Saimaa University of Applied Sciences
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ENERGY CONSUMPTION IN FORESTRY INDUSTRY AND ENVIRONMENTAL PROSPECTS OF BIO-FUELS APPLICATIONS IN FINLAND AND CHINA

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ABSTRACT

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The main objective of this thesis is to clarify the energy consumptions conditions: how forestry industries are requiring and consuming the energy and how the environment is affected; besides, the background of bio-fuel is introduced and discussed to illustrate its potential and impacts on the traditional energy sources with the environmental and economic prospects domestically and internationally.

Two major methodologies are used to complete the thesis work in different chapters and also for different evaluations: The theoretical learning with discussions which aims to study the academic materials and articles with the supervision and guidelines from instructor to appreciate the knowledge Another method is real-life cases´ information analysis, it allows the real-life cases become the research background that more practical information could be obtained that promotes the reliability and practicability of the thesis. The real-life cases are from nations where author has been educated: Finland and the author`s homeland China are especially concerned, with discussions are concentrated on the differences of certain considerations between the two nations, author´s understanding and opinions are provided with supports from scientific and academic fundamentals.

Results of the thesis can be concluded as: combustion of fossil fuel brings greenhouse gas emission which accelerates the climate changes and global warming; within the deeper and more aggressive environmental damage and impacts are continuously occurred from energy consumptions and forestry industry activities. The scales of the developments and the bio-fuel applications have to be accelerated and amplified in order to minimize the impacts on the environment and food security. Besides, the co-operation and learning of the forestry industry between Finland and China should be enhanced, which secures and heals the environment. And simultaneously the related scientific efforts and commercial investments must be achieved and involved in order to promote and reinforce the potential and prospects of the bio-fuel in the future.

Key words: Finland, China, Forest Industry, Energy Consumption, Greenhouse Effects, Carbon Emissions, Global Warming, Bio-fuel Application, Sustainability, Food Security

CONTENTS

1. INTRODUCTIONS

1.1 Introduction of the work

Energy is the fundamental enabler of the modern society; any revolutionary changes on the aspect of energy determine the fate of the future. Within the next wave of changes and challenges after centuries of burning fossil fuels, as the global economic engine integrates new renewable and pollution-free energy technology such as the bio-fuels, reviewing of the traditional energy sources, studying and understanding of these new changes and challenges are considered as the most important task to perform in order to design industrial strategies for the future. Nowadays, demands of the energy supply, and global energy consumption are unexpectedly changing and rapidly growing without any exceptions, certainly our precious environment is also unavoidably involved in this evolution as a fundamental factor above all the others. Energy and industries, the most essential and critical factors which lead the modern civilization also controls and even limit the society where we are all living, that turns the studying and research of the developing industries, traditional energy sources and the energy which is from new concepts a unique and remarkable task that has to be successfully continued by the young technology students, future scientists and researchers. Since the issue of energy consumption and industrial activities bring serious influences and impacts, it is exactly as important to deal with the related issues which deeply affect our delicate living environment.

The way to balance the development of industries, usage of energy and damages of the environment is to clarify the relations among them and manage optimized solutions in order to leave a better future with more advanced industries, cleaner energy usages and more habitable environment. That is the reason to work on this topic based on the studying background with personal research passion in order to obtain the answers to the mentioned better future.

1.2 Introduction of the institution

Finland locates in the northern Europe, the *figure 1.1* below indicates the location, and it is ranked as one of the cleanest and most efficient nations around the world. Due to its global reputation and influences, Finland is an ideal destination of learning how the world´s leading environmental management system is working and how the situations of the issues, for example: energy consumption, industrial emissions and the bio-fuel usages are properly controlled and developed.

Figure 1.1 Location of Finland in Europe

Finland is also the leader for forest industry and its related education and research globally. Saimaa University of Applied Sciences is located in the same place where the largest forest industry production centers in Europe: South-east Finland, Finnish forest industry enterprises, for example: major production mills and research centers of UPM and Stora Enso are located in this area. Those mentioned advantages mark Finland an ideal education destination for the forest sciences and environmental engineering, and two campuses of Saimaa University of Applied Sciences are located in the cities of Imatra and Lappeenranta.

The university is a terminal based on the cooperation with the Finnish advanced forest industry where students are able to be well educated and trained for the forest-based and environmental research and future career in the environmental engineering and forest sciences. The unit of technology offers the degree program in Paper Technology at Saimaa University of Applied Sciences, which provides the essential knowledge and necessary skills to the students who want to make contributions and efforts to forestry industry, environmental engineering institutions and chemical process industries.

1.3 Background of the instructor

Heikki Siitonen
Saimaa University of Applied Sciences, Imatra, Finland

Master of Science, graduated from Helsinki University of Technology, 1972.
Working nearly 40 years as Process Engineer in Pulp and Paper Industry, specialised in the field of Industrial Environmental Protection.
Now teaching courses related with paper & pulping technology; industrial process and environmental protection at Saimaa University of Applied Sciences.

2. ENERGY CONSUMPTION AND FOSSIL FUELS CONDITIONS

2.1 Facts and conditions of fossil fuels

The traditional energy sources are considered as fossil fuel, which includes: oil, nature gas and coal. Fossil fuels are nonrenewable resources that were formed over millions of years from the dead, organic matters placed under intense pressure and heat where high carbon contents in the fossil fuels helps them to store enormous amount of energy.

Coal, one of the largest consumed abundant fossil fuel resources in which the carbon element occupies most of its chemical component. Coal can be discovered almost all over the globe. Approximately 87 percent of total coal production has been consumed by the electric utilities around the world. For example, coal is used to generate more than half of all the electricity produced in the United States of America. Coal is the most widely used energy source for the electricity generation globally, which also contributes the greatest scale of carbon dioxide emissions when combusted. For the productions, the coal is extracted from ground by mining, either underground or in open pits. As the *figure 2.1* indicates, world widely, the reserve of coal production is estimated to be 147 years. [1]

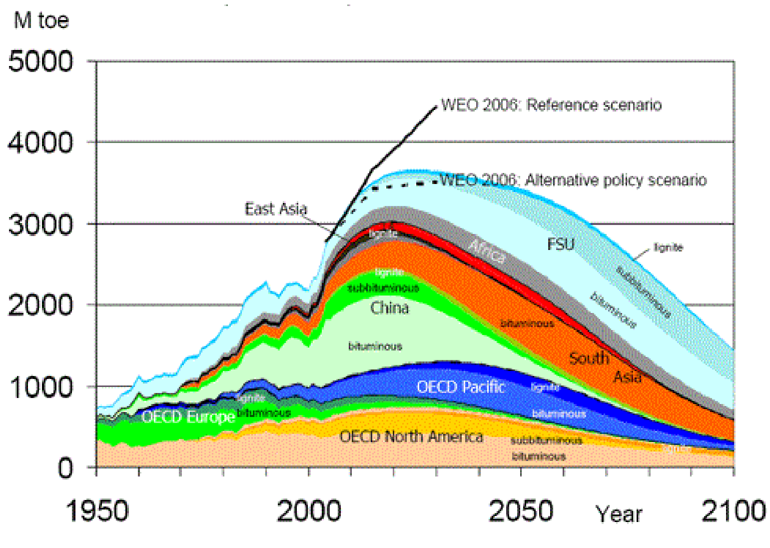

Figure 2.1 Worldwide coal production conditions and predictions

We might notice that coal is measured as the world's fastest growing fuel in terms of world consumption and world production in the next several decades. The bulk of this fuel is produced and also consumed by China.

Oil or fuel oil is one of the most important energy sources that come from crude oil, which is a complex mixture of hydrocarbons with amounts of other chemicals like sulfur. The mixture of crude oil is not in the working condition, which must be sent to an oil refinery to be separated into fuel oil. A process called petroleum distillation basically produces the fuel oil which operates a furnace that heats the crude oil. Organic compounds are evaporated and finally liquefied on different temperature level in an industrial condenser, which is the place where different products are classified and collected. Fuel oil is liquid petroleum product that is burned in furnace or boiler for the heat generation or consumed in engines for the power generation. Long hydrocarbon chains are the basic chemical structure of fuel oil, for instance: alkenes, cycloalkanes and aromatics. After petroleum distillation process, most of the fuel oil consumptions happen in the transportation field. Generally, the distributions of one barrel of refined crude oil are: 3% of asphalt, 4% of liquefied petroleum, 10% of jet fuel, 18% of other products, 23% of diesel fuel and heating oil with the largest part which is gasoline occupies 47%. Currently, Saudi Arabia as the world's top oil producer is producing 1.7 million m^3/d of oil. There are 15 countries that are expected to account for at most 84 percent of the net growth in global oil production capacity in the next decade, Those 15 countries are: Russia, Saudi Arabia, Norway, Canada, Iraq, Brazil, Kazakhstan, Iran, Kuwait, Algeria, Qatar, Libya, Nigeria, UAE, and Angola. [2]

Natural gas is the gas phase component of coal and oil formation, normally when talking about the natural gas, the actual organic compound is: CH_4. Before natural gas can be combusted as fuel, it has to be purified to remove almost all materials other than methane. The purifying and classification process is shown in the *figure 2.2* where the by-products of the processing include: ethane, propane, butanes, pentanes, and higher molecular weight hydrocarbons, elemental sulfur, carbon dioxide and water vapor.

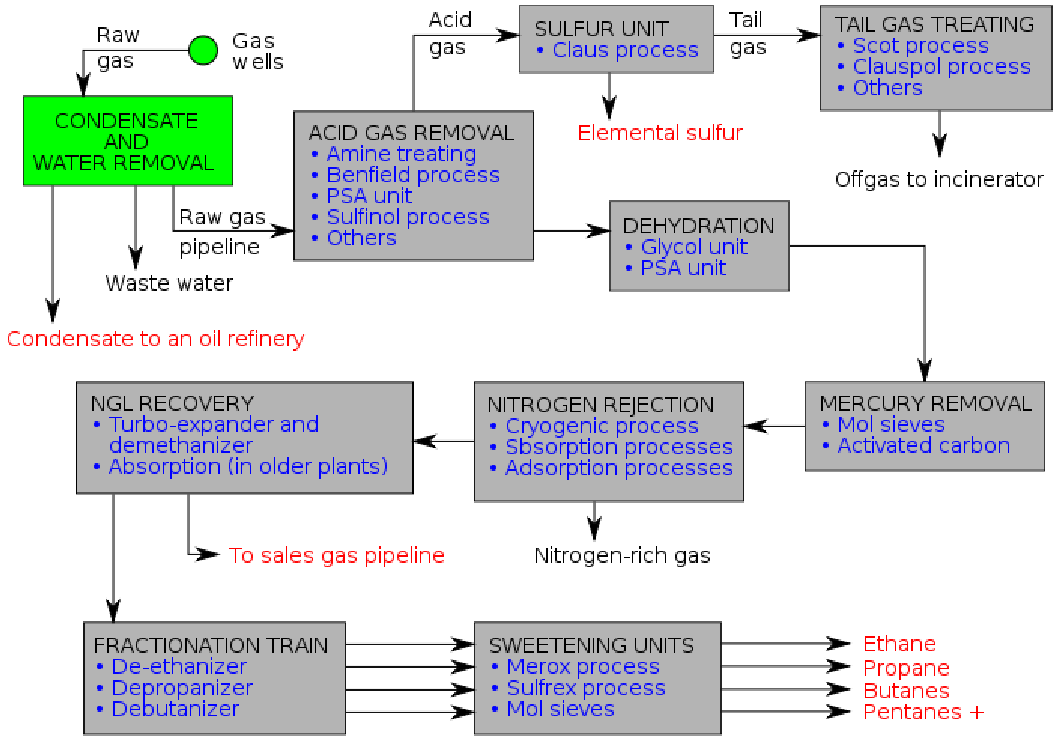

Figure 2.2 Purifying and classification process of natural gas production

Besides, natural gas can also be compressed into liquid form, which can be used as a transportation fuel. The natural gas is either found mixed in oil or is released from coal. Scientifically, methane is considered as one of the major green house gases which correspondently affects the environment and aggravates the current global warming situation. Russia, Iran and Qatar together hold almost 60 percent of the world's natural gas reserves, The United States ranks the second largest producer, but the production is mostly consumed within its region. Canada is the world is third largest producer, its production is responsible for over six percent of the global gas consumption, but future production is expected to remain flat or decline.

Different types of energy sources provide different energy contents indexes, which are considered as the indicators to identify and choose the property usage of each energy source, the *table 2.3* below gives the approximate energy contents of four common energy sources under the certain volume or weight.

Table 2.3 Approximate energy contents of several energy sources [3]

Type	Unit	Energy
Gasoline	*1 US gallon*	*123 MJ*
Coal	*1 metric tone*	*15-19 GJ*
Natural Gas	*1 cubic meter*	*35 MJ*
Diesel	*1 US gallon*	*36.4 MJ*

Fossil fuels are irreplaceably in use to generate electricity and heat which enables the industries and powers the daily life. Under this condition, fossil fuels are rapidly being depleted, which makes the inventions of the new technologies are strongly needed in order to develop alternative fuels for the future. Situations of fossil fuels consumptions and requirements have already become the most serious issue right in front of the entire human race.

2.2 Global energy usage, consumptions and requirements

Generally the global energy consumption has about doubled in the last three decades compared with the past century. In 2004, 77.8% of the primary energy consumption is from fossil fuels where 32.8% from oil, 21.1% from natural gas and 24.1% from coal, 5.4% from nuclear fuels, 16.5% from other renewable resources. With modernization and industrial development of the society, especially during those several decades, energy requirements are quickly raised, this situation leads the energy consumption also claims rapidly as well. *Figure 2.4* from the report of Statistical Review of World Energy points out the continuously growing energy usage of oil, coal, gas, nuclear and hydro power:

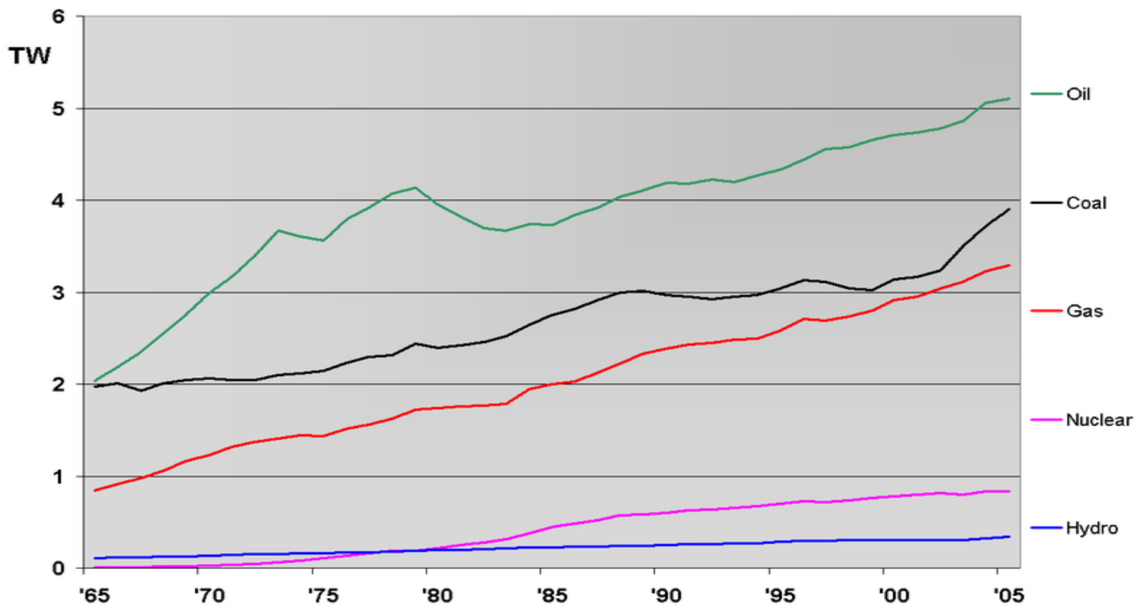

Figure 2.4 Growing electricity generation from major energy sources

According to the scientific report, totally 4.74 x 10^{20} J of energy had been consumed globally back in 2008; this number will be certainly raised with the development of the society and the booming of the world population.

The fossil fuel combustion contributed 80 percents to 90 percents of the whole energy production, the rest was generated by other energy sources which include: Nuclear power, Hydro power, solar power and Bio-fuel to reach the appetite of the global energy requirements, from the figures and descriptions we can easily understand that fossil fuel contributes the energy consumption and requirements mostly.

However the considerations of the environmental impacts and the shortage of the fossil fuels reserve are becoming more seriously than ever before. These issues must be sophisticatedly discussed and properly solved before the fossil fuels are eventually depleted and the irreversible damage with its ultimate punishment has been given from the environment.

2.3 Different energy conditions between Finland and China

When talking about the general energy conditions, energy efficiency, carbon emissions, and energy usages are all considered as key parameters of the estimated energy and electricity demands, which are certainly expected to be developed and improved as results of technological development, replacements of old appliances and equipment with further advanced ones take place both Finland and China. However, differences exist between these two countries because of their unlike economics, technological industrial and political situations.

The *figure 2.5* indicates the energy share conditions in Finland in the year of 2004 and the facts of Finnish electricity consumptions were reported as 90 TWh totally in 2006. As for predictions, growth of the electricity demand is estimated to be about 107 TWh by 2020 and much higher to be 115 TWh by 2030. Compared with the situation in 2006, consumption is expected to have a growth of 17 TWh by 2020 and some 25 TWh is predicted by 2020. [4]

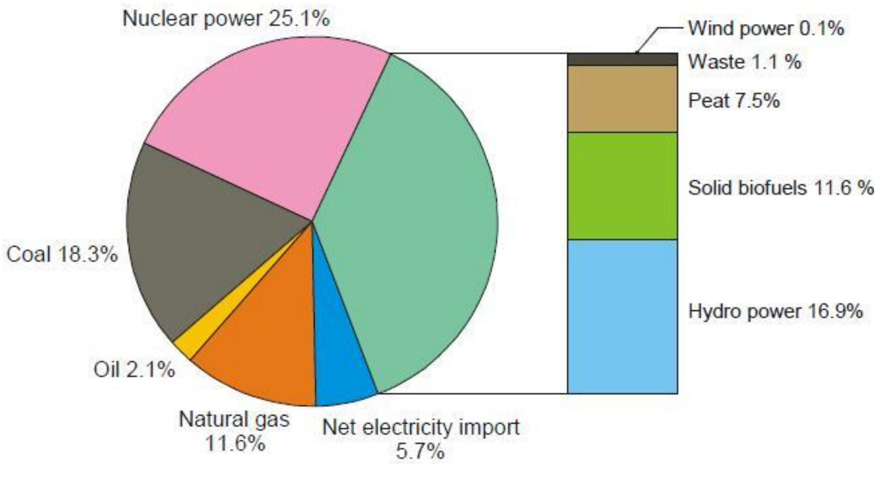

Figure 2.5 Primary energy sources share conditions in Finland, 2004

The growth until 2020 will be about 1.2% annually and a slow decrease will occur between 2020 and 2030 as 0.7%. On average, a growth of 2.6% was added on the energy consumption annually during the past decade. Energy consumption of Finland is high due to the intensive industry, cold climate and long distances transportation. But unfortunately the domestic energy source reserve of Finland is quite low, to respond these needs. Developing an efficient energy system has been a priority in Finnish energy strategy. Energy consumption always brings environmental problems, for example, on the particular aspect of carbon emissions. Finland successfully ranks the lowest carbon emission country in the world as we can see from *figure 2.6*; this title has been achieved by planning and constructing the system on a network basis which includes the stages of production, transmission, and usage and energy reserves and optimizing the whole system in an efficient and environmental friendly way.

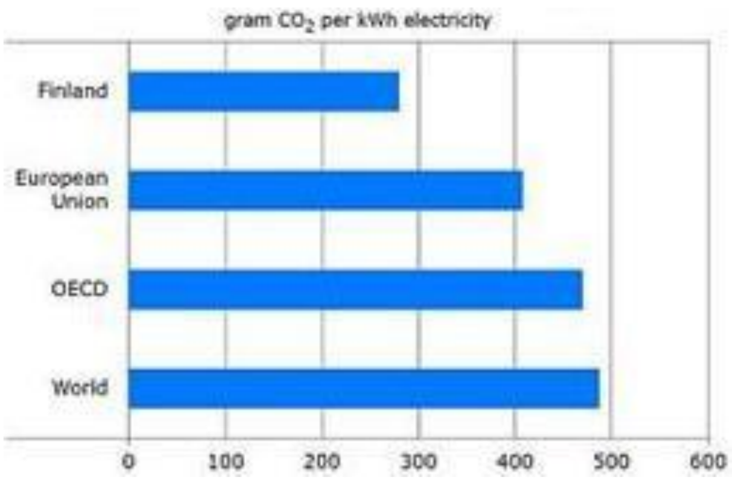

Figure 2.6 Lowest Carbon dioxide emissions of electricity and heat productions

According to the conditions of its energy consumptions and carbon emission, the IEA (International Energy Agency) had awarded Finland the title of ‘model for the world’ in combined heat and power generation and co-generation with high efficiency and low emissions.

Unlike Finland, China faces significant developments of its industries and economy with continuously booming of the population. Under this situation, China records the greatest scale and growth of energy consumption around the world. Most of China`s energy consumption is based on the fossil fuels: coal and fuel oil occupy over 90% of its whole energy demands. In 2007, coal provided more than 70% of the country’s primary energy consumption, gas was responsible to 8.8% and around 20% of the primary energy use in China was based on the fuel oil. Usage of fossil fuel contributes the most; other energy sources were following but with incomparable distributions.

More details from the general energy distributions of China are given in *the table 2.7* which clarifies the energy productions and consumptions facts from several sectors.

Table 2.7 China`s energy production and consumption facts, 2009 [5]

Item	Value
Coal Production	*3,362 million short tons*
Coal Consumption	*3,475 million short tons*
Natural Gas Consumption	*2,929 billion cubic feet*
Natural Gas Reserves	*3,075 billion cubic feet*
Oil Production	*3,991 thousand barrels per day*
Oil Consumption	*8,200 thousand barrels per day*
Electricity Production	*3,446 billion kilowatt hours*
Electricity Consumption	*3,017 billion kilowatt hours*
Wind Power Installation	*25.1 GW*
Nuclear Power Installation	*9.1 GW*

From the table we may clearly notice the comparisons and differences among the fossil fuels uses and uses of other energy sources like: wind power and nuclear power, it indicates that unlike Finland, the Chinese society is considered running totally under the burning of fossil fuels. The energy consumption situation makes China a nation who faces the most serious environmental problems, such as carbon emissions and industrial pollution. With the similar situation which the U.S is facing, it is reportedly over 40% of the global carbon emission that comes from China and the US together. And from the *figure 2.8* we are able to notice this situation is growing successively.

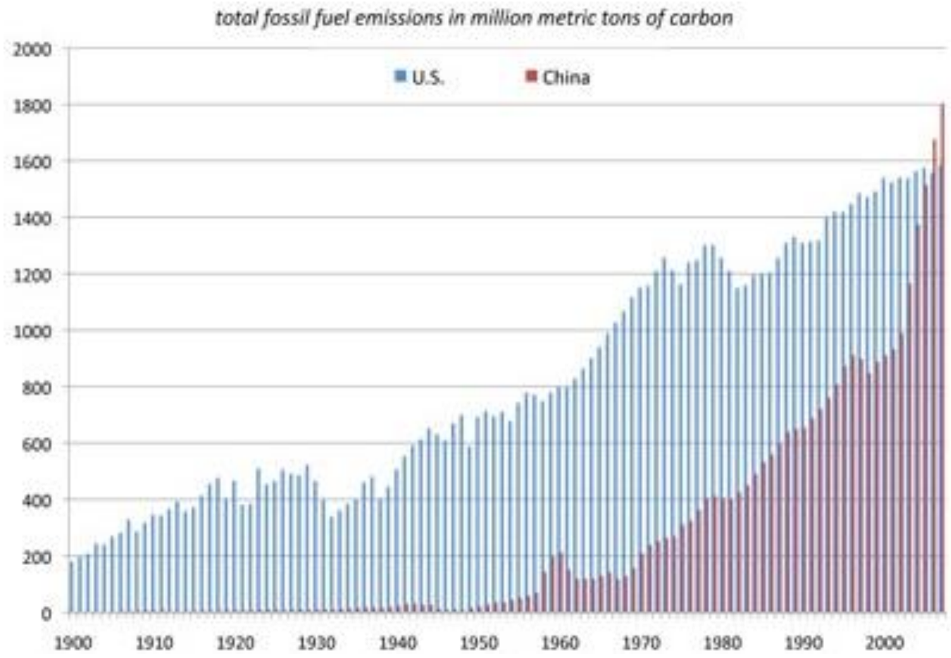

Figure 2.8 Carbon emissions from total energy consumptions in China and U.S

Even though the economic slowdown in exports and domestic demand in the 2007 had occurred, but China's demand for energy still remains high. China has emerged from being a net oil exporter in the early 1990s to become the world's third-largest net importer of oil in 2006. Natural gas usage in China has also increased rapidly in recent year for both import and export fields.

China is also the world's largest producer and consumer of coal, an important factor in the global energy markets, percentage of the total energy production from coal is estimated to increase up to 77.4% by 2015 in China. China's energy profile provides a view of the domestic economic and environmental characteristics. It tells the world about what China does, how fast China is doing it, and how efficiently it can be done. Energy is also a finite global commodity, demand and supplies for both in the costs of running our nations and the influences on the living environment.

With the significant shortage in the supply of petroleum globally and the growing of the environmental tensions, other types of fuels such as hydroelectricity, nuclear power, and Bio-fuels will definitely become increasingly essential and critical, not only to the economy and environment of China, but also to the future of the whole world.

3. FOREST INDUSTRY WITH ENERGY AND ENVIRONMETAL ISSUES

3.1 Finnish forest industry background and energy usage facts

As it shows in the *figure 3.1*, Finland owns the greatest forest coverage in Europe:

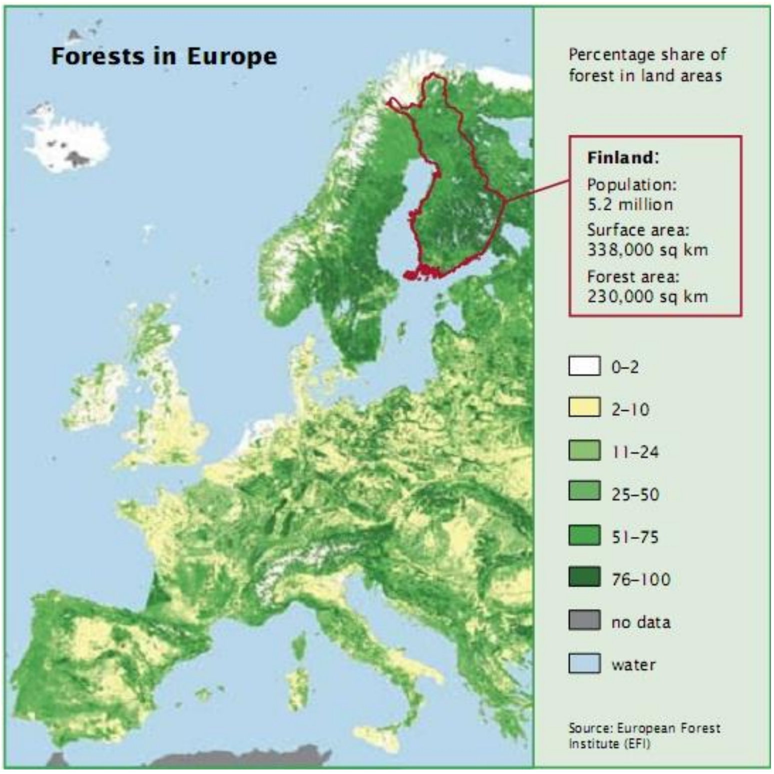

Figure 3.1 Finland has the greatest forest coverage rate in Europe [6]

Because of the remarkable forest coverage rate, the forest industries are the second largest branch among all industries in Finland. According to national economics, related industries employ about 90,000 people in Finland and it generates about 5.5% of Finland's gross domestic product and about one fifth of Finland's export revenue is contributed from the forest industries. Finland has the world´s leading sustainable forestry management systems; its forests are much better protected compared with other countries elsewhere in the Europe. Geographically, Finland is titled as the most extensively forested country in the Europe, the distribution of the forest and land area is shown in the *figure 3.2*: Approximately 86 percent of its land area is covered by forests; woods like pine, spruce and birch are the principle species, which are widely used in the forest industry in Finland.

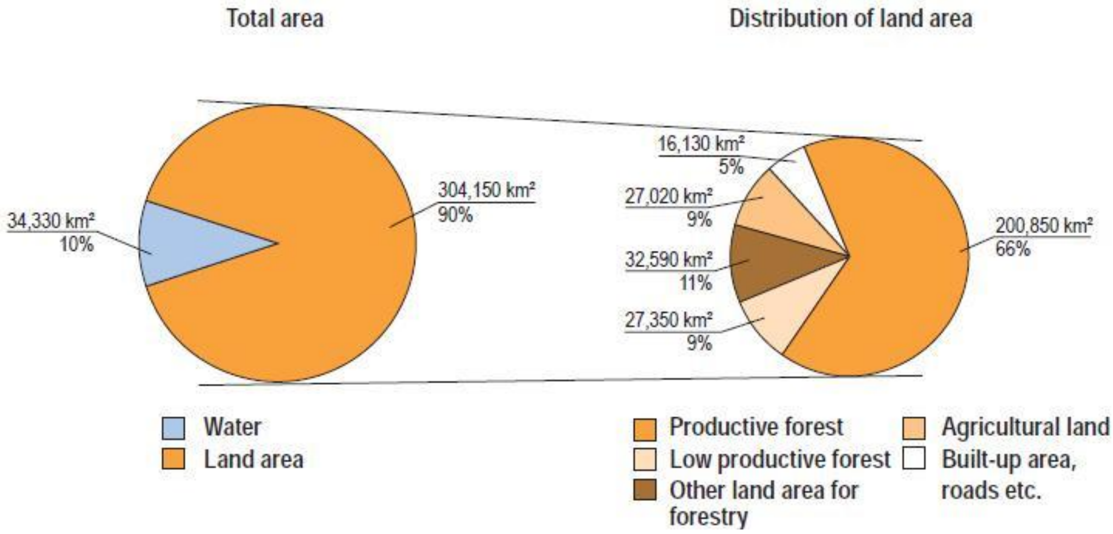

Figure 3.2 Distribution of Finland´s forest and land area

According to the statistic reports, there were 27 paper mills, 14 paperboard mills, 18 pulp mills and 23 mills producing mechanical and semi-chemical pulp in Finland in 2008. The number of industrial sawmills is about 170, and 22 of particleboard factories. Most of those mills and factories belong to Stora-Enso and UPM, who are the leading Finnish and Finnish – Swedish forest industry enterprises. During the last decade the forest industries have undergone considerable centralization and internationalization, and both trends are likely to continue. At the same time, their ownership has spread to become international.

Finland ranks the sixth largest producer of the paper and paperboard and the seventh largest producer of the softwood sawn products in the world currently, *table 3.3* below provides the productivity of forest products and its exportation in Finland, 2009. Today forestry industry totally makes up about 5.1% of Finland's gross domestic product, and approximately 18% of Finnish exports. High-quality printing and writing paper make up over 40% of the total export value of forest industry products, while sawn goods and wood-based panels account for some 20% of export value.

Table 3.3 Productivity and exportation of forest products in Finland, 2009 [7]

Product group 1000 tonnes/m³	Production	Exports	Share of exports, % of production	Number of production plants (*)
Paper, tonnes	8 100	7 400	91	25
Paperboard, tonnes	2 500	2 250	90	13
Pulp, tonnes	8 700	1 360	16	35
- Chemical market pulp	1 698	1 486	88	..
Sawn wood, m³	8 000	5 265	66	170**
Plywood, m³	780	675	87	11
Particle board, m³	170	50	29	2
Fibreboard, tonnes	46	34	74	2

Europe is the most important business area for the Finnish forest industry, about 60% of Finnish forest exports are exported to European countries, and major markets are located in Germany, England, France and Spain. Other European countries account for 11% of forest industry exports, and the rest of the world takes 30%, forest products from Finland are exported also to Asia and North America.

For the forest industry, processing stages like forest harvesting, woods transportations, production progress, products´ packaging, final markets transportations and waste treatments are all involved as the usages of the energy from forest industry, where the transportations and production process consume the most among all stages.

In 2006, the total forest industrial energy consumption was reported as 282,000 TJ, the energy distributions were: 75% from wood-based fuel, 5% from peat; 15% from natural gas; 4% from the heavy fuel and about 1% from other energy sources. About 80 % of bio-energy in Finland is produced by the forest industry and around 40 % of the total wood raw material in forest industry is used for production of bio-energy from bio-fuel. The bio-energy is derived from biomass; all kinds of plants and plant-based material are considered as biomass, such as logging, wood residue and wood-based waste liquors from the forest industry. Behind the total energy consumption of 87 TWh in 2004 and the *figure 3.4* specifies the energy consumptions by consumer groups:

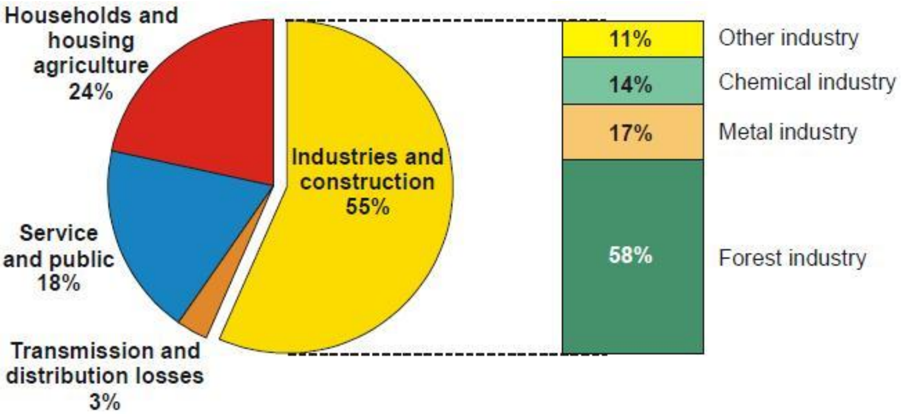

Figure 3.4 Energy consumptions by consumer groups in Finland, 2004

As the world`s leader of forest industry, Finland issued about 31% of the whole energy supply to power the forest industries, which correspondently brings equivalently huge profits to Finnish economy. The energy requirements in forest industry depend on the product types, the reason is due to different equipments, methods and raw materials treatments and preparations which are needed require significantly different energy supplies. *Table 3.5* indicates energy consumptions of different forest products.

Table 3.5 Example of energy consumption of different forest products types

Product	(GJ/ADt)	(kWh/ADt)
Bleached pulp	8,5 - 11	510 - 620
Bleached and dried pulp	10,9 - 14	630 - 760
Groundwood (GW)	0 - 0,6	1400 - 1500
Thermomechanical pulp (TMP)	+ 3,1 (yield)	2100 - 2900
Uncoated mechanical paper	4,5 - 5,4	610 - 720
Coated mechanical paper	4,6 - 5,3	700 - 770
Uncoated woodfree paper	6,6 - 7,1	530 - 670
Coated woodfree paper	5,5 - 7,8	720 - 850
Coated solid board	7,1 - 7,7	600 - 870

Also we are able to notice that the electricity consumption in different areas from the *table 3.6* below are all expected to rise, where as forest industry will increase the most from now on to 2030. Based on this group of values, the forest industry once again has proved itself as Finland`s key industry and the greatest developing industry in Finland.

Table 3.6 Electricity consumptions facts and prediction by sectors (TWh/year). [8]

	1990	2000	2006	2010	2020	2030
Forest industry	19.1	26.3	28.1	28.8	32.3	35.7
Metal industry	5.0	7.0	8.1	8.7	10.9	11.5
Chemical industry	4.5	5.9	6.6	7.0	7.7	8.3
Other industry and construction	4.5	4.6	5.1	5.6	6.0	6.4
Total processing	**33.1**	**43.7**	**48.0**	**50.0**	**56.9**	**61.9**
Services and transport	10.22	13.0	15.8	17.5	19.9	22.2
Housing and agriculture	9.94	12.3	13.9	14.7	16.0	16.6
Electric heating*	6.3	7.4	9.1	9.8	10.2	10.3
Losses	2.8	2.6	3.3	3.2	3.4	3.6
Total consumption	**62.3**	**79.1**	**90.0**	**95.2**	**106.5**	**114.6**

Energy in forms of electricity and high temperature, high pressure steam are required in the forest industry, where the mentioned energy sources are firstly being consumed and transferred into electricity in the power planets, parts of the electricity is being transported directly to the mills; the rest is being used to produce high temperature steam with high pressure which contains large amount of energy. Even though the percentage of wood based bio-fuel consumption is over 75%, however the power generation from bio-fuel is not capable to supply the whole forestry industries, which makes the fossil fuels and other energy supplies, like nuclear powered electricity is still needed.

3.2 Differences and co-operations between Chinese and Finnish forest industry

From the last decade, the spectacular economic growth of China brings the dramatic impacts and influence on the world, China has just been ranked as the second biggest economy nation, with its massive amount of population, demands from every industry and its products are significant, the forest industry with its products are not exceptions. However, comparing the world`s leading Finnish forest industry, the Chinese forest industry has several major differences which are in the fields of: energy consumptions, environmental protection, technology, markets condition and source management.

China owns approximately 175 Million hectares of forest. Based on the China's sixth forest inventory report, it makes China rank the 5th nation from the list of world`s forest coverage among different countries. On the other hand, the *figure 3.7* indicates the a characteristic of China`s forest situation: Imbalanced distribution. It spontaneously causes the development of forest industry to be imbalanced in different areas of China. And it was officially announced that the forest coverage will be raised from the current 16.6% to 20% of total land area by 2010, and another raise to make the total land forest coverage become 28% by 2050. [9]

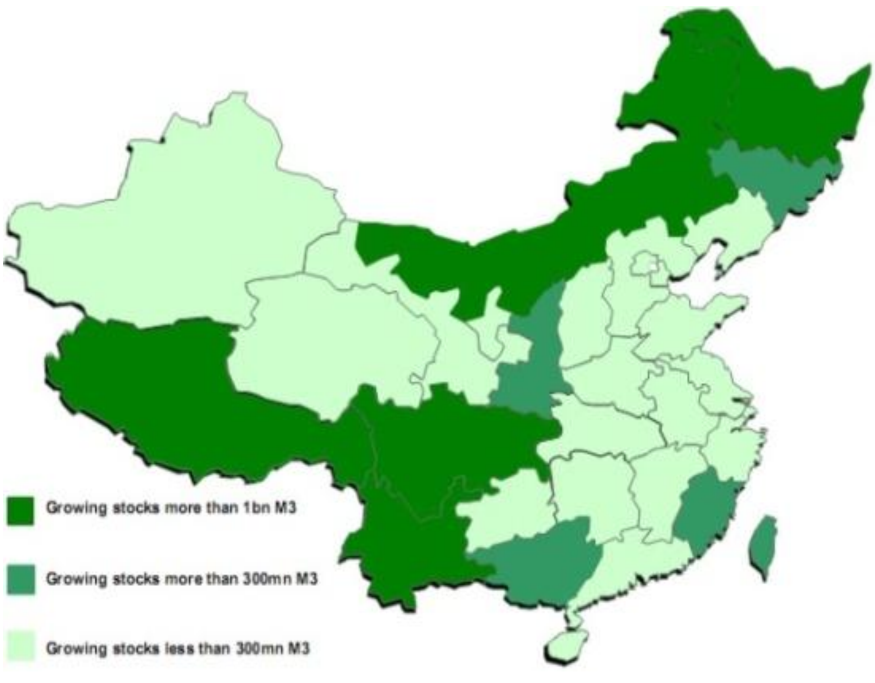

Figure 3.7 Imbalanced distribution of China`s forest sources

The pulp and paper production and consumption of China has made a big progress annually by approximately 12.92% and 10.65% every year since 1980. Nowadays, China has become one of the largest pulp and paper industry countries in the world. The total export and import amounts of pulp and paper in China were 33,228,000 tons and 30,010,000 tons. Oppositely, comparing with the leading figure of forest holding value and the forest products trading position globally, the figures of the forest as percentage of the country's total area and forest area per capital which is significantly below the global average figure due to its world`s largest population. The same reason causes another figure of the paper products usage per capital was reported as 45 kg/year to be also far below the world average which was reported as 56 kg/year in 2004. However, both figures are highly expected to be raised within the fast development of the forest industry and the Chinese economy.

The distributions of the Chinese forest consumption are in four major fields: industrial round wood usage, agricultural logs usage, fuel wood usage and the natural loss. According to the statics report, the total annual consumption of the forest is between 320 and 330 Mm^3, and industrial round wood usage contributed 143 Mm^3 which occupies 44.2%; agricultural logs consume 76 Mm^3 and occupy 23.5%; fuel wood usage takes 93 Mm^3 and occupy 28.8% and the amount of natural loss is around 11 million cubic meters which takes the rest 3.5% of the total forest consumption.

In the field of industrial round wood usage, most of the woods are used in the paper and pulp mills which have been developed rapidly in the last decade, and another wave of the growth is expected to achieve. The paper products´ consumption per capita is still 45 kg / year due to the massive amount of Chinese population, but the total demand and production are continuously growing under the rate of 6.8% and 4.8% annually, from the *figure 3.8,* where the "low line" shows the least amount of change, "base line" gives the picture of normal increase and from the "high line" we can find the prediction of the growth of the industrial round wood requirement which change from the current around 150 Mm^3 in 2005 to over 320 Mm^3 in 2015 maximally.

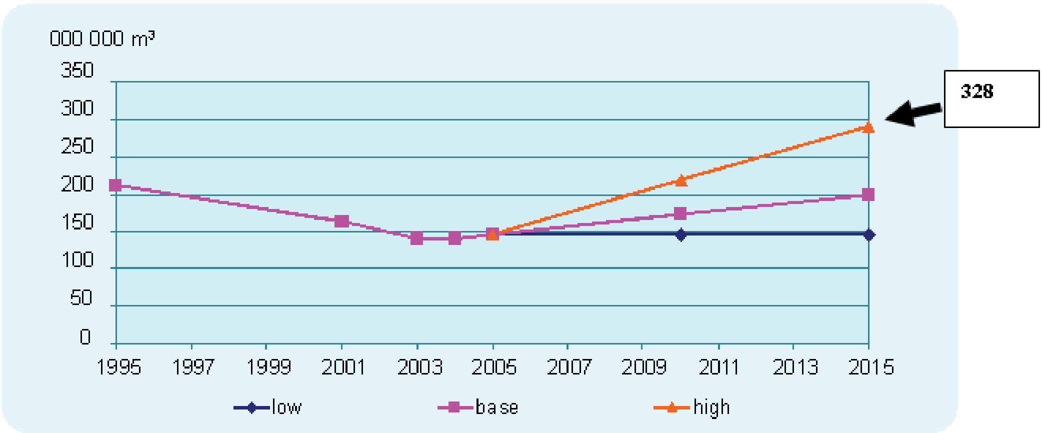

Figure 3.8 Industrial round wood growth predictions in China

Under this developing condition, the forest industry can be titled as one of the fastest developing and growing industries in China and the same to the related markets of the forest products. Nowadays, the forest industry in China is operating many cutting-edge machines which rank as the largest in the world, for example: Shangdong Chenming company was building the world`s largest printing paper line in 2006, productivity is about 400,000 tons per year and the speed is up to 2,000 meters per minute; APP Gold East was building the world`s largest fine paper machine with productivity of 700,000 tons per year; with the cooperation with Finland, leading forest industry: UPM Kymmene`s new world`s largest uncoated wood free machine was also built in China in 2005 with productivity of 450,000 tons per year. All those elite machines have already been built, the contributions of the world`s largest and finest machines are magnificent in order to promote the future of the forest industry in China. The facts of forest industries´ energy consumption are similar as almost all other industries in China, which are mainly operated by the power generated by fossil fuel combustion, or the combustion of coal to be specific. There are more than 3,600 registered pulp and paper mills in China and 6 of them are major considered as large enterprise and production centers whose productivity is above 1,000,000 tons, 30 mills are able to produce above 200,000 tons which are marked as medium enterprise, and more than 100 mills have the ability to produce over 10,000 tons, which are classified as small enterprise. *Figure 3.9* indicates the energy demand of several kinds of pulp which are made in different types of forest enterprises:

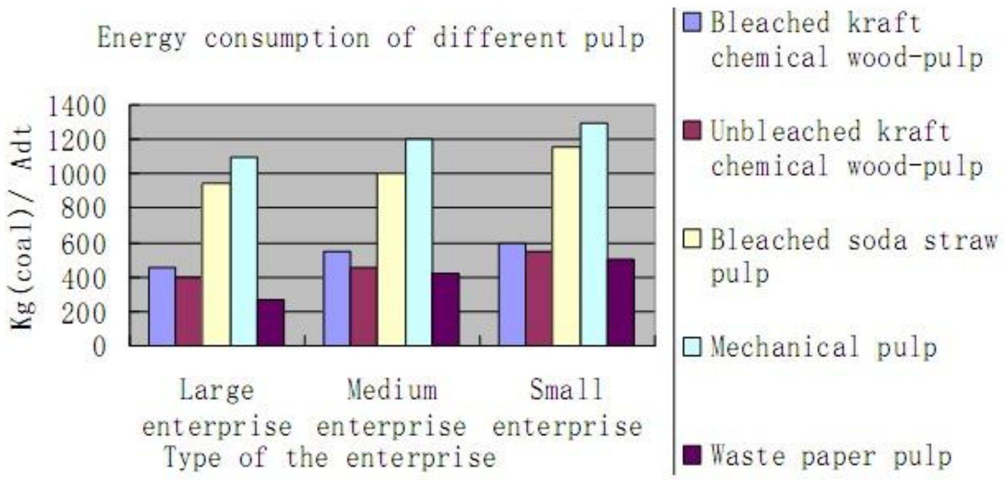

Figure 3.9 Energy consumption of pulp from different size enterprises in China

The differences among large enterprises, medium enterprises and small enterprises are not only concerning about the size of mills and the productivity, but also concerning energy demands when manufacturing the products. Larger enterprises smaller energy consumptions is requested to produce same amount of pulp based on more advanced technology, higher productivity and the much better energy control and management techniques of the large forest enterprises. As the results from the same reason, *figure 3.10* gives the energy consumptions facts of making several types of paper in different scales of enterprises:

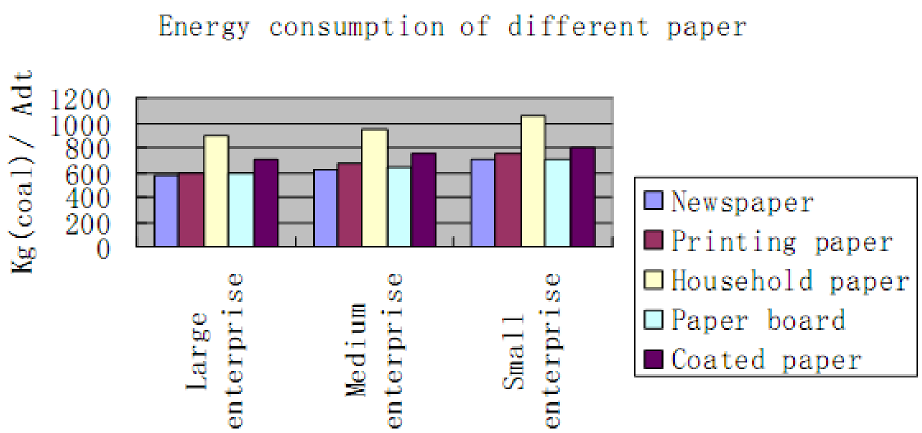

Figure 3.10 Paper production energy facts in different enterprises in China

The smaller energy demand represents the lighter environmental pollution, which makes the large enterprise much cleaner than other medium and small scale forest enterprises. The government deeply noticed the significant influences based on the size difference from the forest enterprises: the larger enterprise means much higher productivity, cleaner operation conditions, better profits and fewer environmental issues, after years of treatments and improvements, lower amount of small scale and even the medium size forestry enterprises have been closed which offers large enterprises a better environment.

For example, it was reported that the Henan Province has already shut down all small paper mills in 2005 which is considered as a huge effort to curb industrial pollution. For those small paper mills which have been closed, licenses were completely cancelled, machines were dismantled, and all water and electricity supplies were cut. Nowadays, annual capacity of at least 100,000 tons for those using wood pulp, 34,000 tons for straw pulp, and 300,000 tons for chemical wood pulp are created as the standards and must be obeyed before launching any new paper mill projects, including upgrading and extension missions.

The history of forest industry trading, investing and learning between Finland and China started ever since the national communication was established. The Finnish leading forest industry enterprises: UPM and Stora-Enso make investments into China continuously which effectively helps China to improve the forest industry performance and promote their own marketing future outside Finland. For instance, In China, UPM has an extensive production and retail network, the *figure 3.11* shows the sales offices, R&D centers, mills, and warehouses´ locations in different areas of China: UPM runs the Changshu mill site in China, located in the Province of Jiangsu, which is UPM´s biggest investment in China. The mill was built as a 900,000 ton per year capacity fine paper mill, Research and Development Center and a label stock factory. [10]

Figure 3.11 UPM´s investments facilities locations in China

The nearly 200 hectare size mill owning a harbor provides logistical transportations by the Yangtze River. Also an individual power plant and an effluent treatment plant are in the service to power the mill operations smoothly. This mill is titled as the biggest production center of the uncoated fine papers in China. Around two thirds of the mill's production is sold through UPM's sales network to the Chinese market. Rest of the products is exported to the Asia-Pacific regions. UPM Asia R&D Center is also located in the Changshu mill site which is responsible for local fiber raw material research as well as manufacturing and technical customer service support for UPM's production units in China and all Asia-Pacific regions.

Stora Enso is another major Finnish - Swedish forest industry enterprise who started its business with China in 1985. Nowadays, the Suzhou Mill, Dawang Mill, Corenso's core plants in Hangzhou and Foshan are Stora Enso´s main interests which promote profitability perspectives of the imported products from its European production units. Besides, the value-adding business like the Forest-Pulp-and-Paper Integrate project in Guangxi province is also highly considered the opportunity to respond to the demands of China´s domestic and the internationally fastest growing forest products market.

There are four production centers with Stora Enso´s investments or which are totally owned by Stora Enso.

Figure 3.12 Stora Enso´s Suzhou mill site, Jiangsu province, China

Stora Enso´s Suzhou mill is shown in *figure 3.12,* it was established in 1993 and operations started in 1996 in the size of 280,000 square meters which produces fine paper with the productivity of 210,000 ton per year; it is titled as the earliest domestic investment to fine paper manufacturer from Stora Enso. [11]

Huatai Paper Co., Ltd with another name of Dawang Mill was built in April, 2006 in Dongying City, Shandong Province. It is a joint venture company by Stora Enso Group and Shandong Huatai Paper Co., Ltd. The Dawang Mill is one of professional paper manufacturers of world-class quality SC paper with designed productivity of 200,000 ton annually. The Hangzhou Corenso Hualun Paper Core Co., Ltd. and the Corenso Foshan Paper Core Co., Ltd. are under control of the Corenso Paper Co., Ltd which is a group member of Stora Enso, the yearly capacity of Hangzhou Mill comes to 30,000 ton and Foshan Mill comes to 20,000 ton. Guangxi Stora Enso Forestry Co., Ltd. was established in Nanning and Guangxi in October, 2006. The company’s main operation objective is to establish large eucalyptus fiber base in Southern Guangxi.

In addition to the four major production centers, Stora Enso has launched a plantation for fast-growing eucalyptus in Guangxi in 2002. Now it has a long lease on an area of 90,000 hectares, half of the mentioned land already has been covered by trees, and 160,000 hectares of the forest-covered land in China to reach Stora Enso plans.

3.3 Pollutions and treatments from forest industry

Scientifically, pollution is defined as a progress in which contaminants are released into an environment which cause related damages and impacts instability, disorder, harm or discomfort to the ecosystem have been caused as results. The elements of pollution are considered as contaminants when they exceed the natural levels. Industries are mostly related and involved when pollution is being mentioned, since the industries are operating as convertors which are transferring raw materials and energy from the environment into final products and by-products, where various kinds of pollution are unavoidably being generated during this progress.

Chemical substances from industries and energy consumption like heat, sound or light can be the sources or so the pollutants that lead the significant air pollution; noise pollution; light pollution and solid waste pollution. *Figure 3.13* provides an example of the raw materials and energy flow with the related pollutants from the forest industries.

In the forestry industry, water pollution, air pollution, noise pollution and solid waste pollution are considered as four major pollutants which affect environment; however the influences of those pollutions are not on the same level, the environment could not be badly affected by the noise and the solid wastes since all the mills and factories are located in the remote places, and solid waste is properly being land filled in certain locations.

But the environmental impacts from air pollution and water pollution are enormous and getting stronger with the development of energy consumptions from the ever-growing requirements simultaneously. Without the solid waste pollution and the industrial noise pollution, air pollution gives the most serious impacts on the environment and affects the environment most widely. [12]

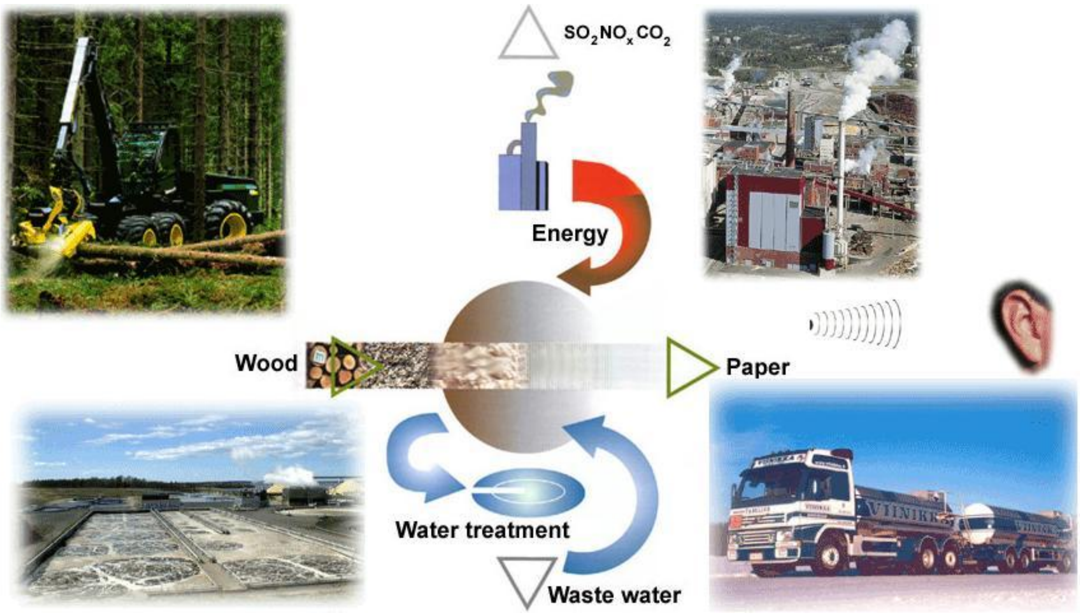

Figure 3.13 Materials and energy flow with related pollutions from forest industry

As the air pollution, sulfur compounds from chemical pulp process, nitrogen oxide emissions from power production and carbon dioxide from fossil fuels´ consumption are considered as the three most sophisticatedly concerned pollutants. *Figure 3.14* below indicates that the cooking department, recovery boiler, lime kiln and the power boilers are major sources of all the harmful chemical compounds which cause the air pollution. Acid rain is one of the most harmful consequences from the industrial air pollution, when sulfur dioxide has been released from industrial stages like recovery boiler processing, NGC combustion;

Component	Main sources
Sulfur dioxide (SO_2)	Recovery boiler, lime kiln, NCG combustion, energy production
TRS-compounds	Digester, evaporation, dissolving tank, tall oil plant, liquor processes in general
Nitrogen oxides (NO_x)	Recovery boiler, energy production in general
Particles	Energy production, lime kiln
Carbon dioxide	All fossil fuel combustion

Figure 3.14 Air pollution compounds and sources of air emissions in forest industry

It reacts with moisture in the air and forms sulfuric acid which is the main component of acid rains. Also the chemical smog could be formed by the reactions and participations of chemical compounds which contain the element of sulfur. Finnish forest industry sulfur emissions have diminished to a fraction of their former levels. Actually nowadays the sulfur emissions control is nicely operated so that the majority of sulfur compounds entering the Finnish environment are from outside Finland.

In the forest industry, for instance, the *figure 3.15* illustrates the cooking stages from the pulp making process. In the pre-steaming or the initial stage of cooking, the gases of turpentine and Methanol can be produced and released. Because the existence of the sodium sulfide in the cooking chemicals, when the chips are cooking and reacting with the cooking chemicals, gases like the sulfur dioxide, hydrogen sulfide, dimethyl sulfide and dimethyl disulfide are produced and released as the sulfide pollutants contribute the industrial air pollution.

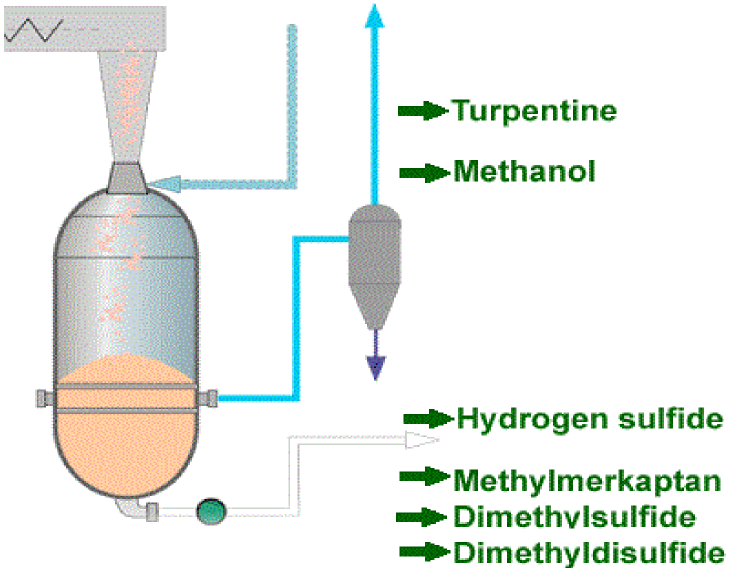

Figure 3.15 Sulfide pollutants from cooking stages

When dealing with the sulfur dioxide pollutions, various combustion-related techniques can be used as the treatment of reducing the emissions. The fluidized bed boilers use an effective and inexpensive treatment, where sulfur compounds are eliminated from the flue gases by feeding lime. After this treatment, separation rate is measured as approximately 90% by using lime and no more separate sculpture extraction device is needed in the smoke flue. When limestone is added into the flue, the reaction shows the *formula (3.16)* takes place:

$$CaCO_3\ (s) \rightarrow CaO\ (s) + CO_2\ (g) \qquad (3.16)$$

When CaO and Carbon dioxide are formed, the sulfur dioxide is injected to react with calcium oxide, reaction shows in the *formula (3.17)*:

$$2CaO\ (s) + 2SO_2\ (g) + O_2\ (g) \rightarrow CaSO_4\ (s) \qquad (3.17)$$

This reaction forms the sediment of calcium sulphate, and this product is removed from the furnace with ash and flue gases along with inert lime residue. Afterwards the electric precipitator or a fabric filter is operated which purifies the flue gases. Besides, limestone consumption is reduced by returning inert lime to the furnace by using the cyclone in circulating fluidized bed boilers. Due to the serial treatments and some other emission controls, the sulfur emission is properly controlled which makes the sulfur emissions from forest industry not significantly harmful to the environment comparing with other industries.

Besides, pollutants of nitrogen oxides (NO_x) are also considered as the source of acid rain and chemical smog, when nitrogen oxides react with water in the atmosphere, the nitrogen acid is being formed and that is the source of the acid rain expect for the sulfur dioxide; the nitrogen oxides increases the ozone levels in the lower atmosphere and contribute to the occurrences of smog in the city environments. The *figure 3.18* shows the situation of nitrogen emissions in Finland, and it is reported that less than 5% of the total NO_X emission in Finland is released from the forest industry.

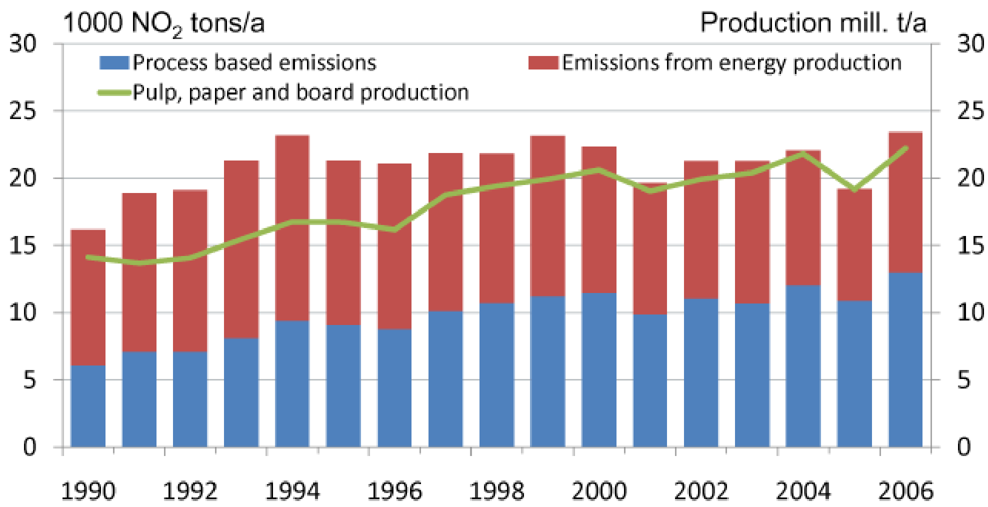

Figure 3.18 Nitrogen oxides emissions from forest products manufacturing in Finland

When nitrogen oxides emissions are being mentioned, purifying the flue gases of the nitrogen oxides which are formed by combustion and reducing the productivity of nitrogen oxides in the furnace must be concerned. The nitrogen oxide emissions of fluidized bed boilers are actually low because of the low temperatures of combustions. Due to this low reaction temperature, the nitrogen is unable to react with oxygen easily in the circulating fluidized bed boilers, as the result, almost zero thermal nitrogen oxides are formed and the sources of the nitrogen emissions from circulating fluidized bed boilers are actually fuels which contain the element of nitrogen. Besides, the nitrogen oxides emissions could be further eliminated by injecting the fluidized bed with ammonium, this action reduces the nitrogen oxides to water and nitrogen molecules.

Carbon dioxide, a major pollutant from industrial activities which has different influence compared with the environmental damages from sulfur dioxide and nitrogen oxides, contribute and accelerates the greenhouse gas effect. The *figure 3.19* indicates the comparison between the carbon dioxide emissions and forest industry productivity in Finland during the recent decade. [13]

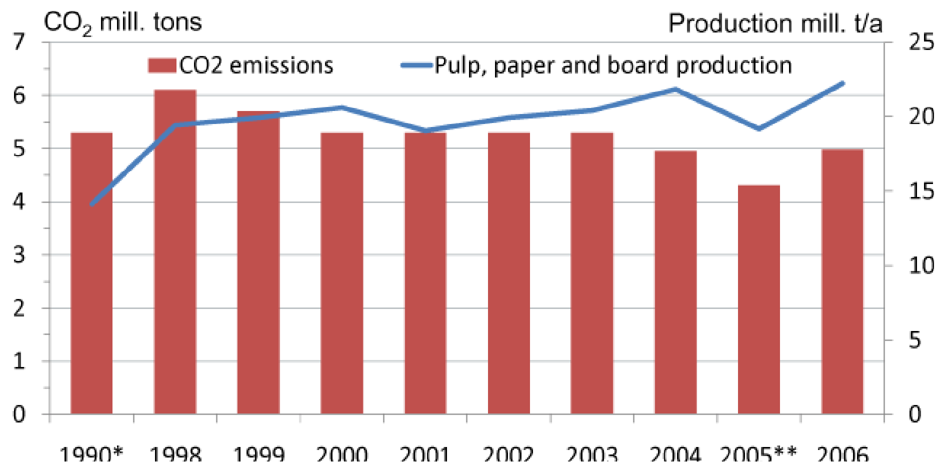

Figure 3.19 Carbon dioxides emissions from forest products manufacturing in Finland

Carbon dioxide is mainly produced and released when fossil fuels are combusted, as we know that forest industry uses renewable sources of energy, like wood-based Bio-fuel for more than 70% of its whole energy demand, that makes the emissions of carbon dioxide and its contribution to the greenhouse gas effects are insignificant, but since the rest of the energy consumption are from fossil fuel burning or other energy sources, a certain amount of carbon dioxide is still being released into the atmosphere and affects the environment due to the greenhouse effects.

Except for the sulfur dioxide, nitrogen oxides and carbon dioxide from the air pollution, chemical compounds of chloride oxides and chloride hydrogen from the bleaching progress in forest industry are also categorized as pollutants. One reason is that acid rain which contains HCL could be formed when chloride hydrogen has been released and reacts with the moisture in the air, and harms the environment similarly like the sulfur acid rain and nitrogen acid rain.

The compounds of chloride oxides are active oxidizers, they require large amount of oxygen from environment to reduce itself, for which a massive demand of Bio-oxygen is needed, especially when this situation happens in the water system. That makes the water system lack oxygen so deeply that chloride oxides are concerned as major pollutants for the industrial water pollution.

3.4 Greenhouse effects and contributions from forest industries

The mentioned major greenhouse gases include: carbon dioxide, methane, nitrous oxide, ozone and sometimes even water vapor. Greenhouse gases have significant influence on temperature of the Earth because of its heat-storing capacity and ability. The average temperature of Earth could be 33^{o}C cooler than the temperature which allows us to leave now if there were no greenhouse gases exist in the atmosphere.

The greenhouse effect is defined as a process in which the energy leaving from the surface of the planet is absorbed by certain types of gases in the atmosphere, which are greenhouse gases. Energy is being generated, given, absorbed, and released between space, the atmosphere, and the surface of earth. The *figure 3.20* gives the energy flows which illustrate the principle of the greenhouse effect.

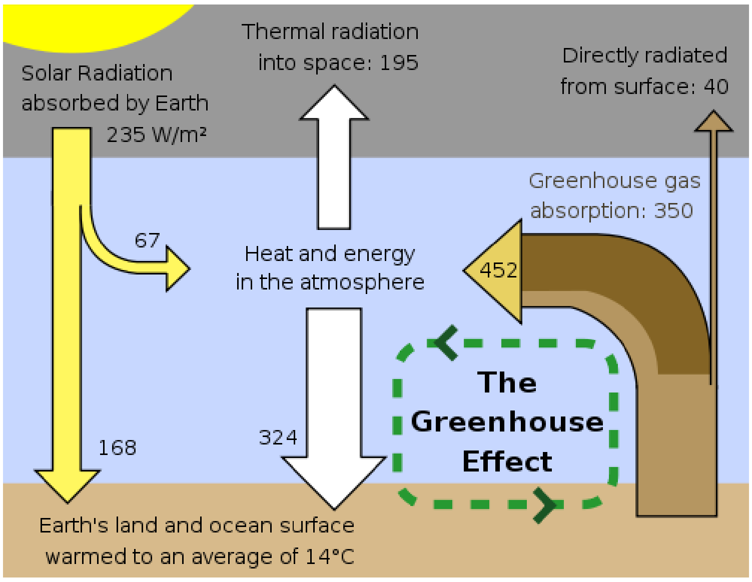

Figure 3.20 Energy flows of the greenhouse effects [14]

Sun is performed as the ultimate source of all kinds of energy that reaches the Earth's surface. Based on the scientific reports, sunlight radiates energy 1366 W/m^2 maximally; however, only average of 235 W/m^2 is absorbed due to the geometric effects and reflective surfaces annually. It is measured that more than 75% can be contributed to the action of greenhouse gases that absorb thermal radiation emitted by the Earth's surface of the surface heat which is captured by the atmosphere, the atmosphere transfers the energy that receives 38% into the space and 62% is back to the Earth's surface. Sun never stops to provide massive amount of energy to Earth, a part of it is being absorbed and consumed, the rest is leaving the earth surface to the space, but the greenhouse gases store and transfer this part of energy to other components in the atmosphere, afterwards the stored energy is radiated once again in all directions, that makes the energy which is supposed to leave move back again down towards to the planet surface and lower atmosphere. As the result, temperature is being raised due to the extra energy offering.

Approximately a third of the energy consumption and 36% of carbon dioxide emissions are attributable to manufacturing industries around the world. Especially to those large primary materials industries, such as: petrochemicals, metal industry and paper/pulp forest industries, they all together account for more than 2/3 of the total industrial energy consumption and carbon dioxide emissions. Industry's manufacturing facilities require magnificent amount of fossil fuels and fuels´ combustion effectively generate greenhouse gases. Because of the massive demand of energy supply for industries, manufacturing facilities and units are contributing the carbon dioxide emissions largely and directly.

The condition of the forest industry is that the manufacturing emissions of pulp, paper, paperboard and wood products are significantly influenced by the industry's biomass or bio-fuel usage, since the bio-fuel is greenhouse gases emission-free. Biomass generates more than half of the used by the pulp and paper industry and about 60 percent of the fuel energy used by the wood products industry which is much more than any other industries require. It was reported that totally 890 million tons of carbon dioxide were released from the forest products´ value chain annually.

However, the forest products value chain also contributes a large scale of the carbon dioxide removals from the atmosphere, because certain amount of CO_2 is stored as carbon compounds in the woods which as the sources when making forest products in use for land filling; once the woods have been made as products and land-filled, the carbon compounds have been locked simultaneously. The situation when carbon is being locked in the products and being land filled is defined as carbon sequestration, *figure 3.21* indicates the carbon circulation and carbon sequestration principles from the forest industry and forest value chain.

When this circulation applies, the net greenhouse gas emissions from forest products´ value chain declines to around 467 million ton of CO_2 equivalent annually, and the direct greenhouse gas emissions which was measured by carbon emission mass per ton produced pulp and paper had reduced by 13 percent from 2002 to 2007 while that from wood product facilities fell by 16 percent. [15]

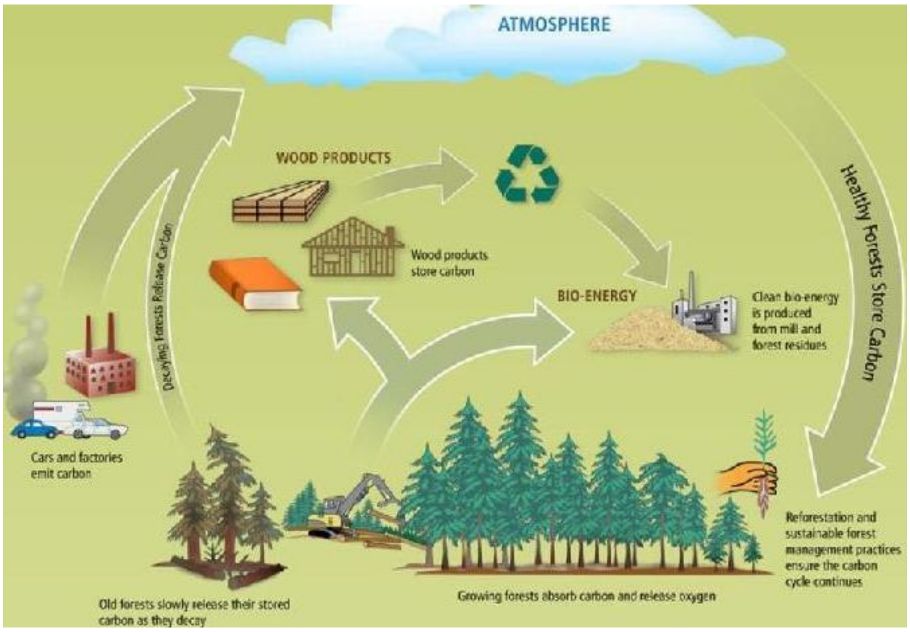

Figure 3.21 Carbon circulation and carbon Sequestration in forest industry

Due to the functions of the carbon sequestration, the net sequestration of CO_2 from the atmosphere into the forest product industry´s value chain was 424 million tones of CO_2 equivalent in 2007. This amount of the CO_2 storage was enough to eliminate over 85% of the total greenhouse gas emissions associated with the producing forest goods, and almost half of the carbon emissions from the complete forest value chain could be reduced. The *figure 3.22* indicates the carbon emissions and sequestration facts from the global forest products value chain.

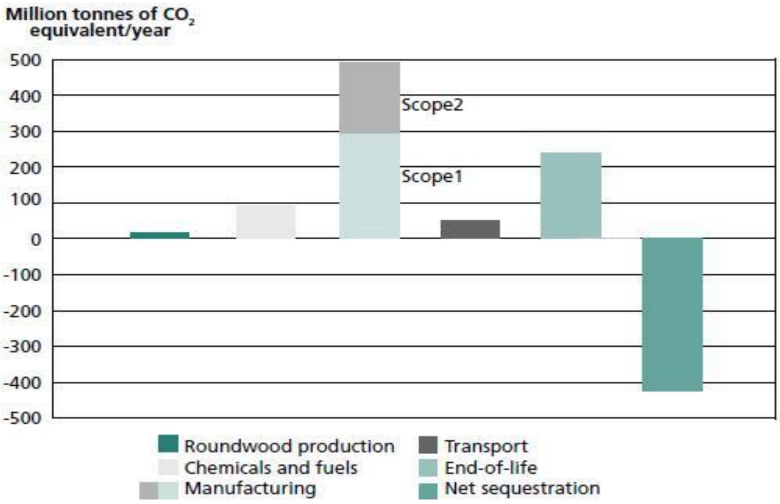

Figure 3.22 Carbon dioxide gas emissions from the global forest value chain

Transportation is an essential factor of forest value chain, in which carbon emission has to be concerned as essential as the industrial level carbon emissions; the forest products value chain involves great amounts of raw materials and the final products shipments domestically and internationally.

Due to the special environmental characteristics of the forest industry, it releases and eliminates the carbon dioxide simultaneously, operating under this mentioned carbon circulation and sequestration conditions, the net carbon dioxide emissions from the whole forest industry and the related forest value chain are considered as on the lowest level among all industries. This condition even makes the contribution to the greenhouse effects on aspect of carbon dioxide from the forest industry insignificant.

3.5 Global warming facts and situations in Finland and China

After understanding the greenhouse gases´ characteristics and the effects with its contributions from the industries energy consumption and exhaust emissions, one of the ultimate consequences must be concerned: global warming. Basically, the global warming condition represents the raise of the Earth´s near surface temperature and the oceans´ temperature since the mid-20th century and it is believed that the situation is successively increasing. Most of the observed temperature increase since the middle of the 20th century has been caused by increasing concentrations of the mentioned greenhouse gases like carbon dioxide and sulfur dioxide, which is caused by the human activity since the Industrial Revolution. It has massively increased the concentration of greenhouse gases in the atmosphere, where concentrations of CO_2, methane, ozone, CFCs and nitrous oxide were highly amplified. According to the scientific reports, the concentration of carbon dioxide in the atmosphere increased to 383 parts per million in 2007, about 37 percent raise above the concentration level at the start of the industrial revolution in 1750. The current concentration is measured as the highest recorded in the last 650,000 years and perhaps in the last 20 million years.

The annual mean growth rate of carbon dioxide was at 2.2 ppm in 2007 and the 2.0 ppm was the average value during the period of 2000-2007, while the average annual mean growth rate for the previous 20 years was about 1.5 ppm per year. The fundamental of the modern society is the power generated by the fossil fuels; its burning has produced approximately three-quarters of the extra CO_2 from human activity over the past two decades and the rest is contributed by the deforestation, and other human activities and natural events. [16]

Nowadays, we might clearly notice the consequences from the global warming already: because of the chemical characteristics with the ever-growing concentrations of the greenhouse gases, more extra heat is trapped in the atmosphere and less escapes back into the space. This part of extra heat energy changes the climate and causes related natural disasters, which might hasten species extinction, influence the length of seasons, caused the sea level rising which correspondently leads to coastal flooding, and create more frequent and serious storms.

As a matter of fact, to control the global warming has become the very first priority which determines the fate of the modern society, which means the greenhouse gases emissions must be property measured and controlled since the gases are the main sources of the global warming situation. The *figure 3.23* indicates the greenhouse gas emissions by nations in the year of 2000. The indicator of the figure uses the colors that from green to red which presents the amount and scale of the greenhouse gas emissions. As we can notice that China appears in the deep red which produces and releases the world´s largest amount of carbon dioxide annually because of its economic booming and magnificent industrial appetite; oppositely, Finland, as the world´s cleanest country, where the light green presents that Finland produces and releases the least scale of carbon dioxide in the world.

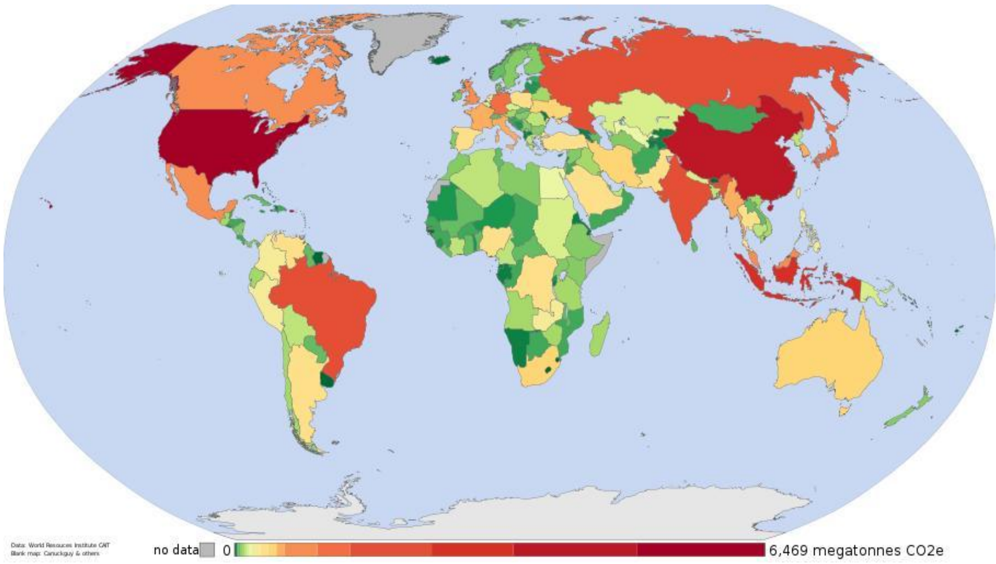

Figure 3.23 Greenhouse gases emissions by nations in 2000

However, the warming situation is effective globally, which means the temperature raise occurs to anywhere on the earth, no matter whether the country contributes more greenhouse gases or less, but the conditions of the temperature raise and climate change are very unlike in the different areas in the world.

Under the global effects, although Finland is titled as the country with the world´s least greenhouse gas emission, the consequence of the climate change from the global warming caused by the greenhouse gas emissions domestically and internationally is still detected. That the surface air temperature of Finland´s has increased by approximately 0.7 °C during the 20th century; it was not extremely serious to affect the environment rapidly, but the new scenarios for Finland have predicted that the annual increase by the 2080s is from 2.4 °C to 7.4 °C.

From the *figure 3.24*, we can see that eventually the average temperature of Finland and rest of the Scandinavia area are expecting to get an average 4 °C raise in the last two decades in the 21th century comparing with the recent average temperature, which will definitely become a major problem of the ecosystem of Finland if the warming situation continues to grow. Such climate changes conditions are highly expected to bring significant adverse effects on the considerations of biodiversity, human health, and even flood risks in Finland, but some beneficial effects exist like the crop yields and timber production will increase and a reduction of the energy demand in winter times can be obtained.

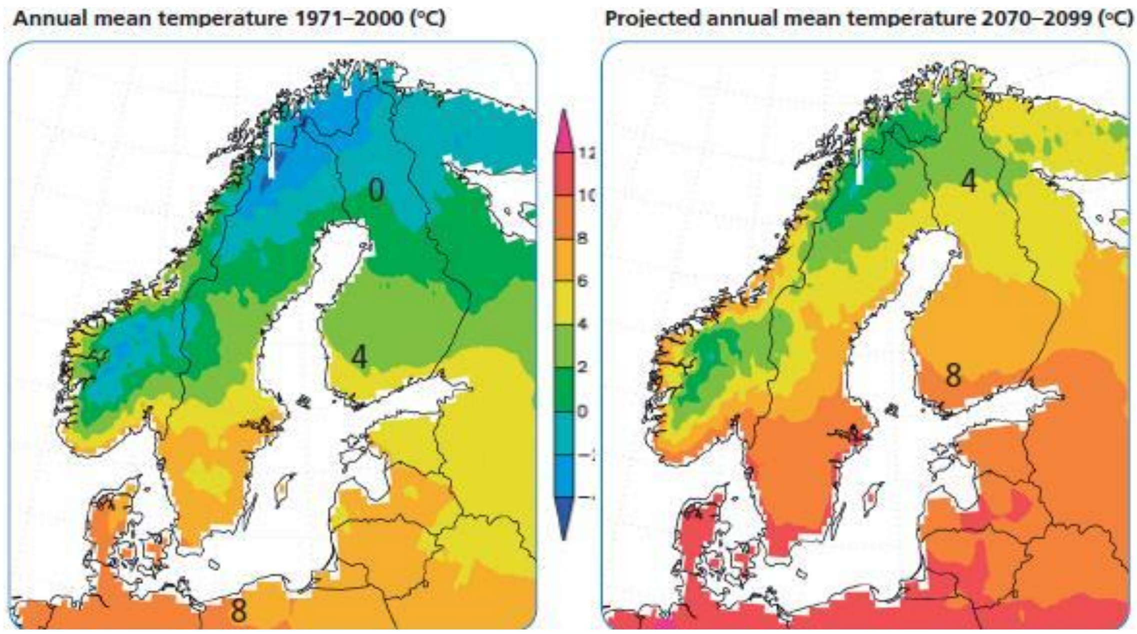

Figure 3.24 Climate change conditions and predictions in Finland

Due to the world´s largest forest coverage rate in Finland, the global warming effects could be significantly reduced, with the effective energy controlling and environmental management systems, which make the warming situations in Finland, remain on the acceptable level. [17]

As opposition to Finland, China has the world´s largest greenhouse gases emissions, over 40% of the whole carbon emissions of the world is from the combination of China and the U.S nowadays, which correspondently contributes the most to the effects of the global warming. *Figure 3.25* indicates the concentration of the carbon monoxide which is indicative to the carbon dioxide emissions in China and nearby regions:

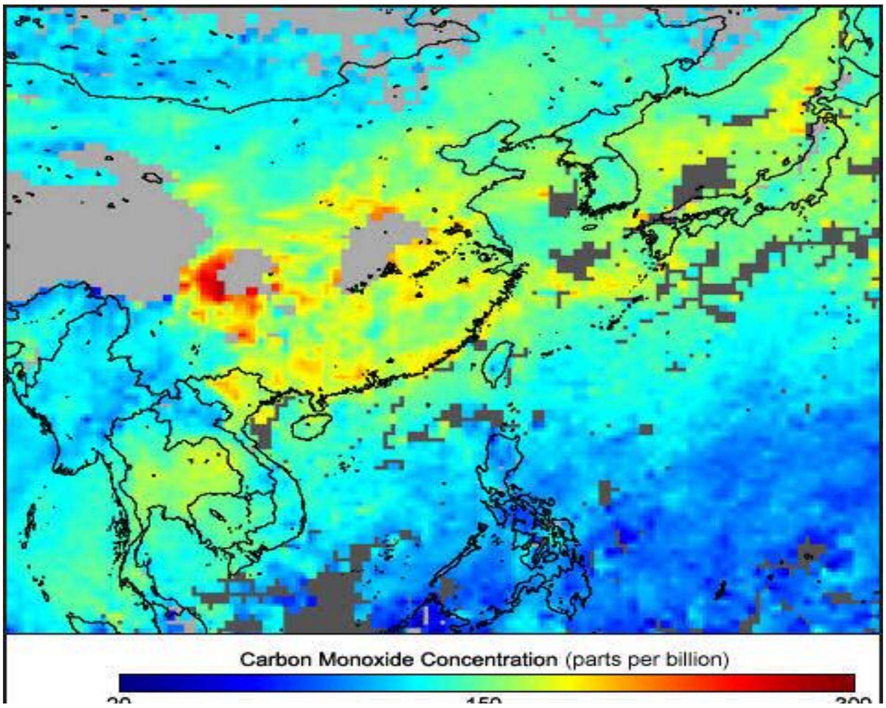

Figure 3.25 Carbon monoxide concentrations in China and nearby regions [18]

Comparing with the warming situation in Finland, China faces much stronger and more critical situations from the influences which are caused by the climate change and the temperature raising. Generally the global warming effects in China are expected to bring a raise of 2°C to 3°C to the average temperature by the end of the 21st century.

Problems are, for example: intensifying typhoons, drying up of the scarce water supplies, forests depletion, and coasts flooding might be occurred. Since most of the Chinese industries are powered by the fossil fuels combustions, the carbon dioxide emissions in China are enormous. *Figure 3.26* shows the carbon dioxide emissions in the economy booming period of China from 1980 to 2006; the trend of the greenhouse gases emission is similar as the accumulations of the related environmental issues and impacts. Environmental impacts from the warming situations are occurred simultaneously while the industries are developing and economy is booming in China. For example, the Qinghai-Tibetan Plateau is originally covered by the ice because of its high altitude and extremely cold climate. Recently, it has reported that the glaciers are melting in many places in this area, the temperatures are rising and rainy seasons have become unpredictable. The Yellow River originates: The Mado area in Qinghai province used to have over 1,000 lakes; now there are less than 300. According to the environmental research, the main reason for the disappearance of lakes is the climate change from the global warming without any doubt.

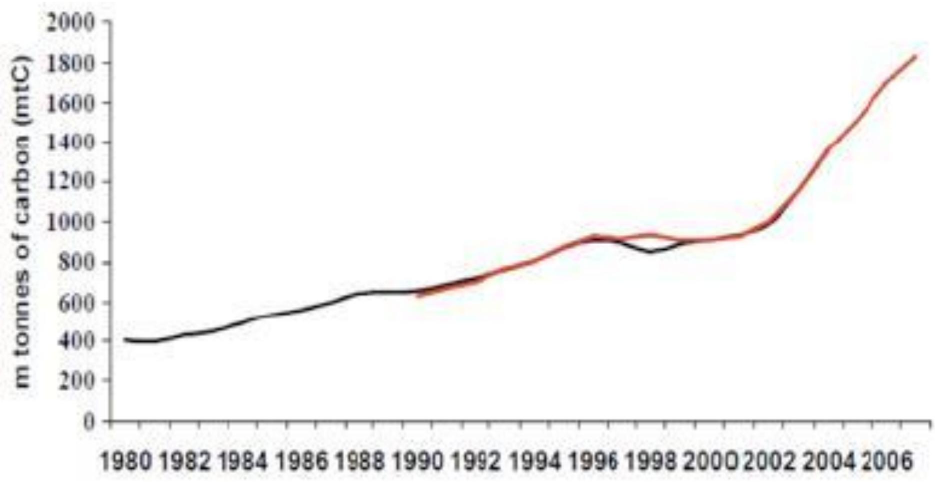

Figure 3.26 Growth of carbon dioxide emissions in China from 1980 to 2006

Except for the glaciers melting, China is also facing the world's worst water shortages; the water distribution is highly uneven: the country is divided into two regions: the “Dry North” is referring to all areas that are north from Yangtze basin, and “Humid South” represents the Yangtze River basin and everywhere south of it. The north owns two thirds of the China´s cropland, and one fifth of the water. The South has one third of the cropland and four fifths of the water, the climate change situation might further this imbalance and even affect the food production conditions in China which indirectly causes a food crisis. As the concentrations of greenhouse gases are continuously accumulating and the related environmental issues are keep happening, which are caused by the global warming different nations are giving a very serious future of the living environment right ahead. To prevent any climate calamity from happening, the usual business and production methods and operations, even policies have to be changed: large developing country like China must balance its economy developments and the environmental situations and learn the management techniques from the advanced properly environmentally controlled country like Finland. Also the developed countries will have to cut emissions drastically by using their technology and be willing to make efforts which help the developing countries to reduce their carbon emissions as well.

3.6 Climate Change Conference, Copenhagen, Denmark, 2009

The “2009 United Nations Climate Change Conference”, commonly known as the Copenhagen Summit, was held in Copenhagen, Denmark, between 7 December and 18 December. Main tasks of the 2009 climate change conference were focused on the climate change situations, environmental risks, and international challenges with an environmental scientific decisions conference.

Generally, a "meaningful agreement" from the U.S government was presented which recognized that climate change is one of the greatest challenges of the present day and any efforts should be taken to keep temperature increases below 2°C. Besides, under the framework of this conference, agreement of proposed changes in absolute carbon emissions shown in the *table 3.27* was highly expected to be reached by different nations before 2020. Finland was not individually on the list due to its perfect emissions and environmental conditions, but as same as the emission scale: China has to make the greatest effort to reach the expected proposed changes in absolute emissions. It is definitely a tough mission, but China is believed to impress the world on emissions control in the same way as how its economy is booming.

As the conclusion, the holding of the conference has clearly indicated the international determinations on controlling the greenhouse gases emissions, improving the living environment and solving the environmental issues, which also reflected how critical the current situation that all nations are facing and how situations might be changed when all nations are working together.

Table 3.27 Agreement of proposed changes in absolute carbon emissions [19]

Area	1990→2020	Reference base
Norway	−30% to −40%	CO_2e w/o LULUCF
Japan	−25%	
EU	−20 to −30%	CO_2e w/o LULUCF @ 20%
		CO_2e w/- LULUCF @ 30%
Russia	−20 to −25%	
South Africa	−18%	
Iceland	−15%	CO_2e w/- LULUCF
New Zealand	−10 to −20%	CO_2e w/- COP15 LULUCF
Australia	−4 to −24%	CO_2e w/o LULUCF
	−15 to −33%	CO_2e w/- human LULUCF
United States	−4%	CO_2e w/o LULUCF
Canada	−3%	CO_2e (LULUCF undecided)
Brazil	+5 to −1.8%	
Area	**2005→2020**	**Reference base**
China	−40 to −45% (per GDP)	CO_2 emissions intensity
India	−20 to −25% (per GDP)	CO_2e emissions intensity

4. BIO-FUEL CONCEPTS, PRODUCTION AND APPLICATIONS

4.1 “Pollution-free”: Characteristics and usages of bio-fuel

Bio-fuels are defined as the liquid or gas form fuels which are converted from biomass; The sources of the biomass can be selected within a wide range, but mainly the range is divided into agriculture based sources and forestry based sources. Straw of cereals and pulses, stalks and seed coats of oil seeds, stalks and sticks of fiber crops, pulp and wastes of the plantation crops, peelings, pulp and stalks of fruits and vegetables and other wastes like sugarcane trash, rice husk, molasses, coconut shells etc. comes under this category and are all considered as the agriculture based biomass sources.

On the other hand, forestry biomass means by-products of current forest management activities, the biomass is not wood from old growth forests, and also biomass does not include municipal solid waste. Based on this concept, harvesting and thinning residues, thinning from hazardous fuels reductions, habitat improvement, and other ecosystem restoration projects, sawdust from paper mills, trees and woody plants and their other woody parts are all included as the biomass sources from the forest. Correspondently woody biomass is also largely and directly consumed as the one of the major energy sources for the forest industries.

Biomass can be used directly as bio-fuel when burning, but however the biomass is mostly converted thermally, biologically and physically, the *figure 4.1* indicates that each method of conversion provides the different products and usages. One of the products from the biological conversion of the biomass is the bio-diesel, to be specified, this type of bio-fuel could be manufactured from algae, vegetable oils, animal fats or the recycled restaurant greases; besides, it can be distinguished from the SVO: [19] Straight Vegetable Oils or WVO: Waste Vegetable Oils, production process of the biodiesel is made through a chemical process called transesterification where the glycerin is separated from the fat or vegetable oil; two products can be formed from this process: methyl esters, the bio-diesel and glycerin.

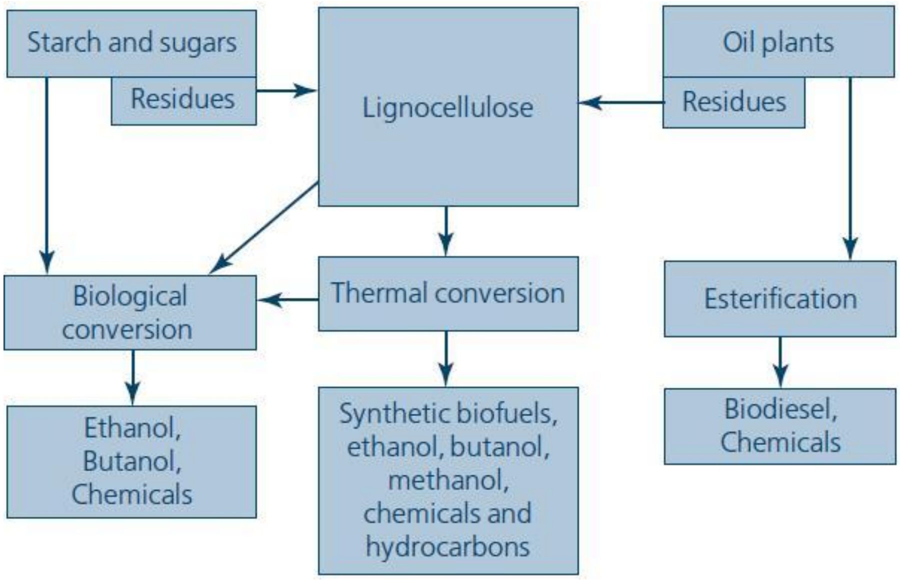

Figure 4.1 Methods of the Biomass conversions and products [20]

The property of the bio-diesel is non-toxic and biodegradable; typically about 60% less net carbon dioxide emissions is produced when burning comparing with the petroleum diesel. Nowadays the Bio-diesel is widely used in the transportation sector comparing with other directions of usages and applications. However, the major disadvantage is that the biodiesel is much more expensive than petroleum which somewhat limits the potential of the usage of the bio-diesel, but the relatively high price is expected to tear the future with the research, development and optimization of the bio-diesel. Another product from the biological conversion which ranks a widely used type of bio-fuel is the bio-ethanol. The bio-ethanol is a type of alcohol that is made by fermenting the sugar components of plant materials and it is made mostly from the sugar and starch crops. Ethanol is able to be used as fuel for vehicles in its pure form, but it is usually in use as a gasoline additive to increase octane and improve vehicle emissions.

Both bio-diesel and bio-ethanol have the major usage field in the transportation sector. Nowadays, with the developments and research, not only the vehicles like cars and motor-cycles can be operated by bio-fuel, like the *figure 4.2* shows, even the aircraft engines can be modified to fit the combustion from bio-fuel and certain scale of the fossil fuel could be replaced by the bio-fuel, the detail is that a Boeing 747-400 aircraft from the KLM which ran on bio-kerosene was seen at Amsterdam Schiphol airport, one of its four engines was powered by fuel in which 50% of the Bio-kerosene mixed with regular aviation fuel. It circled the Netherlands for an hour which the KLM claimed the world's first passenger flight powered by the bio-fuel. [21]

Figure 4.2 KLM´s Boeing 747-400 that "Powered by Bio-fuel"

Environmentally and economically, low pollution or even "pollution-free" is the most valuable characteristic and property of the bio-fuel, the explanation is that the bio-fuel is created and used based on the constant conversion and transferring which takes place between bio-energy and biomass.

Bio-energy can be defined as one type of energy which can be obtained or retrieved form biomass sources, unlike the fossil fuels which were formed from the accent living organism, these embrace vegetable and forestry woods considered as sources which are living in CO_2 carbon cycle. As the *figure 4.3* indicates, during the lifecycle of the plants, carbon dioxide is being continuously absorbed by the plants from the air. When the living plants died and their left biomass is converted into bio-fuel and finally burned to retrieve the bio-energy, carbon dioxide is released to the atmosphere again.

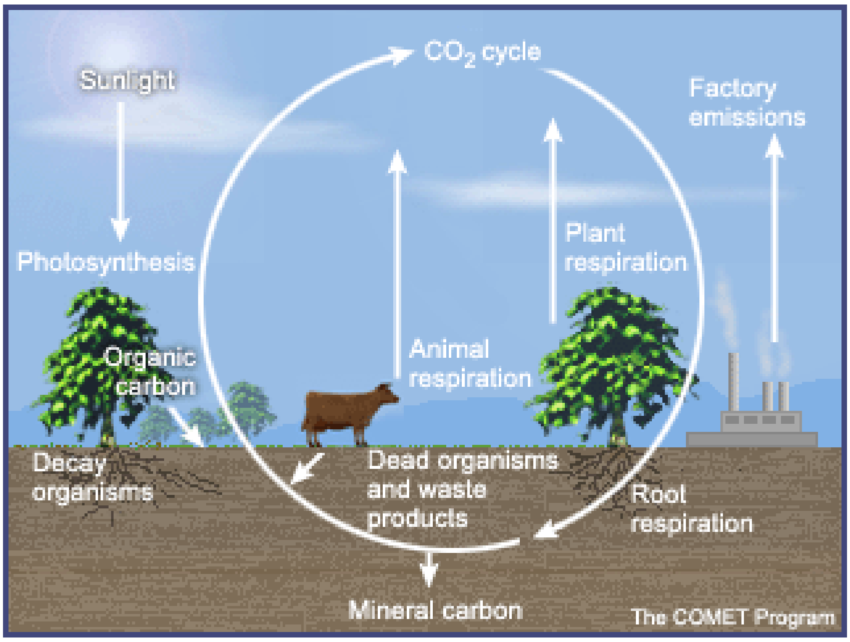

Figure 4.3 Carbon cycle indications of the biomass sources [22]

However, due to the carbon cycle where the biomass was created, the amount of the carbon dioxide emissions from the combustion of biomass is almost the same as the subsequently captured carbon dioxide amount by the growing biomass such from the plants and trees.

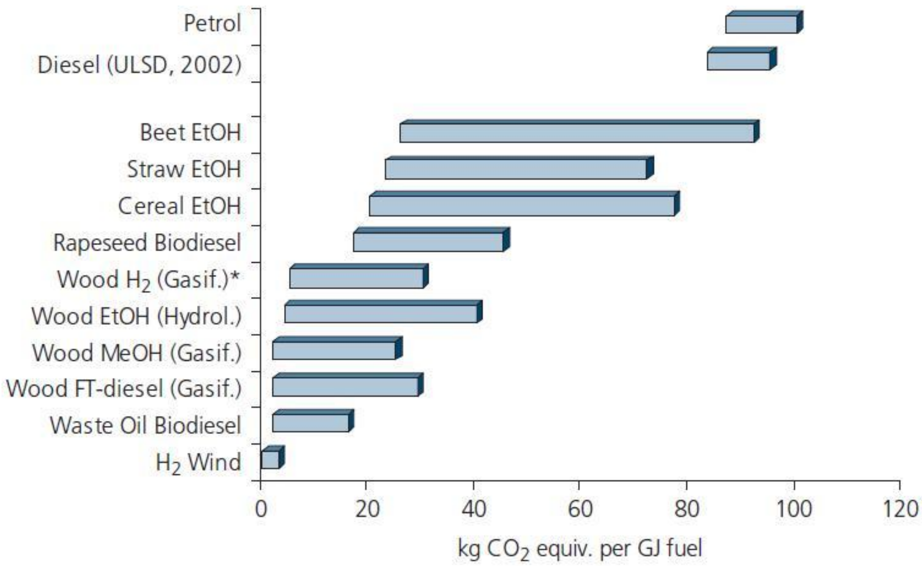

Figure 4.4 Carbon emissions from bio-fuel compared with conventional transport fuels

The *Figure 4.4* shows the comparisons of the carbon emission among different types of fuel usages in the transportation sector. Without the carbon dioxide emissions from the production and transportation of the biomass sources, the bio-energy is perceived and measured to be carbon neutral. To minimize the extra carbon emissions from the Bio-fuel production and transportation is essential to achieve the ultimate destination of being “pollution-free”.

4.2 Black liquor as Bio-fuel from the forest industry

The pulp and paper industry has substantially increased its use of woody biomass for energy in recent years, and was able to reduce its demand for fossil fuel energy. The increased use of bio-energy by the pulp and paper industry now generally accounts for 18% of the total energy consumption by this industry sector. Expect for the biological and physical conversions, thermal conversion is the most commonly applied method in the forest industry where the biomass from the black liquor is burned to generate the high temperature, high pressure steam and electricity.

In the forest industry, the share of the black liquor energy consumption was 157 PJ which contributed 51% of the wood fuel use and 11% of the total energy consumptions in Finland in the year of 2004. [23] The energy production from the black liquor is a solid part from the chemical pulp making process.

Two main components cellulose and lignin and other organic and inorganic substances from wood chips are dissolved during the chemical cooking stages; afterwards the black liquor is separated from the pulp during washing stage. Washing process aims to recover the cooking chemicals and remove the organic substances that weaken the quality of the pulp. Weak black liquor is the black liquor that contains a large amount of water which is removed in the evaporation plant and the strong black liquor that appears in the *figure 4.5* is formed:

Figure 4.5 Appearance of the strong black liquor

The strong black liquor is functioning in the recovery boiler as bio-fuel. Physically, the density of the weak black liquor which has dry solids content between16% to 18% is approximately 1.07 t/m^3 and that of strong black liquor which has the dry solids content over 60% is approximately 1.33 t/m^3, 1.30 t/m^3 is expected when the solid content is 56%, when at 65% dry solids content, density is approximately 1.36 t/m^3. All density values are measured under the temperature of 90^{o}C.

Expect for the density, the specific heat value is one of the most important parameters of the black liquor, which increases with the raising of the temperature, but when the dry solids content starts to increase, drastic reduction of the specific heat occurs. Based on the research, the average specific heat calculated per volumetric unit is considered as a constant value of 3.94 MJ/m^3 °C, when the dry solid content is in the range of 10% - 60% and temperature is between 50°C to120°C.

Chemically, the inorganic substances in black liquor are measured: Na_2CO_3, Na_2SO_4, Na_2S, $Na_2S_2O_3$, NaOH and also NaCl if the chlorine is added into the recovery system. Typical black liquor elemental compositions in sulfate mills are: coal 34%, hydrogen 4%, oxygen 36%, sodium 19%, sulfur 5%, potassium 1,7%, and chlorine 0.3% Besides, the organic compounds: lignin, carbohydrates and extractives are measured as the main organic chemical compositions, the portions of the organic compounds are that: lignin: 47%, hydroxylic acid: 28%, formic acid: 7%, acetic acid: 4%, extractives: 7% and other organic compounds: 9%. The carbohydrates in the sulfate cooking are the products from decomposition of a complicated carbonic acid compound following the peeling off reaction, in the softwood cooking, glucoisosaccharine acid corresponds to approximately a half and the lactic acid to about 20% of the non-volatile acids of black liquor. The most important acids are formic acid and acetic acid, fatty and resins acids are originating from the extractives in wood appearing in black liquor as sodium soaps.

These mentioned organic compounds are dissolved into the liquor during the cooking process, when the organic compounds are burned, thermal value of carbohydrates is measured as: 17.2 MJ/kg, extractives: 39.4 MJ/kg, softwood lignin: 26.4 MJ/kg and hardwood lignin 24.7 MJ/kg. Over all those mentioned figures, the measured average calorimetric thermal values of black liquors are between 12 and 15 MJ/kg of the dry solids. The properties of these mentioned organic compounds are the preconditions why black liquor can be burned and used as a kind of fuel.

4.3 Situations and co-operations of the Bio-fuel application in Finland and China

In Finland, the usage of the black liquor as a renewable energy source is much higher than in other countries, based on statistics report from the Finnish research institute in the *figure 4.6*, which reported that averagely around 6 TWh of the electricity power was generated by burning from the black liquor, and about 4 TWh of the electricity power was generated by other wood-based fuels annually from 2000 to 2008 and this number is highly expected to grow in the future due to the fast developments of the forest industry and technology with the efforts of the environmental protection.

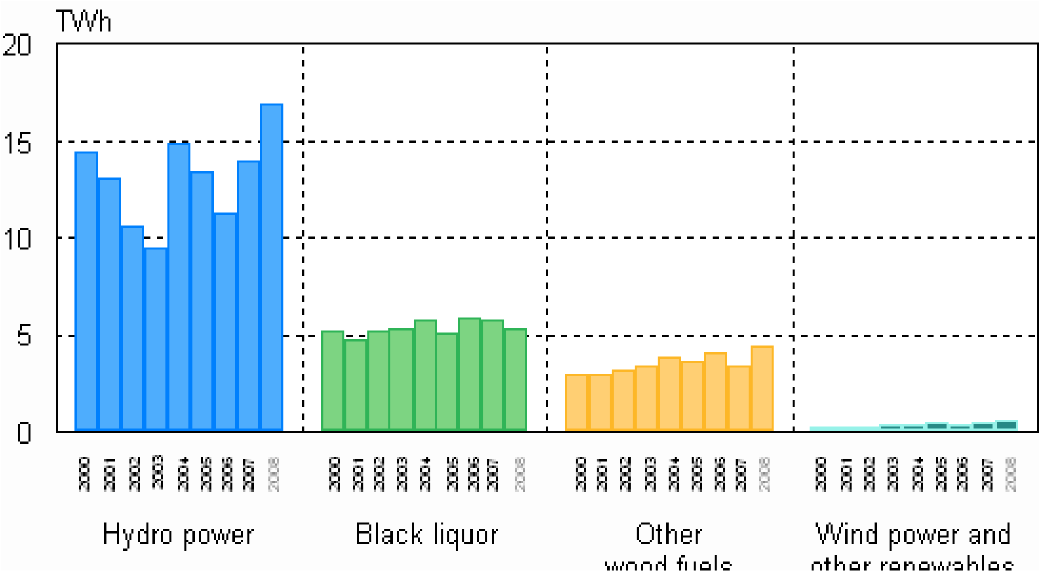

Figure 4.6 Electricity productions with renewable energy sources in Finland 2000-2008

From *figure 4.7* we notice that the black liquor as renewable bio-fuel fuel contributes the most in electricity and heat productions in Finland. The bio-fuels are widely used in Finland extensively. Roughly 20% of primary energy in Finland comes from biomass and more than 12% of electricity is produced from bio-fuels. Besides, the use of liquid bio-fuels as transportation fuel has been almost negligible currently and this situation will remain growing. [23]

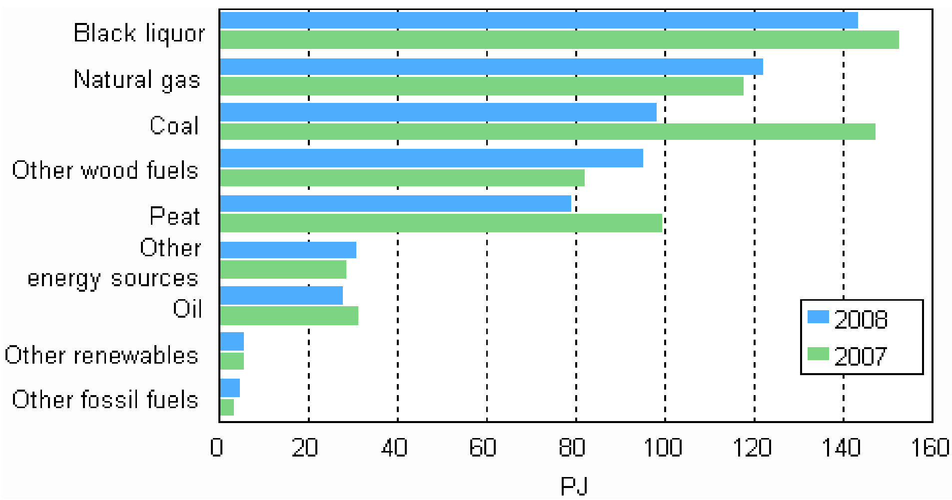

Figure 4.7 Fuel use in electricity and heat productions in Finland, 2007-2008

The Finnish government made a proposal for a law on "Promoting Bio-fuels Usage in

Transportation” to the parliament. This law has been fully activated on 1st of January 2008. It forces fuel distributors to deliver and sell a certain amount of liquid bio-fuels to consumers annually. According to the spirit of the law, the share of bio-fuels has to be at least 2% of the energy content of sold bio-fuels in 2008.

For instance: the target of the public transportation service in Helsinki from the city transportation HKL company shown in the *figure 4.8* is “Metropolitan Helsinki provides the cleanest public transport in Europe”, HKL´s methods to do so are focused on four aspects of traffic system management; skilled personal training, rolling stock selection and the fuel selection. [24]

Figure 4.8 HKL: Helsinki City Transportation Company

Details of the aspect of “Fuel selection” are that the share of Bio-fuel usage in Helsinki bus services could be improved as high as 50 %. There are some 1,400 buses and 100 dumping trucks running on the fuel oils in Helsinki and this number is highly expected to reduce. Helsinki city transportation also focus on using high concentration between 30 % to even 100 % of the second generation Bio-fuel for improved air quality of the Helsinki urban area.

Finnish Funding Agency of Technology and Innovation has already prioritized liquid bio-fuels in financing strategy for long period and the aimed targets are to amplify the applications of the liquid bio-fuels technology developments and to create firms for successful company sector development and investment projects.

The oil company Neste Oil also individually has built its first biodiesel plant, which produces synthetic biodiesel from vegetable oils, waste food oils and waste fats based on their proprietary technology NexBTL. The *figure 4.9* below shows the slogan of the NexBTL technology based Green-diesel products in Finland, which shows in Finnish: Puhtaasti parempaa suorituskykyä, the meaning of English can be translated as: "for the (environmental) performance improvement, purely."

Figure 4.9 Neste Oil Green-diesel: "Puhtaasti parempaa suorituskykyä."

This technology presents fuel the possibility that reduces total life cycle CO_2 emissions by approximately 40% and up to 60% comparing to regular diesel fuel. The company is also researching the use of non-food vegetable oils, wood waste and algae to make diesel fuel. The company has announced that they have already decided to build the second Bio-diesel plant in Finland just after the previous Bio-diesel plant construction.

Recently, the world´s leading Finnish–Swedish forest industry enterprise Stora Enso has started co-operation with the fuel oil company Neste Oil in order to develop and demonstrate wood Syn-gas based bio-diesel production in the plant located in the city of Varkaus. Another world's leading forest industry enterprise UPM-Kymmene has announced that an investment of biodiesel plants is launched, the biodiesel technology is connected with the Finnish Syn-gas technology: where the wood biomass is gasified and being converted into bio-diesel.

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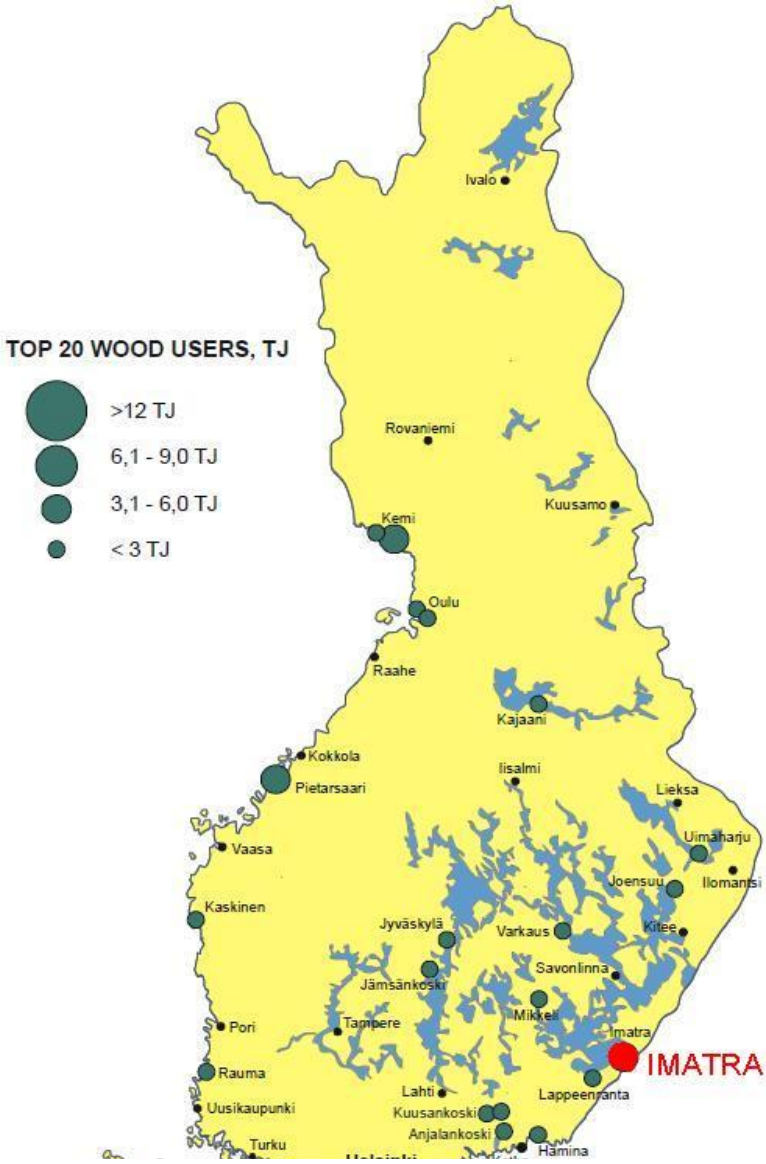

Figure 4.10 Finland´s top 20 bio-energy generation / consumption towns

The industrial level of the bio-energy is also reflected in the bio-energy consumption conditions in cities, for example, as we can notice from the *figure 4.10*, there are 20 towns in Finland where most of the wood and forestry biomass are consumed. The energy generated by the wood and forestry biomass based bio-fuel was from less than

3 TJ to over 12 TJ depending on the scales of the industrial facilities close to these cities. Imatra, the city where Saimaa University of Applied Sciences is located, shows in the red dot that near the Finland-Russia border. It is located in the world´s largest forest industry productions center in Europe: the South Karelia area of Finland and the city itself ranks the greatest bio-energy generation / consumption town in Finland with the energy scale over 12 TJ, due to the contributions of the bio-energy developments and usages from the nearby leading forest industry enterprises such as UPM, Stora Enso and the International Papers from America.

Considering all aspects of the major industrial wood usages and other factors of the bio-fuel considerations, the Finnish forest industry has invested heavily in bio-energy, energy-efficiency and the bio-energy conservation from biomass. Finland titles as the “leader of clean” in wood based energy usage in the Europe. About a fifth of Finland’s energy is generated from wood. This is five times the EU average and places Finland at the clean leader of industrialized countries in the energy use of wood.

For example, the wood flow in 2004 was concluded in *figure 4.11:* approximately 40% of wood raw materials received by the industrial production facilities which are used to generate energy in the different process stages that makes the bio-energy production and consumption a fundamental operating requirement for the forest industry.

The productivity of the bio-fuel is quite high which correspondently makes the forest industry the largest producer of wood energy and bio-energy in Finland. And it is reported that about 80% of the Bio-energy production and consumption in the country is from the forest industry. Forest industry takes positive prospects of using renewable energy forms, as long as availability of wood raw material for manufacturing is also concerned and secured. [25]

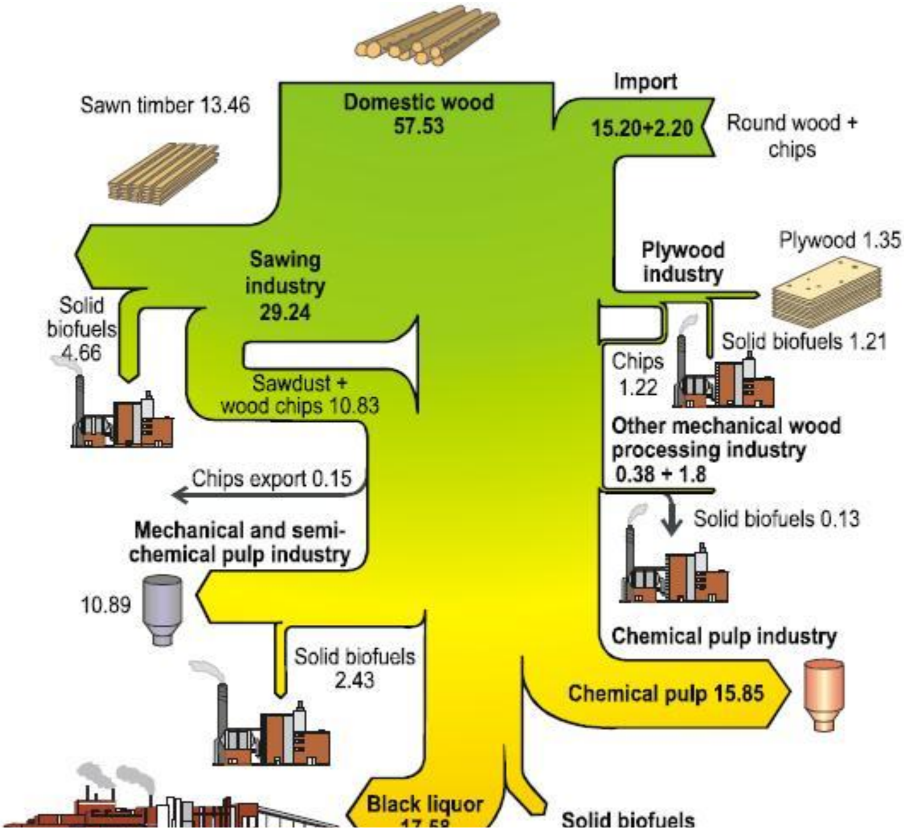

Figure 4.11 Wood flows in the Finnish forest industry in 2004, Mm^3

Besides, the Alholmens Kraft Power Plant, Pietarsaari, ranks as the world´s largest biomass Combined heat and power: CHP plant. Its operation has been launched in since 2002. The plant is situated near the UPM Kymmene pulp and paper mill, the heat and power generated by this plant are serving both the local paper industry and the residents of the Pietarsaari. The boiler of this plant has capacity of around 550 MWh and an estimated efficiency over 90%. The fuel consumption of the plant is showing in the *table 4.12*. [26]

Table 4.12 Fuel consumption of the Alholmens Kraft Power Plant

Fuels	Sources	Shares
Wood based fuel	*Pulp and paper mill*	*30% - 35%*
Sawing waste	*Sawmills*	*5% - 15%*
Peat	*Production plants*	*45% - 55%*
Coal and oil	*Imported fuel*	*5% - 10%*

Examples and values prove that due to the background of Finland´s leading forest industry with various bio-fuels investments and developments, bio-fuel including the black liquor is definitely acting as an essential sector affecting and contributing not only in the forest industry itself, but also on more general aspects of energy consumption, which can be concluded as another reason to explain why Finland ranks one of the world`s cleanest and release the least amount of carbon in the world.

China produces two types of Bio-fuel: bio-ethanol and bio-diesel. The raw materials of bio-fuel productions basically include: corn, root crop, sugarcane, sugar beet and rape seed, *figure 4.13* indicates the production areas of the raw materials. Approximately one million tons of the bio-fuel production has made China the world's third largest Bio-fuel producer in 2005.

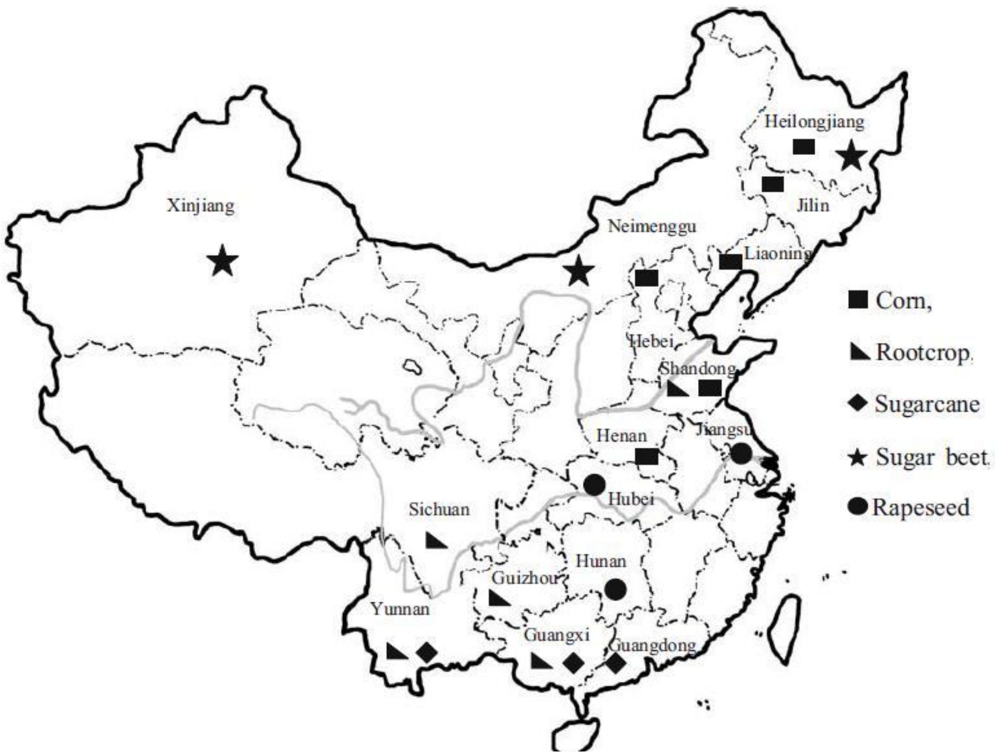

Figure 4.13 Production areas of bio-fuel raw materials in China

Bio-fuel has quickly occupied a certain part of China's energy political considerations, but unlike the conditions of the bio-fuels in Finland, there are much more issues that

China is facing, such as: energy security, food security, climate change, economic acceptation, urban development, rural development, and the ecological restoration. All mentioned issues might bring large limitations to the developments and usages of the bio-fuel in China.

The current situation of China´s bio-fuel usage is that Chinese government has been issued more emphasis on bio-ethanol development since China lacks the sources for biodiesel production. China is a major importer of all the major edible vegetable oils, China's bio-diesel production is produced from animal fat or waste vegetable oil from oil crushing plants or restaurants currently, and basically the most of bio-fuel plants are considered as in the small scale, which are capable to produce from 100 to 20,000 tons. As for the usage situation of bio-fuel in China, for instance in the transportation sector, a target of 15 percent of transportation energy needs to be replaced by using Bio-fuel by 2020 has been discussed and launched by China's chief planning agency National Development and Reform Commission. To be specific, targets of 15 percent of China's motor vehicle fuels consumption in 2020 are expected to be around 39-44 million tons. [27]

Although under the aggressive efforts and contributions to promote vehicle efficiency and at the same time reduce the amount of the vehicles, and the ever-growing fuel oil demands in China will be strongly considered in the next two decades. In 2005 per capita car ownership in China was about 11 per 1,000 people, or about 30 per 1,000 households, auto industry is essential and considered as the key industry of Chinese economy, with the economy booming and the improvements of the life quality, China´s car ownership might be increased continuously. 1.3 billion, as a massive population which causes even a slight raise in per household car ownership and use will trigger a significant consumption from the fuel oil demand. The same concept to bio-fuel applications, the raise of the fuel oils demands represent the equivalent scale of the bio-fuel demand, which gives a tough mission to the China´s energy markets and also to the production and research areas.

In order to deal with the dramatic growth of the petroleum products demand and the expected Bio-fuel demands, Chinese government has started to support the research and development efforts on Bio-fuels and selected several cities from the providences, for instance Hubei, Aanhui, Henan, Heibei, Jilin, Heilongjiang and Liaoling which are shown in green dots in the *figure 4.14* as the example locations of the extensive pilot projects in 2004 to largely use the bio-fuels, which were highly expected to be the places where petro usage could be widely reduced and the bio-fuel is able to be actually accepted as one of the major alternatives of the fuel oils and the solutions to energy problems caused by the China´s massive pollution issues.

Figure 4.14 Extensive pilot projects of Bio-fuel usages locations in China

Based on the projects, nowadays there are already four bio-ethanol plants have been authorized by the government to produce fuel ethanol from grains, as shown in *figure 4.15*: Jilin Fuel Ethanol Co. Ltd., Anhui Fengyuan Biochemical Co. Ltd., Heilongjiang

Huarun Ethanol Co. Ltd., and Henan Tianguan Group. All of them are located in the main corn and wheat producing areas and use mainly these grains to produce ethanol. 1,020,000 million tons of denatured bio-ethanol is able to be produced which is divided as: 300,000 tons from the Jilin Fuel Ethanol, 300,000 tons from the Henan Tianguan Group, 320,000 tons from Anhui Fengyuan Biochemical, and 100,000 tons from Heilongjiang Huarun Ethanol. Additionally, 100,000 tons of fuel ethanol from Jilin province would be consumed in the province and the other 200,000 tons would be distributed in Liaoning; 300,000 tons of bio-ethanol production in Henan, 130,000 tons would be consumed locally and 170,000 tons would be distributed to 13 cities in Hubei and Hebei; 320,000 tons of fuel ethanol produced in Anhui province, about 100,000 tons would be sold in the province and 220,000 tons would be delivered to 14 cities in Shandong, Jiangsu, and Hebei. Besides, 100,000 tons of bio-ethanol which produced by Heilongjiang Huarun Ethanol would be distributed in local areas.

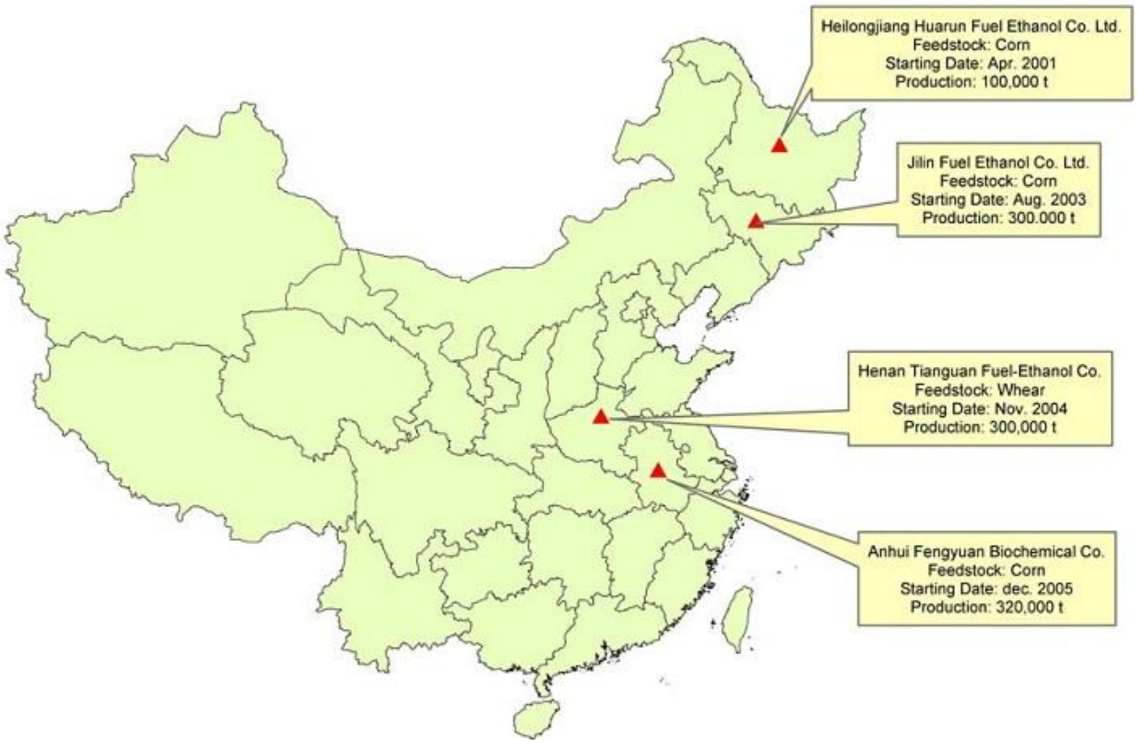

Figure 4.15 Major production centers of bio-ethanol and their productivities in China

Forest is one of the most essential sources of the bio-fuel productions, the Chinese

State Forest Administration notices the importance of the Bio-fuel production and other related activities from the forest, and established a target that 13 million ha of biodiesel plantations should be fully functional by April of 2010, which has already been reached roughly, according to the plans from Ministry of Science and Technology plans, the production of the biodiesel should reach 1.5-2 million tons by 2010, and a large scale rising to 12 million tons annually by 2020.

Technical co-operation regarding bio-fuel technology between Chinese energy firms and Finnish energy companies are growing, and bringing closer connections between the two nations. The Preseco Oy which is a growing Finnish environmental technology company that solves challenges related to waste, water and energy which also aim to produce added value from the waste.

Its leading bio-carbon technology responds to the need to increase renewable energy production and reduce CO_2 emissions rapidly which exactly fits the solution to China`s current situations of the carbon emissions and the usages of bio-fuel. Bio-carbon is an emissions-neutral bio-fuel with a superior energy value and low emissions. Bio-carbon from a Preseco Carboniser plant can be used in traditional coal power plants without any modifications or new investments in the power plant technology. Residual biomass can be brought to market by converting it to bio-carbon; it could be utilized efficiently in existing power plants while reducing CO_2 emissions, due to the measurement of one ton of bio-carbon that equals to 3.5 tons of CO_2. Due to its advanced technology, a MOU: Memorandum Of Understanding has been signed by the Preseco Oy company during Chinese business delegation's visit to Finland on 10th of July, 2009 in Helsinki, shown in *figure 4.16,* which was considered as an essential part of the Finland-China Economic and Trade Cooperation Forum organized by the high level governmental organizations in Finland and China. Signing of the Memorandum of Understanding was an important step in implementing state-of-the-art innovative the Bio-carbon technology from Finland in China, detail of the agreement was the establishing a joint venture between the Preseco Oy and Anneng Thermal Power (Group) Co., Ltd. in the province of Hubei, China. The purpose of the Joint Venture is to build Preseco Carboniser plants producing and selling high quality Bio-carbon. The facility is hoped to be fully operational within the first quarter of the year of 2010. The first stage of the agreement includes construction of a multi-million Preseco Carboniser Demonstration Plant, which is highly expected to have capacity of approximately 16,000 tons of bio-carbon annually; this number is equivalent to 15 MW of electricity power. Besides, the joint venture will independently build Preseco Carboniser plants in the province in the second stage. [28]

Figure 4.16 Finland-China economic and trade forum signing ceremony of projects

The pressure for usage of renewable energy keeps growing in China; there are numbers of areas that definitely need to be changed from fossil fuels to renewable energy sources. Based on this current situation, the bio-fuel usages and bio-energy developments are considered as one of the top priorities which China must try to achieve. Nowadays, the main challenge for bio-fuel productions in China is how to establish the steady, low-cost, non-food feedstock supply and highly efficient bio-fuel production system. All development scales are significant where simultaneously the co-operations with Finland that has the advanced technology of the bio-fuel usages must be enhanced and amplified indeed.

5. PROSPECTS AND INFLUENCES OF BIO-FUEL

5.1 Food security vs. bio-fuel production

When producing the bio-fuel, the considerations from the food security must be highly concerned. Food security is a concept describing like one´s availability to food, it exists all the time when people have the physical, social and economic access to sufficient, safe living and nutritious foods to reach their dietary needs, and foods for active and healthy lives. Food security can be stroked by the factors of: food prices rising, food productivity reduction, farming conditions changing, global warming and unstable area economy. The *figure 5.1* indicates the concerns and impacts on the food security from the bio-fuel productions: [29]

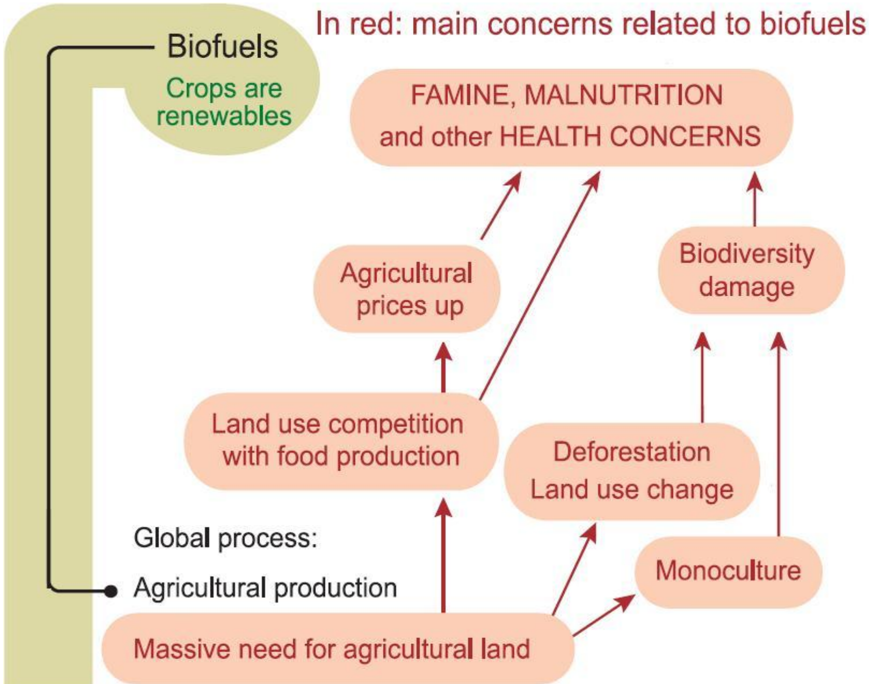

Figure 5.1 Bio-fuel production concerns and impacts to agriculture and food security

The fast growing world population with the rising productions and consumption of bio-fuel intensify demands for much more food than ever. The use of food crops such as corn grain to produce bio-ethanol raises major nutritional and the ethical concerns. Nearly 60% of humans globally are short of food supply and currently malnourished, the requirements of food for grains and other basic types of foods are critical. Using corn for bio-ethanol indirectly raises the prices of various kinds of food, items like: meats, rice, eggs, breads, cereals, and milk have already risen by 10% to 30% in the U.S and higher rising are expected to be detected in other nations. Generally, between 2002 and 2007, the prices of foods have increased by approximately 140% because of critical factors including: increased demand for bio-fuel feed stocks, rising agricultural fuel consumptions and the growing of fertilizer prices.

The conditions and situations when bio-fuel production affects the food security are completely different by nations. For instance China ranks the third largest producer of the bio-fuel and nearly 20 percent of the world’s population and owns 10 percent of the world´s framing lands, food is considered as the most critical problems of the Chinese society and other related economic and industrial issues. In 2009, China’s bio-ethanol production was reported to rise to 1.7 million tons, an increase of 8% compared with the value in 2008. Production of the bio-ethanol primarily requires the feed stock, from wheat and corn. A Major food price raise was occurred in 2007, due to the raise and, the plans which were prepared for the rapidly increasing bio-fuel production in China have spurred domestic debate of food security implications of an upgrading from food to energy crops; the growing prices of the food has made the China’s State Council abandoned the usage of grain crops for bio-ethanol production, which limited the bio-fuel development to non-grain energy crops.

In order to minimize the impacts from the bio-fuel productions on the food security, the government also halted approval of any new grain processing and bio-fuel ethanol plants, more attention has been turned from making investments of building more Bio-fuels plants to supporting the non-grain based fuel ethanol production; To speed up development of the bio-fuel industry, as with ethanol, China needs to set biodiesel standards and introduce incentive policies .China aims to use around 6.7 million tons of bio-ethanol and 11 million tons of bio-diesel by 2010, meeting 10 % of its forecast transport fuel demand. The country's emphasis is about to produce the ethanol from cassava, sweet potato and maize, and biodiesel production from animal and vegetable oils, and besides China has planned to reserve 44 million ha of its land for growing the bio-fuel feedstock. However, the situation of the food security in Finland is completely opposite, according to the global food security ranking from the risk-management consultancy Maplecroft, based in Bath, England. Finland ranks the first and thanks to its advanced agriculture management and the forest industry & bio-fuel technology, Finland is considered as the best country that has nearly no issues on the food security problems. This result could be another reason to explain why Finland is widely using the bio-fuel as one of its major energy sources without any resistance. [30]

Based on the dramatic price rising, it was reported that the shortage of food supply has already been detected in some poor nations. Growing crops for production of bio-fuel obeys the need to reduce fossil energy and land use, but it exacerbates the tensions of the malnourishment and strikes the worldwide food security. Scientifically, a mentioned method of optimizing the food-versus-energy competition is considered as growing crops and other food based bio-fuel sources on degraded or barren land not suitable for food production. Besides the support of new technologies should be invited quickly and properly to increase efficiency and productivity of the crop production. Besides, in order to avoid negative impacts occurred from the bio-fuel production on the food security, any usage of bio-fuel must need to be controlled and measured by concerted research efforts to protect the food security from any negative influences. The most important priority is to ensure that future food supply is enough to feed the population and only surplus agriculture production could be available for the bio-fuel production.

5.2 Can Bio-fuel be the replacement of the fossil fuel?

There is a question which is being asked so frequently that it has become priority that the whole world is responsible to answer:" Can the bio-fuel be capable to replace the current usages of the fossil fuels like coal, natural gas or even the fuel oils?", the answers might be found from some examples and facts about how bio-fuel is being applied in different fields. Environmentally, bio-fuel´s main vantages are: low pollution, low carbon emission and toxic-free comparing with the usages of fossil fuels. In *the table 5.2,* we can notice that why "Low" is used to describe the pollution and emissions from the bio-fuel itself.

Table 5.2 Emissions comparison between fossil fuels and Bio-fuel [31]

Emissions	Fossil Diesel	Bio-diesel
Carbon dioxide	*100*	*-78%*
Carbon monoxide	*100*	*-41%*
NO_X	*100*	*+5%*
Particles	*100*	*-55%*
PAH	*100*	*-80%*
NAPH	*100*	*-90%*
Sulfates	*100*	*-100%*

Generally, the carbon dioxide emissions are measured as 78% less and 41% less of the carbon monoxide from the combustion of the bio-diesel than the fossil diesel combustion, with several lower emissions and even 100% lower from sulfates; bio-fuel is completely more environmental friendly.

Besides, for instance, due to the environmental advantages and potentials, bio-fuel has been selected as a solution to dependence on foreign oil in America, and also one green alternative energy source to the gasoline. Besides, from the *figure 5.3* we notice the effects of carbon emissions reduction when partly using the bio-fuel is remarkable comparing with the usage of the fossil fuels only.

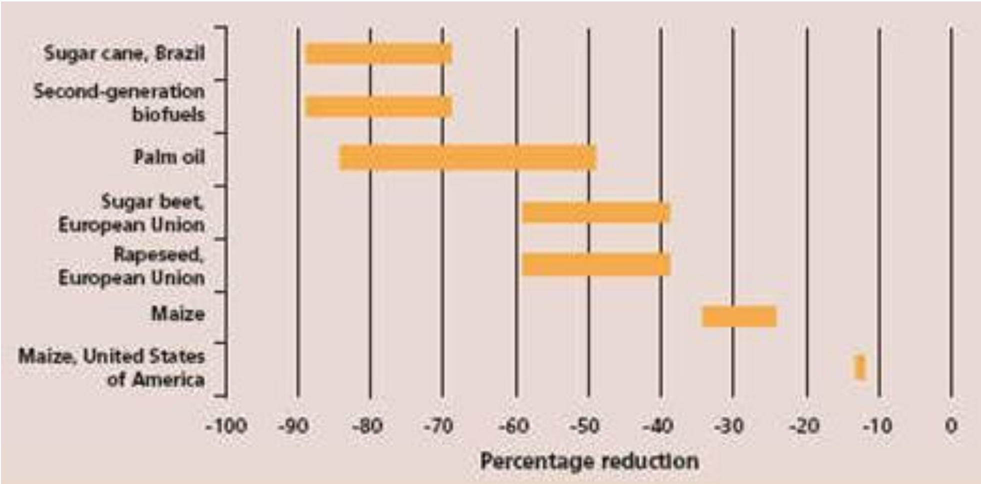

Figure 5.3 Reductions in greenhouse gases emissions of Bio-fuel relative to fossil fuel

It appears that the bio-fuels have the ability to replace the traditional fossil fuels due to the ideal environmental characteristics, but however, they are not the perfect choices to do the replacement: Although the bio-fuels produce less greenhouse gas emissions than the petroleum-based fuels do, but the *figure 5.4* indicates that, sometimes it actually might require more fossil fuels to create and transport that bio-fuel than using the fossil fuel itself that can produce same amount of energy. Expect for America, this is the same question which many countries are also facing, which put countries into an awkward situation and cooling their passion for the bio-fuel.

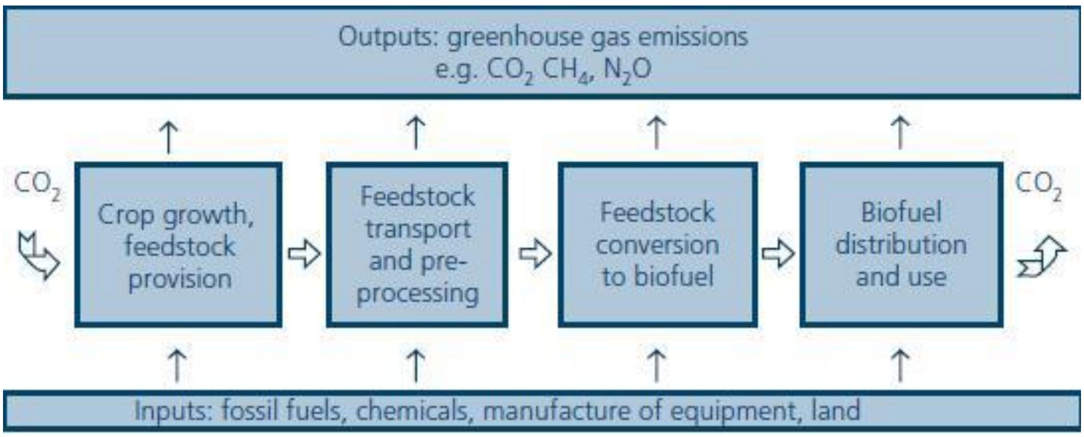

Figure 5.4 Extra external carbon emission when creating and transporting bio-fuel [32]

The fuel usages are divided into several fields, on the industrial level of usages, except for forest industry; other industries are not much connected with bio-fuel. Replacing the fossil fuels with Bio-fuel might reduce the pollutions from the industries but the cost is massive, which means the fundamental re-construction of their facilities and it is not certain whether the bio-fuel energy output can be enough to power the facilities. After industrial level fuel consumption, another major field is the transportation: nowadays, almost all kind of transportation depends on the fossil fuel consumption directly or indirectly due to the technology limitation of engines and other components of the vehicles. Due to research and developments, large achievements and progress have already been obtained by the bio-fuel application in the transportation field, but the modifications and replacement are not complete, only partly. It tells there is still a long distance ahead of the destination that all engines, fuels and other parts of vehicles can be transformed to be the “bio-fuel-adaptable” due to the future technology with the huge investments and efforts.

When discussing any products, the economy factor must be highly considered, the factor is the price of the bio-fuel when considering whether the bio-fuel can be the replacement of the fossil fuel. The world faces the situation that fossil fuel is running to deplete faster than expectations, but the fossil fuel is still able to power the world for decades, this situation makes the demand of bio-fuel is not critical currently, besides, with the pressure from the food productions and the production facility investments, the price of the bio-fuel is considerably higher than the price of the regular fossil fuel, especially when comparing the prices between bio-fuels and the cheapest fossil fuel: coal.

“Different Bio-fuels vary enormously in how eco-friendly they are and we must be smart and trying to promote the right bio-fuels to fit very different situations and the prices of the Bio-fuel must be minimized, or we won't be helping the environment and the economy much at all.”, said Dr. William Laurance, who works as staff scientist at the Smithsonian Tropical Research Institute. [38] This idea can be also considered as the first priority of the research and development projects of the bio-fuel in the future: to reduce the extra energy input while producing bio-fuel and to create different types of bio-fuel that fits different fields in order to achieve the optimization and amplification of the Bio-fuel applications.

Bio-fuel is definitely a key to a better living environment and the question of the global energy consumption, however, is based on the facts and current situations, unless the Bio-fuel technology, productivity and related issues like food security, modifications and price are achieved and properly solved, the bio-fuel is still unlikely to completely replace the fossil fuels in any time soon.

5.3 Multiple prospects of the Bio-fuel and improvements

Except for the well-known advantage of low carbon emission, bio-fuel stands for much more vantages that make the fuel itself a priority not only on the environmental aspects, but also for the economic and social considerations.

For instance, the bio-fuel oil industry involves people from all segments, including farmers that provide more job to reduce the poverty; Bio-fuel production is a chance for the government to increase the economic development by creating a new industrial area that offers considerable amount of jobs. Not all bio-fuel production developments institutions and industries are operating in the same scale; the scale is evaluated by fuel development investments, bio-fuel productivity and numbers of employees.

Briefly, the activities from bio-fuel related institutions and industries are summarized into large-scale bio-energy developments and small-scale bio-energy developments, the description shows in the *figure 5.5,* shows differences between the large and small scale bio-energy developments somewhat determine the potential and prospects of bio-fuel they may develop and produce, which mainly focuses on the energy economy considerations.

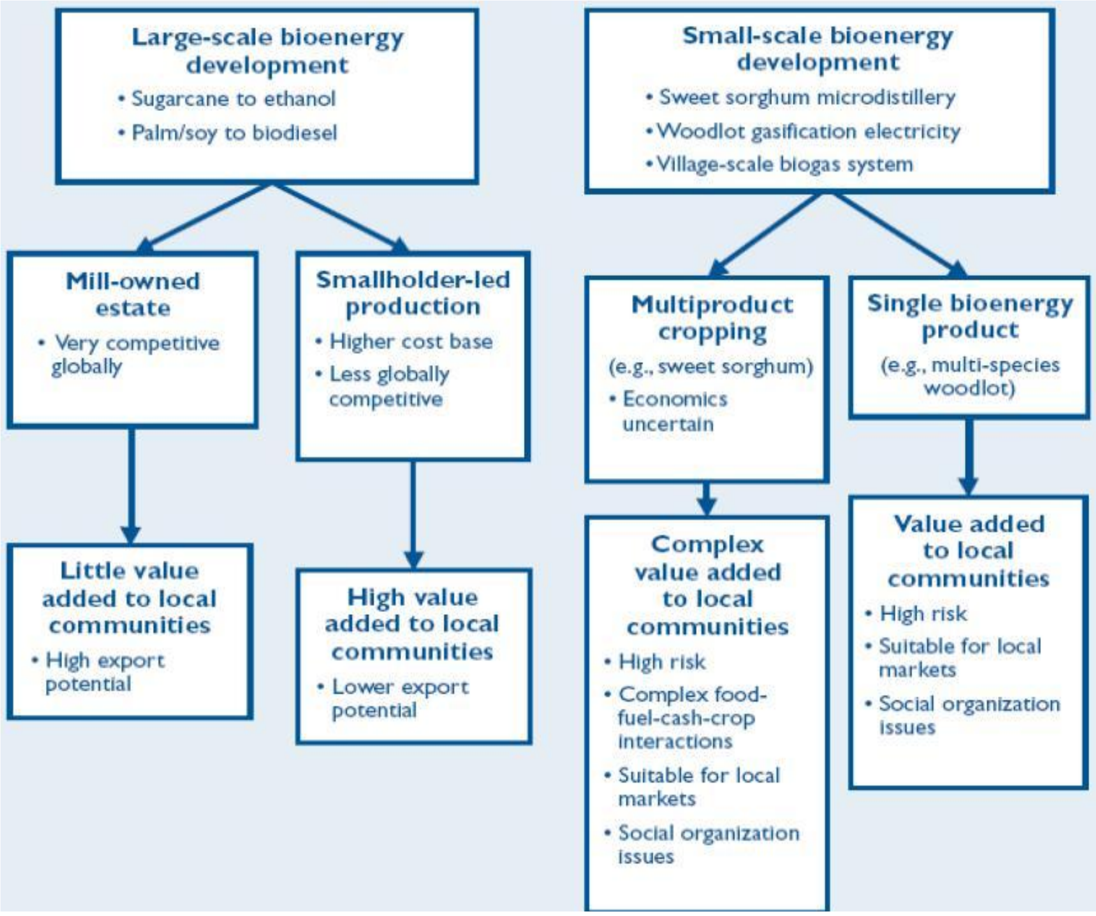

Figure 5.5 Characteristics of large and small scale bio-energy developments

Large-scale bio-energy developments usually cost less and bring more profits than the small-scale bio-energy developments do, because the smallholder led production is more labor intensive and less capital intensive, and for the small-scale development, they may encounter technological challenges. More research and pilot experiments are urgently needed to further develop and test in small-scale productions, these issues are all considered as the limitations of the bio-energy development and fuel production from the small-scale Bio-energy developments. However, the number of the large-scale bio-energy development is less than the number to the small-scale developments, that makes the transformation changes small-scale developments into the large-scale an essential step to promote the prospects of the bio-energy.

Globally, the production scale indicates the potential and prospect to major bio-energy products: bio-ethanol and bi-diesel, from the *figure 5.6* and *figure 5.7* we notice that the scales of production which also equal to the demands of bio-ethanol and bio-diesel are increasing continuously, which gives a positive preview of their prospects. [33]

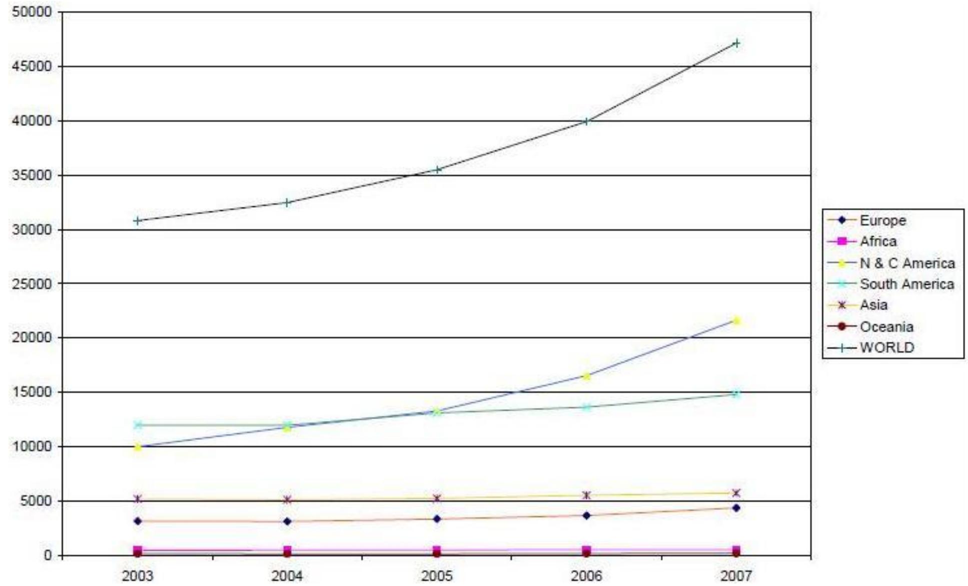

Figure 5.6 Worldwide Bio-ethanol productions outlook (in 1000 tons)

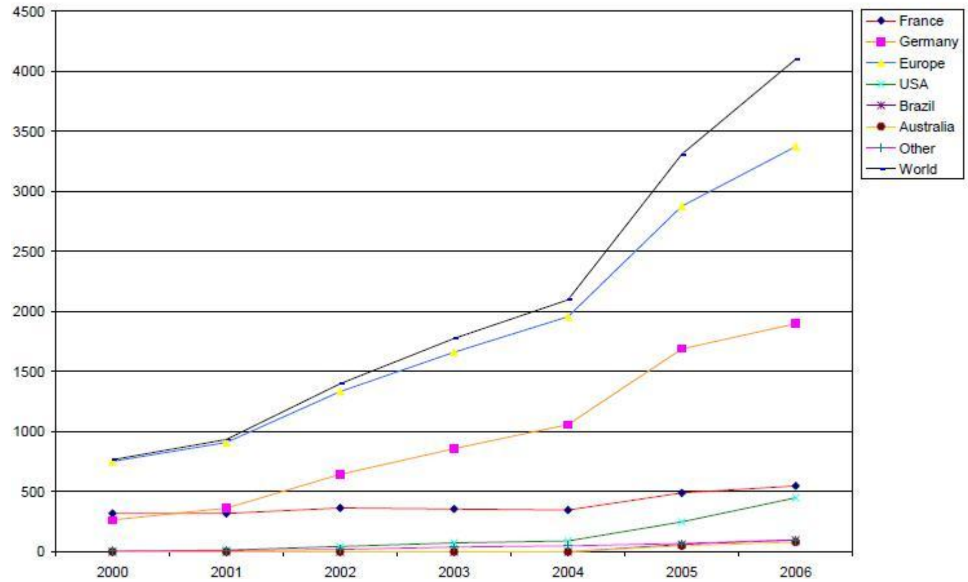

Figure 5.7 Worldwide Bio-diesel productions outlook (in 1000 tons)

The world's production of bio-diesel reached 4.1 million tons worldwide in 2006; it shows that most of world's bio-diesel production occurs in Europe. The productions from U.S, Brazil and Australia almost occupy the bio-diesel market entirely. Because almost all kinds of vegetable oil can be consumed to produce the Bio-diesel, it has clearly been seen a related increase in the demands for cheaper vegetable oils, such as palm oil. The trends of bio-ethanol and bio-diesel production outlined indicate that an increasing amount of world's production of sugar, corns, and vegetable oil will be used in energy production.

This rising productions and demands represent the bio-fuel will be one of the major alternative energy sources that keep booming. Booming of the bio-fuel productions and at same time the booming of the raw materials demands strikes the food security, but after all, the growing productions and demands of bio-fuel are considered as trend, the prospect of the trend is that any resistances and problems like: food security, raw material production, energy security from developing and improving of the mentioned trend will be removed and the trend itself still remains fast growing.

When prospects and potentials of new technology and products are mentioned, they can be noticed more clearly in the developing countries, since the new technology brings the large scale of changes, national economy could be significantly affected and even policies could be modified by the technology and products. Under this condition, prospects of the Bio-fuel which acts as a new member in the energy market in China, the world´s largest developing country are bright and fully loaded with undiscovered potentials, at the same time, resistances can be removed by using suitable methods.

An example is that in order to enlarge the Bio-fuel usage in China while minimizing the impacts on food security and any other concerns, the "11^{th} 5-year Plan" of renewable energy development in China has planned that the bio-ethanol production from nonfood-based feed stocks will be the main direction of bio-ethanol development in the future. Due to this condition, more employment opportunities can be created in the bio-fuel production area and equipment for fuel productions will be built or imported, which at the same time stimulates and promotes the technical markets and research investments. The change of the Bio-fuel production has indicated the modifications and optimizations, which offers a better operating environment and conditions to enhance the potential and prospects of the bio-energy research and related bio-fuel products developments. [34]

The annual output of bio-fuel in China has increased dramatically in the last few years. However, bio-fuel development in China is still evaluated in the initial stage and there are significant challenges ahead in developing and research in order to make it ready for large-scale commercial reality. The critical research challenges for the bio-ethanol production are, for example: the applications of advanced biotechnology introduce the new characteristics which obtain the high yield of raw materials; improvement and innovation of technologies for starch-based bio-ethanol, such as: the fermentation of untreated feedstock, filtrate and the recycling of clear broth, the waste treatment for bio-ethanol production from the cassava. The development of new processes for the production from non-food-based feed stocks, such as lignocelluloses biomass which helps to reduce the impacts to the food security from the bio-fuel production. As for the bio-diesel production, the researches challenges are, for instance: the development of cultivars and hybrids of conventional with development of no edible oil-producing plant species with high yield and reasonable environmental adaptation. All these mentioned challenges are considered as reflection of bio-fuel´s prospects in China which cause massive investments and concerns in the field of bio-fuel development and research.

Bio-fuels are one of the few technologies currently available that have the potential to displace oil and provide benefit to the transport system in a certain scale. The fact is that the bio-fuel on their own cannot deliver a sustainable transport system and must be developed as part of an integrated package of measures, which promotes other low carbon options and energy efficiency, as well as moderating the demand and need for transport. It requests that the supply chain of the bio-fuel production and usages must be improved and optimized in order to establish the chain efficient that really delivers substantial greenhouse gas savings. The following improvements and modifications are priorities to achieve the requested targets which promote the Bio-fuel potential and prospects: To increase the productivity per hectare of the feed stock while reducing negative environmental and agricultural impacts as much as possible; To develop new feed stocks which could be grown in more hostile environments; To be more readily processed and be capable of generating a variety of products; To improve methods of processing and create new physical and chemical systems for bio-fuel synthesis; To integrate the supply chain to gain the maximum efficiencies; To integrate the bio-fuel research with engine developments and to agree methods of assessing sustainability internationally. [35]

6. CONCLUSIONS

Fossil fuels have been burned over centuries, they are contributing as major energy sources of the evolution and revolution of the modern society, industries and people´s daily lives depend on the energy which is generated by them almost completely, but the related environmental issues and the incoming crisis of the fuel supply shortage are getting more significant and hugely affecting the entire planet. It has become fatal to change current situation properly and quickly; to develop and optimize the alternative energy sources in order to minimize any kind of potential impact on the society from environmental problems and any other problems related with the energy consumptions in the future. Among those problems, greenhouse gas emissions and the ultimate consequence of climate change and the global warming are mentioned as the most aggressive and harmful. Since continuous usage of fossil fuels will seriously accelerate and aggravate the conditions of the global warming, the significant negative influences caused by it have already been detected over the world, which badly hits forest, agriculture and other human interests.

Finland and China are two nations which are totally different on the concerns of the energy usages, where Finland ranks the world´s cleanest country with the least carbon emissions and oppositely China consumes one of the world´s largest energy sources and correspondently pollutes the most. Situations of Finland´s will remain and China´s must be improved and completely changed. Under this condition, comparing with the people´s daily lives, energy consumptions on the industrial level is considered as main usage fields, and the industries themselves are correspondently and fully responsible and capable to carry the missions, also afford the contributions that are able to change the conditions and situations of the fossil fuel consumptions, since the fossil fuels are the fundamental and essential to all related problems. Nowadays, among all industries, practically forest industry, which is not only contributing on the economic aspect from the forestry value chain, but also the supports and efforts also have been contributed to the protection of the environment with developments and usages of “pollution-free” bio-fuel, due to its special operating background and the sources of the bio-fuel raw materials. Bio-fuel is able to provide certain environmental and economic advantages with future potentials which make the fuel capable to solve the greenhouse gas emissions problem and simultaneously minimize the effects from the climate change and the harmful global warming.

Finland and China own large scale of forest and related industry, but the difference is that Finland pollutes much less, and it has much more advanced industrial technology, management system and background of forest-based bio-fuel usage and techniques. They are exactly the knowledge and resources which China must learn in order to drop the title “World´s largest pollutant producer” and to improve the industrial performance. At the same time, the developed countries should offer assistances and necessary support to promote and improve the quality of the industrial performance in developing countries; these two major aspects make the learning and co-operation scales of the forest industry, bio-fuel research, developments and other considerations between Finland and China become more essential and meaningful.

The fossil fuels will be still consumed in the next several decades like oils and even up to centuries for example the coal. So the bio-fuel and fossil fuels will be seen on the markets at the same time, people are questioning whether the bio-fuel is able to completely replace the fossil fuels due to their wonderful characteristics and potentials, but the answer is still concluded as “no” currently, since magnificent scales of research and developments are still in front of the final goal of the final replacement. Such as the reductions of the extra carbon emissions when producing and transporting bio-fuel with the bio-fuel prices controlling, etc. Enlarging research scale and bio-fuel usage certainly reduces the consumptions of the fossil fuels which correspondently decrease scale of the environmental stress, but however, except for the forest-based biomass, the production of bio-fuel requires foods supply: larger fuel production means larger foods demand, and this condition might negatively influence the food security. Impacts on the food security from the bio-fuel production and usages are considered as one of the most serious considerations since the food supply shortage and even starvation have already been detected in same poor nations in the world. The impacts must be minimized to secure the potential and prospects of Bio-fuel by investing and offering greater research on both aspects of bio-fuel production and agricultural developments in the future.

Environment, energy consumption, forest industry, bio-fuel and other related and close factors such as: agriculture and social economy are deeply and widely connected and inter-influenced. The balances and adjustments controlling the relations among them are definitely the key to the fundamentals of our modern society and the future: cleaner environment, better industry performance, more stable society and eventually to obtain ideal solutions to any impacts and negative influences from the energy consumption and industrial activities.

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