatively more cost efficient than fossil fuels and emit lower CO<sub>2</sub>; thus the Netherlands and Belgium use almost 100% and 85% of wood pellets respectively for co-firing in large-scale coal-fired power plants (Goh, et al., 2013). Therefore, their national consumption of wood pellets is generally higher than their national production.

Finally, many European countries have been trying to increase their use of renewable energy sources as the EU's goal is 25% renewable energy by 2020 (Kuokkanen, Kuokkanen, Stoor, Niinimäki, & Pohjonen, 2009)

### **Canada and United States**

Wood pellet markets in Canada and the United States grew rapidly in the last decade, and with its vast wood resources, Canada has become the most important wood pellet exporting country in the world. Heinimo and Junginger (2009) reported that in 2010, about 75% of produced wood pellets were exported to Europe and 25% to the US. Currently, more than half of Canada's wood pellet industry plants are located on the West Coast with 11 plants in British Columbia (Goh, et al., 2013). The WBA reported that the US and Canada have become the world leaders in pellet production; As shown in Table 3, the US and Canada ranked first and third in pellet production in 2013, accounting for about 30% of global production. Because production is geared for exports, national consumption of wood pellets in Canada is much lower than national production. In the US, on the other hand, production is targeted for domestic use, as in 2010, over 80% of pellets produced in the United States were used domestically with the remainder exported to Europe (Goh, et al., 2013). By 2013, US production of wood pellets reached 5.70 million tonnes and consumption accounted for 2.97 million tonnes (Kumnamuru, 2015). As international demand for wood pellets continues to rise, Canadian and US production will expand.

**Table 2: Pellet production and consumption in top 10 countries in 2013 (million tonnes)**

Country	Production	Country	Consumption
USA	5.70	United Kingdom	3.63
Germany	2.21	USA	2.97
Canada	1.80	Denmark	2.24
Sweden	1.31	Italy	2.04
Latvia	1.09	Germany	2.03
Austria	0.96	Sweden	1.86
Portugal	0.90	Belgium	0.89
France	0.89	Austria	0.86
Russian Federation	0.81	France	0.83
Poland	0.60	Netherlands	0.68
Total (Top 10)	16.3	Total (Top 10)	18.0
World	22.1	World	21.7

Note: Adapted from Kummamuru (2015)

### Other Countries

Countries outside North America and the EU generally have very small wood pellet production capacity. In East Asia, Japan and South Korea have extremely small pellet plants mainly because of insufficient raw material, lack of policy support and technical quality support (Goh, et al., 2013). Kummamuru (2015) reported that there were only 118 pellet production plants in Asia compared to a worldwide total of 749 plants in 2012 (Kummamuru, 2015). However, Japan planned to import up to 0.4 Mt wood pellets per year for co-firing (Goh, et al., 2013). South Korea uses wood pellets for power generation and its imports from China, Vietnam and Malaysia have almost tripled since 2007 (2013). Its pellet market will grow dramatically starting in 2012 because the government introduced new renewable energy standards to increase the proportion of renewable energy the country uses (2013). However, in 2015, the South Korean government implemented new import requirements based on the Apostille Convention, an international certification comparable to notarization in domestic law (Fletcher, 2015). As a



result, non-signatory countries, such as Canada, cannot legally export wood pellets to South Korea. This rules has impeded the increase in wood pellets.

South America has a large potential to become one of largest wood pellet markets. Currently, only, Brazil and Chile are involved in wood pellet production. Brazil's current annual production is only about 0.3 Mt but this is expected to grow exponentially since there has been a very active renewable energy movement (Goh, et al., 2013).

## **Opposing Viewpoints**

### **Possible challenges**

Wood pellets have many advantages but there are also a few issues and barriers to consider, including using them is labour intensive, and their use presents some environmental and health risks. First, wood pellet boilers require more maintenance than conventional boilers because users are required to refill them with pellets, clean the stoves and burn the ashes and slag after use (Thomson & Liddell, 2015). In addition, wood-fired boilers generally require regular and maintenance to prevent efficiency loss. If pellet boilers are poorly adjusted or poor quality wood pellets are used, imperfect combustion may occur and high amount of ashes may be produced, which increases cleaning and maintenance time (2015).

Wood pellets also pose some environmental risks if wood is harvested unsustainably or in environmentally sensitive areas leading problems such as biodiversity and habitat losses (2015). Clearcutting wetlands and forests for wood pellet production creates deforestation, alters soil composition and changes the water cycle.

Health risks are another factor. In storage areas, carbon monoxide builds up without sufficient ventilation. This is a very serious problem and has resulted in several deaths in homes across Europe (2015). Furthermore, harmful air pollutants can be released if the pellet boilers are

not properly maintained or adjusted. As well, inhaling dust and ash can damage the respiratory system and may cause allergic reactions. Finally, when wood pellets decay, they can release fungal spores or toxins, which may also cause allergic reactions and irritation (2015).

### **Conclusion: Towards Sustainability**

Renewable energy is an emerging issue, as most global energy consumption today comes from non-renewable energy such as coal, oil and natural gas. This essay introduced and addressed the development, importance and potential markets for wood pellets. The markets for wood pellets have grown in the last few decades and are expected to continue to develop rapidly. The European Union countries are the largest wood pellet producers with over 80% of the wood pellet volume in the world, while Canada and United States are also large producers. In other countries, such as in Asia, awareness of renewable energy is growing and they have been trying to apply new techniques to increase their use of renewable energy. This will result in significant growth, especially if they create better policies and achieve their wood pellet production and export goals.

This essay showed that wood pellets generally have many distinct advantages among other energy sources; they are environmental friendly and cost efficient, and they are easy to use and transport. However, despite their advantages, end-user problems and environmental and health risks are not negligible. Small scale markets and poor understanding result in insufficient fuel service systems and lack of pellet standards, causing limited production growth.

Overall, the global consumption of bioenergy will continue to increase in the future to reduce carbon emissions. Further study regarding wood pellets as well as other important renewable energy sources should be more made to solve environmental concerns and lower our dependence on fossil fuels.

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