World Biofuel Maritime Shipping Study

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Executive Summary

Concerns over climate change and energy security combined with high fossil fuel costs have resulted in an unprecedented demand on biomass as an alternative fuel. In future, with expansion in 2nd generation biofuels, demands for biomass will increase. Since large sources of biomass are not often found where they are needed, long-distance transport of biomass and biofuels will put new demands on maritime shipping capacity.

This study examines two maritime shipping markets; dry bulk, and liquid bulk. Dry bulk tankers commonly carry commodities such as ores and grains and are segregated by capacity; from 20-35,000 tonne Handysize, which is accessible to many ports, to the 100-300,000 tonne Capesize, which cannot even pass through the Panama Canal and only the largest seaports can handle. Large liquid bulk carriers commonly carry crude oil & LNG while smaller chemical tankers often have stainless steel or coated tanks that can handle aggressive chemicals.

Efficient seaports are often critical to enabling cost effective transportation of biomass. The most advanced ports can accommodate large ships and offer a range of facilities for handling and storage and well as excellent land transport connections; such as Rotterdam, Singapore Hamburg and Hong Kong. The least efficient ports, often nearer to biomass sources, have low port productivity and poor transportation logistics; such as in Africa and South America.

The most transported biofuel is **ethanol**. Of 2.8 billion litres in ethanol exports in 2008, Brazil shipped 97%, primarily to Europe, Japan, India and the US. Net exports of **biodiesel** were 1.1 billion litres in 2007, the largest shippers being the US, Indonesia and Argentina, primarily to the EU and Japan. Wood **pellets** have become a major biofuel export due to EU demand. Of 1.8 million tonnes exported in 2006-7, Canada was the largest exporter at 740,000 tonnes, much to Belgium and the Netherlands. Exports from the Baltic States have fallen sharply due to lack of wood, while the US South is projected to be a major exporter. **Raw biomass** is also shipped by sea. In 2006 20% of 231 million m^3 of wood chips and particles produced were exported. The largest exporters were Australia, South Africa and Chile; the largest importers were Japan, China and Finland. Most of these imports were for pulp and paper, but increasingly they are expected to be exported for energy. **Palm oil** is shipped in large volumes, 12.7 million tonnes in 2007-08. Major exporters were Malaysia and Indonesia, the major importers China and India. While most palm oil is shipped as a food product, like wood chips it may be increasingly shipped for energy.

Ethanol and biodiesel are shipped in chemical tankers. Brazilian ethanol is shipped through five ports to various European ports including Antwerp and Rotterdam. Products such as fast pyrolysis oil, not yet ocean shipped, initially will require chemical tankers due to a low pH, and will probably utilize smaller ports like Quebec in Canada and small Argentinean ports. Pellets are increasingly shipped in very large ocean going dry-bulk tankers. They must be covered to protect against water, must be loaded to minimize fines, and procedures are changing to minimize dangers of off-gassing and fire. Canada's pellets are shipped from the ports of Vancouver and Prince Rupert in the West and Halifax in the East, primarily Antwerp, Rotterdam and Stockholm. It is projected that biomass concentrations in Quebec will result in major exports from the St. Lawrence Seaway, either as pellets, or as products of bio-refineries. US South exports are shipped from the deep-water port of Panama City

Florida. Most wood chips for energy were transported on smaller ships from Baltic ports to district heating and power plants in Sweden and power plants in the UK. The pulp and paper industry has been shipping wood chips long distances from Australia and Brazil, suggesting that longer distance travel is possible for energy.

Products became increasingly manufactured in low-cost countries such as China and India in 2005-08 resulting in a huge demand for shipping to bring products to traditional consuming countries. Shipping rates skyrocketed accordingly, putting competitive long-distance transport of biofuels at risk. It took a financial crisis which led to a worldwide economic recession in 2008 to bring shipping rates crashing to extremely low levels.

Obstacles to competitive maritime shipping biomass include; shipping demand for other products, reliability of biomass supply from plants, port inadequacies, lack of back-haul, and characteristics of biofuels requiring specialty shipping. Anticipate new or growth routes include;
Pellets- Vancouver to UK and China, Quebec to EU, Chile to China and Japan, Australia to China, Norway to EU, Russia to EU
Biofuels- Brazil and Argentina to EU, North America, Asia.

Two major issues in maritime shipping of biofuels are:
1. Getting large quantities of biomass from regions that have poor land transportation infrastructures and ports, such as Africa and parts of South America, to countries where biomass is in great demand, such as in the EU;
2. Preparing for the technological breakthroughs anticipated in 2nd generation biofuels and the demands it will have on new shipping.

To improve the viability of trade routes to far-flung biomass sources will take major investment in ports and biomass conversion plants. Investing in ports to reduce costs is risky, unless large volumes of biomass supply are assured. Similarly investing in biomass production that must be shipped through old, inefficient ports is also risky. Something must be done to reduce those risks to enable efficient, low-cost production and transport of biomass. Options to do this include;
- Manufacturing purpose-built ships for products like pellets, bio-oil, wood chips etc
- Forming consortiums of biomass shippers
- Promoting long-term maritime shipping contracts now that shipping costs are low
- Developing "Biomass investment funds" to modernize and enhance ports and port facilities in areas of high biomass potential, supported by guarantees of volume purchases and contracted prices
- Investing in 2nd generation biofuel plants right in developing countries where there is surplus biomass

It is projected that more than 150 new Handysize tankers will be required just to handle exports of biofuels to 2014. It is further projected that with anticipated breakthroughs in 2nd generation biofuel technologies an additional 400 similar sized ships will be required to 2030 to handle biofuel exports. It is surmised that flexible ship designs are needed to control initial costs while allowing subsequent modification at lower cost; for example, building Panamax oil tankers in such a way that they can later be converted easily to Chemical tankers.

1. INTRODUCTION

Increasing costs of fossil fuels, energy security, and climate change concerns have resulted in increased demand for renewable biomass for energy production. For example the total primary energy supply (TPES) of combustible renewables & waste grew from 645 Mtoe (million tonnes oil equivalent) in 1973 to 1185 Mtoe in 2006 (IEA 2008). The use of biomass for energy production is expected to continue to grow in importance. According to IEA (2008), with policies under consideration the relative importance of renewables is projected to grow from 11% (TPES) to 14% by 2030. Since biomass resources are surplus in some countries and non-existent in others, international trade in biomass for energy production ("biofuels") is projected to increase.

Examples of current biomass fuel trade include; wood pellets from Canada to Europe, palm oil from Asia to Europe, and bio-ethanol from Brazil to Europe. Shipping is the main method for international transport of biomass, as it has been for roundwood and saw wood for several hundred years.

The purpose of this study is to describe main properties of biofuels in relation to shipping, examine current shipping lanes, capacities, costs and obstacles, and analyze factors that influence future biofuels shipping opportunities. Literature reviews and communication with key actors in the shipping industry was the main methodology applied in the study.

2. INTRODUCTION TO SHIPPING

Shipping describes the physical transport of goods and cargo by ground, water and air transport. In this report the focus is on the transport of biomass for bioenergy by large ocean-going vessels. Ocean shipping is generally divided into two main sectors; dry goods, and liquids. In 2007, dry cargo shipments were estimated at 5.34 billion tons and accounted for 66.6 per cent of total world goods loaded. A quarter of the total world goods loaded (2.0 billion tons) were made up of the five main bulks traded: coal, iron ore, bauxite/alumina, phosphate and grain. The difference of 3.34 billion tons was made up of minor bulks and liner cargoes.

According to UN (2008) more than 80 per cent of world merchandise trade by volume is carried by sea, hence maritime transport remains the backbone supporting international trade and globalization. Strong demand for maritime transport services has been fuelled by growth in the world economy and international merchandise trade. In 2007, the world gross domestic product (GDP) grew at 3.8 per cent while world merchandise exports expanded by 5.5 per cent. Such growth was driven by emerging developing countries and transition economies, which set the pace. In 2008, nationals of the top 35 ship-owning countries together controlled 95.4% of the world fleet, a slight increase over the previous year figure. Greece maintains its predominant position, followed by Japan, Germany, China, and Norway. Together, these five countries hold a market share of 54.2%.

Economic growth, production processes and consumption patterns largely determine demand for maritime transport services. Figure 2.1 shows growth in GDP of developed economies such as the US and Japan, developing economies such as China, India, and Brazil, and economies in transition, such as Russia. Developing economies are growing more swiftly than traditional developed economies, particularly due to industrial production. Also shown is world seaborne trade, which outstrips almost all economies in terms of growth, indicating that developing economies are taking over a larger share of manufacturing and shipping these goods in ever increasing amounts to developed countries. Ocean shipping is clearly increasingly important to world economies.

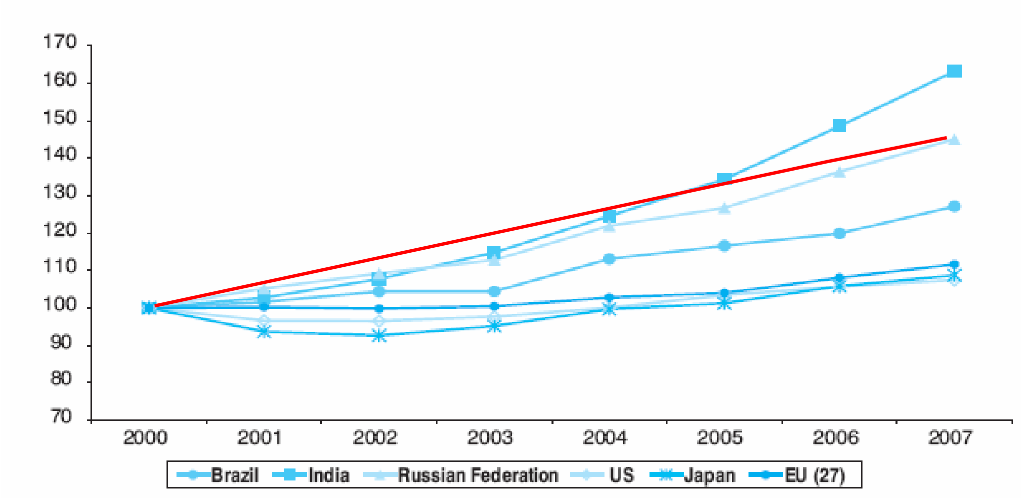

Figure 2.1. Industrial Production Index, selected countries, 2000–2007 and global index of international seaborne trade (red line). *(2000 = 100)*. *Source*: UNCTAD secretariat on the basis of *OECD Main Economic Indicators*, April 2008.

As shown in Table 2.1, international seaborne trade was estimated at 8.02 billion tons of goods in 2007, a volume increase of 4.8 per cent over the previous year. 63.2 % of major loading areas were located in developing regions, 33.3% by developed economies, and 3.5% in transition economies

Table 2.1 Development of international seaborne trade, selected years *(Millions of tons loaded)*

Year	Oil	Main bulks[a]	Other dry cargo	Total (all cargoes)
1970	1 442	448	676	2 566
1980	1 871	796	1 037	3 704
1990	1 755	968	1 285	4 008
2000	2 163	1 288	2 533	5 984
2006	2 595	1 876	3 181	7 652
2007[b]	2 681	1 997	3 344	8 022

Source: Estimated by the UNCTAD secretariat on the basis of annex II and data supplied by reporting countries, ports and specialized sources.
a Iron ore, grain, coal, bauxite/alumina and phosphate.
b Preliminary.

2.1. Types of ships

Commercial vessels can be classified on different criteria. There are three main types of commercial vessels: cargo, passengers and special purpose vessels. This study will focus on cargo vessels. Cargo can be differentiated into: general cargo (loose items like boxes); standardized containers and wheeled cargo (e.g. cars); and bulk cargo.

Bulk commodities are shipped in large quantities without any packaging. In the following text two types of bulk vessels will be described:

- Dry bulk carriers for the transport of dry bulk cargo like coal, iron ore, grain and bulk biomass, like oil seeds, wood chips and pellets
- Tankers for the transport of liquid bulk cargoes, like crude oil, gasoline, chemicals and other liquids like vegetable oils, biodiesel and ethanol.

2.1.1. Dry bulk carriers

Generally a dry bulk carrier is a ship that carries dry unpackaged goods. In the International Convention for the Safety of Life at Sea (SOLAS)[1] the International Maritime Organization defines a bulk carrier as a ship constructed with a single deck, top side tanks and hopper side tanks in cargo spaces and intended to primarily carry dry cargo in bulk; an ore carrier; or a combination carrier. Dry bulk carriers usually have several holds that are covered by hatches and equipment for loading and unloading of the cargo. In large part the design of dry bulk carriers depends on the density (stowage factor) of the cargo that will be transported. The densities of common cargoes vary from 0.6 tons per cubic meter for light grains to 3 tons per cubic meter for iron ore. For high density cargo the limiting factor for the ship design is the overall weight of the cargo, while for light cargo it is volume.

The majority of dry bulk cargo is transported in general purpose bulk carriers designed for the transport of unpacked cargo. Besides general purpose bulk carriers a number of special ship designs exist, for example OBC- (Ore-Bulk-Container) and OBO- (Ore-Bulk-Oil) vessels, which are more expensive in construction, but are more flexible in the variety of goods that can be transported.

The size of dry bulk carriers ranges from small single mounted vessels to giant vessels for the transport of coal and ore. Dry bulk carriers can be segregated into four main divisions: Handysize, Handymax, Panamax and Capesize, as shown in Table 2.2. The size (beam and draft) determine the size of ports and waterways to which a ship can travel. Handysize bulk carriers have a capacity range from 20.000 dwt[2] to 35.000 dwt. Handymax bulk carriers have a carrying capacity from 35.000 dwt to 50.000 dwt. Both Handysize and Handymax carriers are ideal for shipments of different cargoes from smaller ports. Since biomass for bioenergy often is shipped locally from small harbors they are ideal for the transport of these goods. Usually they have their own equipment for loading and unloading and therefore they are independent of shore-based equipment.

[1] International Convention for the Safety of Life at Sea (SOLAS), 1974: http://www.imo.org/Conventions/contents.asp?topic_id=257&doc_id=647

[2] Deadweight tonnes- see 2.1.3

Table 2.2 Bulk Ship Size

Ship type	Dead Weight Tonnes
Handysize	20,000- 35,000
Handymax	35,000-50,000
Panamax	50,000-80,000
Capesize	100,000-300,000

Panamax bulk carriers have a capacity range from 50.000 dwt to 80.000 dwt. The dimension of these ships is determined by the dimensions of the lock chambers, and the depth of the water in the Panama Canal. These types of ships operate on routes from North America, Canada, South Africa, China, India, Sweden and Indonesia and are used e.g. for the transport of oil seeds and wood pellets.

Capesize bulk carriers (100.000 dwt - 300.000 dwt) are specialized on the transport of coal and iron-ore and are too big to take the Suez and Panama Canals.

2.1.2. Tankers

Tankers are ships specially designed for carrying bulk liquids. The main types of tankers are petroleum tankers (crude and product tanker), LNG carriers and chemical tankers. Generally chemical tankers are used for the transport of the following categories of cargo: organic and inorganic chemicals, lubricating oils, animal and vegetable oils and molasses. These kinds of ships are also used for the transport of ethanol, biodiesel and bio-oil.

Usually chemical tankers have a number of separate tanks. Depending on the material and the coating (e.g. epoxy or zinc paint) on the tanks, these ships can be used for the transport of different chemicals. Stainless steel tanks can be used for carrying acetous liquids whereas epoxy coated tanks can be used for less aggressive chemicals, e.g. vegetable oils. Parcel tankers that have separate pumps and pipes for each tank are able to handle different chemicals without any mixing. These types of chemical tankers are often used to carry molasses and vegetable oils.

For some chemicals (e.g. palm oil) it is necessary to maintain a defined temperature so that viscosity remains at a certain level. In this case, a boiler transfers heat to the tanks through heating coils.

In the Maritime Safety Conventions the International Maritime Organization (IMO)[3] develops the safety regulations for the transport of dangerous goods. The International Code for the Construction and Equipment of Ships carrying Dangerous Chemicals in Bulk (IBC Code) provides an international standard for the safe carriage by sea of dangerous and noxious liquid chemicals in bulk. To minimize the risks to ships, their crews and the environment, the Code prescribes the design and construction standards of ships and the equipment they should carry, with due regard to the nature of the products involved.

Carriage of chemicals in bulk is covered by regulations in SOLAS Chapter VII - Carriage of dangerous goods and MARPOL Annex II - Regulations for the Control of Pollution by Noxious Liquid Substances in Bulk. Both Conventions require chemical

[3] International Maritime Organization (IMO): http://www.imo.org

tankers built after 1 July 1986 to comply with the International Code for the Construction and Equipment of Ships carrying Dangerous Chemicals in Bulk (IBC Code).

In 2004, IMO adopted a revised MARPOL Annex II Regulations for the control of pollution by noxious liquid substances in bulk. It includes a new four-category categorization system for noxious and liquid substances. The revised annex is expected to enter into force on 1 January 2007. Amendments to the International Bulk Chemical Code (IBC Code) were also adopted in 2004, reflecting the changes to MARPOL Annex II. The amendments incorporate revisions to categorizing certain products relating to their properties as potential marine pollutants as well as revisions to ship type and carriage requirements following their evaluation by the Evaluation of Hazardous Substances Working Group.
The list of products omitted from the amended IBC Code due to missing safety data, pollution data or both is available to download.

Ships constructed after 1986 carrying substances identified in chapter 17 of the IBC Code must follow the requirements for design, construction, equipment and operation of ships contained in the Code.
A type 1 ship is a chemical tanker intended to transport chapter 17 products with very severe environmental and safety hazards and requires maximum preventive measures to preclude an escape of such cargo; a type 2 ship requires significant preventive measures; a type 3 ship require a moderate degree of containment. Thus a type 1 ship must survive the most severe standard of damage and its cargo tanks shall be located at the maximum prescribed distance in board from the shell plating.

2.1.3. Ship measurement

Ships can be measured e.g. in terms of dimensions (length, tonnage...), speed, draft, weight and so on. The tonnage usually refers to the volume of a ship, sometimes it refers to the weight. Historically the term derives from the taxation paid on tons of wine. As port dues, registration fees and manning rules are calculated based on the size of ships, a commonly defined measurement system is very important. As of 1969 tonnage measurements have been regulated in the International Convention on Tonnage Measurement of Ships, which now applies to all ships built after July 1982. In accordance with the Convention, the correct terms are gross tonnage and net tonnage. Some examples for other definitions for the measurements of tonnages are deadweight, displacement, gross registered and net registered tonnages.

The gross tonnage of a ship is a unit-less entity. It is a function of the volume of all spaces enclosed by the ship's hull and is calculated by using a simplified standard procedure. Net tonnage gives the tonnage as a function of the moulded volume of the ship's cargo spaces. Like the gross tonnage it is calculated by using a standard procedure and the result again is dimensionless.

Deadweight tonnage (DWT) is the difference between the number of tons of water the vessel displaces when submerged to its load line and the number of tons of water the vessel displaces light. Usually it is expressed in metric tons. In simple terms it expresses the number of tons of cargo a vessel can transport, including everything (crew, fuel, water, and stores) that is necessary for the transport.

Displacement gives the total weight of the ship (usually in metric tons). It is determined by multiplying the volume of water a ship is displacing by the density of water.

Gross register tonnage and net register tonnage have been used for a long time to describe the internal volume of ships. Gross register tonnage is a measure of the total internal volume of the vessel, whereas net register tonnage gives the cargo volume capacity of a vessel.

2.2. Seaports

Since ports are the gateways for the international distribution of cargo, ports and ports efficiency are of great importance to the development of international trade of biomass. As important links in the transport chain, ports offer strong interfaces to other modes of transport services and good connections to the hinterland. Ports offer equipment for loading and unloading of cargo and storage for goods. The infrastructure of ports and the logistics management of ports are crucial to the efficiency of loading and unloading and therefore to the costs of shipping.

2.2.1. Top sea ports – logistics - port efficiency

Port efficiency varies widely from country to country and region to region. It is well known that some Asian countries (Singapore, Hong Kong) have the most efficient ports in the world, while some of the most inefficient are located in Africa and South America. In India for example landed cost is nearly double the global average because of low port productivity and poor transport logistics.[4] In India this problem is addressed by investing in port modernisation (e.g. by increasing the berth draught).

Port efficiency will be crucial to the future development of internationally traded biomass. Efficiency strongly depends on the point of origin. In rural regions where the infrastructure for transport often is poorly developed (particularly in developing countries) biomass-loading ports will often be local ports with low processing capacity. Other regions, where biofuel processing plants are situated close to industrial areas (e.g. pellets industry in Canada), shipping efficiency will benefit from the existing distribution infrastructure.

Top ports have to offer a high availability of traffic, which may be from rail, road, inland waterway, transhipment, free trade zones and so on. They are operational 24 hours a day, seven days a week and have to offer a comprehensive range of facilities for handling and storage. Examples are Singapore, Hamburg and Rotterdam. High operating costs of these ports can possibly be fully compensated by a high availability and reliability of dedicated services.

2.2.2. Requirements for loading/unloading – cargo handling equipment

Ports offer cargo-handling equipment for loading and unloading of ships. This equipment may be provided by private interests or public bodies. Generally the loading and unloading of dry bulk cargoes such as coal, ore, sugar, grain and pellets, and liquid bulk cargoes like oil, are suited for high-tech mechanized and computerized handling. In the best case the type of cargo-handling equipment that is used is adaptable to the cargo. In practice it will strongly depend on the average volume of trade of a certain type of cargo in the respective port.

[4] Alan E. Branch: "Elements of Shipping", Routledge, London 2007

All-purpose equipment for loading and unloading of dry bulk cargoes are cranes and grabs. Bulk material can be loaded into large hoppers that are fixed to high capacity travelling cranes to feed railway wagons, trucks or conveyor belts. Some ports offer pneumatic handling equipment. Whereas cranes and crabs can be used for a broad variety of dry bulk cargoes, pneumatic installations are suitable just for free flowing materials like pellets, grain, soybeans, soy meal, rape etc. The processing capacity of this equipment ranges from 10 to 2000 metric tons per hour. For the loading and unloading of grain, usually elevators (bucket elevators or with pneumatic suction) are used.

Liquid bulk cargoes are loaded and unloaded by pumps. Tankers are connected to the shore-based storage tanks by pipelines. Pumping equipment is offered onshore by the tanker storage plant. Additionally chemical tankers usually have appropriate pumping equipment on board.

2.3. Chartering of ships

Large companies (e.g. steel companies) that have continuous demand for huge amounts of bulk materials (coal, ore) often run their own shipping fleets. Companies that have long term requirement for bulk transport but don't want to become ship owners may charter ships on a long-term basis. In the trade of agricultural biomass, where the volatility of the market makes it difficult to plan shipping requirements, it is common practice to charter ships via ship brokers on charter markets such as the Baltic Exchange for single voyages.

The main stakeholders in charter markets are: charterers with cargo to transport, professional ship owners with ships for hire, and ship brokers. Institutions like the Baltic Exchange act as clearing house where ships and cargoes can be matched. A contract where the terms and details of a certain arrangement are set out is called charter-party. Generally there are two broad categories of charter-parties: demise and non-demise. A demise (or bareboat) charter is a lease of a ship. Demise parties are arrangements where the charterer pays all operating costs (crew, maintenance, repair...) and voyage costs (bunkers, port charges, canal dues, cargo handling costs). The ship owner merely provides the vessel. Non-demise charter parties are arrangements where the ship owner provides the vessel (including operating costs) and its crew while the charterer just supplies the cargo and pays for the service of carrying goods. Examples for non-demise charter parties are voyage charters, contracts of affreightment and time charters.

Under a voyage charter, a vessel is hired for a voyage between a load port and a discharge port. In the charter-party the type and volume of cargo, the laytime (period of time for loading/discharging the cargo), demurrage (detention in port of a vessel beyond the allowed time) and despatch are defined. As ports are organised based on the "first come - first served" principle, it easily can lead to port congestion. Demurrage can have a great impact on costs.

Contracts that agree on the transport of a specified amount of cargo for a specified fright rate but where the ship owner is not tied to a specific vessel are called contracts of affreightment. Time charter is hiring of a vessel for a specific amount of time. The charterer has to pay a fixed charter rate to the ship owner and has to pay all voyage expenses (bunkers, port charges, canal dues, cargo handling costs). The owner has to pay the operating costs of the vessel (crew, maintenance, repair...).

3. PROPERTIES OF TRADABLE BIOMASS

3.1. Dry/bulk material

3.1.1. Wood chips

Wood chips are pieces of wood that are a random blend of soft and hard wood which are rough-chipped to a non-uniform size of approximately 2 - 3 inches. Properties of wood chips are specified in the standard *CEN/TS 14961 Solid biofuel - fuel specifications and classes*, and can be classified according to moisture content, bulk density, net calorific value, energy density and particle size classification. The CEN Standard –CEN/TS 15103 describes methods for the determination of bulk density, sampled with moisture content. *Bulk density ar* (as received) includes moisture content, whereas *bulk density wd* (dry matter) excludes moisture content.

Bulk density ar is typically 300-350 kg/m^3. With a moisture content (MC) of 50-55%, bulk density wd is 140-150 kg/m^3. Energy content is the basis for wood fuel trade and the acceptable range should be stated in the contract. Recommended methods for specification are Net Calorific Value (Gj/tonne), or Energy Density (kWh/ m^3 loose volume). Energy content falls with increasing moisture content. Net Calorific Value is approximately 7.8 GJ/ton for 53% moisture content and 6.7 GJ/ton for 58% moisture content. Energy density can typically vary from 600-700 kWh/m^3 lv. Normally, energy chips are brought to dry and the moisture content of traded energy chips, in contrast to pulp chips, is lower, in the range of 30%.

Wood chip particle size can be described by methods defined in IS EN 15149-1 and 2 for particle sizes under and over 3.15 mm respectively. The particle size classes are defined in the following table:

Table 3.1 Particle Size Classes for wood chips.

Wood chips particle size	Main fraction > 80% of weight	Fine fraction < 5%	Coarse fraction Max length of particle
P 16	3.15 <= P<= 16 mm	< 1 mm	Max 1% > 45 mm, < all 85 mm
P 45	3.15 <= P<= 45 mm	< 1 mm	Max 1% > 63 mm
P 63	3.15 <= P<= 63 mm	< 1 mm	Max 1% > 100 mm
P 100	3.15 <= P<= 100 mm	< 1 mm	Max 1% > 200 mm

Most countries have treatment standards for wood chip import. As an example, New Zealand accepts one or more of the following treatment options for sawdust, wood chips, shavings, and wood wool:

- Fumigation, in separate units no larger than 2 m^3, with methyl bromide or sulphuryl fluoride at 80 g/m m^3 for more than 24 continuous hours, and at a minimum temperature of 10^{O}C.
- Heat treatment for more than 4 hours at a minimum continuous core temperature of 70^{O}C.

The importer of wood chips needs an import permit and a valid phytosanitary certificate.

3.1.2. Wood pellets

Wood pellets are usually made from dry, untreated, industrial wood waste such as sawdust, shavings or wood chips. In manufacture, wood is dried to 10% moisture and made homogeneous in size. Under very high pressure it is pressed through a pellet die with holes determining the size of pellet, and then cooled to allow the natural bonding agents to set. Countries with well developed pellet industries, like Austria, Sweden and Germany, have their own pellet standards. Sweden for example has three classes of pellets differing primarily in size and ash content, as shown in Table 3.2. In Europe, pellet diameter varies from 4 to 10 mm. There are length preferences also, Germany preferring 6 cm and Sweden 8 cm. Wood pellets have a lower heat value of 16.6-18.2 GJ/t. Ash standards vary from <.5% to <1.5%, sulphur <.04 to < .08%, nitrogen <.3 % etc.

Table 3.2- Sweden Pellet Standard SS 18 71 20[5]

		Group 1	**Group 2**	**Group 3**
Diameter	mm	>4	>5	>5
Density	kg/m3	>600	>500	>400
Fines	%	<0.8	<1.5	<1.5
Ash Content	% wt	<0.7	<1.5	<1.5

Pellets can be distributed in bulk by truck, rail or ship, or bagged in smaller quantities. Pellets do not degrade over time if they are stored in dry conditions, but tend to fall apart when exposed to water. Pellet delivery systems are modelled after the livestock feed industry, using pneumatic tanker trucks. Gentle pellet loading, storage and transportation systems are essential to minimizing the amount of dust or fines generated during handling.

Although wood pellets in bags are benign, when shipped in large volumes in bulk pellets are classified as hazardous material. Research shows that off-gassing is critical on long voyages, with high levels of CO, CO_2 and methane[6] found on several test ships, even after one week at sea. Handling procedures are being revised, including redesign, locking and labelling of access doors, and training of onboard crews. Other events have occurred including microbial and chemical oxidation caused by bacteria and fungi which has led to build up of temperature and explosions. Fire extinguishing research is going on at the University of British Columbia to resolve this issue. Shipping over long distances is a major expense for producers almost tripling from $35/tonne Vancouver Rotterdam in 2004 to almost $100/tonne in 2007[7]. To reduce unit shipping costs, much research is being undertaken today to increase pellet density from 750 kg/m^3 to 850-900 kg/m^3.

[5] IEA Bioenergy Task 40- Global Wood Pellets Markets and Industry: Policy Drivers, Market Status and Raw Material Potential.
[6] Safety in Handling Wood Pellets- Staffan Melin June 2008
[7] Wood Pellet Association of Canada- 2008

3.1.3. Bio-Char

Char is the remains of solid biomass that has been incompletely combusted, similar to charcoal. For example, it is a co-product of fast pyrolysis, a process whereby small particles of biomass waste are rapidly heated to high temperatures in the absence of oxygen, vapourized, and then condensed into liquid fuel. The process typically yields 65-72% biooil, 15-20% solid char and 12-18% non-condensable gases. Char is 65-76% carbon by weight, 5-12% ash, and less than 2% moisture. It has heat value of 28-30GJ/tonne. It is a charcoal powder with particle size less than 1 mm, and has bulk density of 0.25-3 tonnes/m^3. Since char is very fine, it has low bulk density, around 250-350kg/m^3.

Char can be shipped in powder form or as pellets. However, char is not thermally stable and freshly produced char can auto ignite spontaneously into a smoldering fire when exposed to air or oxygen. The heat is a result of fresh char absorbing water, resulting in an exothermic reaction. Char is classified as TDG class 4.2 dangerous goods. It can be stabilized in a number of ways; wetting well with water, deactivating in a gas stream, or simply waiting, since char deactivates over time. When transporting, it can be more difficult to handle in powder form because of its very low density. Pelletizing char is recommended if transported any great distance.

3.1.4. Torrefied wood

Torrefied wood is manufactured by heating wood in a process similar to charcoal production. At temperatures up to 160 °C, wood loses water and little else. Most of its physical and mechanical properties remain intact, particularly its ability to absorb moisture (hygroscopic properties).

Between 180 and 270 °C, wood begins to brown and give off moisture, carbon dioxide, and large amounts of acetic acid with some phenols. The amount of phenols increases proportionally as the process approaches the point where the reaction gives off heat (exothermic) instead of requiring heat. Other physical and chemical properties also change with increasing temperature including the wood becoming more friable (easily crushed) and less hygroscopic.

Torrefaction occurs at temperatures between 200 and 270 °C. Wood at this stage acquires the properties which are specific to the substance known as torrefied wood, namely;

- High amounts of energy per unit volume (energy density), as compounds with high-energy value have not been lost.
- Hydrophobia: re-absorption of moisture is practically nil when torrefied wood is stored, with moisture content stabilizing at about 3 percent.
- Optimum durability/friability balance.

Torrefied wood typically contains 70% of its initial weight and 90% of the original energy content. The moisture uptake of torrefied wood is very limited, varying from 1% to 6% (Uslu et al 2008). One of the big advantages of torrefied wood is that it converts biomass feedstocks, which generally do not have uniform qualities, into a more uniform substance. Torrefaction serves as a pre-conditioning process, eliminating the need for energy conversion systems to include inefficient and expensive methods to handle feedstock variations and thus make conversion and use of biomass feedstocks more efficient (Anon 2000). Torrefaction technology is however not yet commercially available.

3.2. Liquids

The terms biodiesel, bio-alcohol or biofuel do not appear in the IBC code. However, as ethanol and biodiesel are considered as noxious liquid substances they fall under the purview of MARPOL Annex II and the IBC Code (see chapter 2.1.2).

3.2.1. Ethanol

Ethanol (ethyl alcohol) is a colorless liquid. It can either be produced as a petrochemical, through the hydration of ethylene, or biologically by fermenting sugars with yeast. Crops and feedstock's containing sugar (i.e. sugarcane, sugar beet), starch (i.e. maize, wheat) or cellulosic materials (i.e. woody materials) can be used as basic raw materials for the production of ethanol. Today it is primarily used as a transportation fuel, either in pure form (E100) or mixed with petrol in all blends. Anhydrous ethanol (ethanol with less than 1% water) has a heating value of 28,900 kJ/kg and at 15°C it has a density of 794 kg/m³.[8]

Ethanol is listed in chapter 18 of the IBC code as a mild pollutant and not a safety hazard, thus transporting by chemical tanker is not required. However, it has a low flashpoint requiring explosion proof equipment[9]. A complication is that ethanol absorbs water from the atmosphere, and to stop this occurring there is a current provision for a nitrogen blanket in the tank. Nitrogen is usually supplied from shore before the cargo is loaded in the tanks and is kept topped up by nitrogen tanks on the vessel. For a vessel of Aframax (80,000-120,000 DWT) or Panamax (60,000-80,000 DWT) size, this may be a limiting factor. Ethanol should be carried in tanks coated with dedicated tank coatings such as phenolic epoxy or zinc silicate.

3.2.2. Biodiesel

Biodiesel is a type of biofuel that is produced by processing vegetable oils or animal fats. In the transesterification process the triglycerides of vegetable or animal fats and oils are broken and the glycerol is replaced by another alcohol, usually methanol. The properties of biodiesel are similar to conventional fossil diesel fuels but depend on the raw material. Rapeseed and soybean oils are most commonly used as feedstock. According to EN 14214 the heating value of biodiesel has to be higher than 37,100 kJ/kg and the density (at 15°C) has to be in the range of 860 to 900 kg/m³.

According to Strode 2008 Biodiesel (more precisely palm oil fatty acid methyl ester, coconut oil fatty acid methyl ester and rapeseed oil fatty acid methyl ester) is listed in chapter 17 of the IBC code. Ships carrying biodiesel must follow the requirements for design, construction, equipment and operation of ships contained in the Code, therefore ships of type 2 are required.

For transport and storage, most tanks designed to store diesel fuel will store pure biodiesel (B100) without any problems. Aluminum, steel, fluorinated polyethylene, fluorinated polypropylene, Teflon, and most fiberglass are well suited storage tank materials. Similar to the transport of petroleum diesel, biodiesel must be transported in a way that does not lead to contamination. Also, procedures must be used in storage and handling that prevent the temperature of B100 from dropping below its cloud point. The cloud point of biodiesel, the ambient temperature, and the time the

[8] Kosaric N. et al.: "Ethanol", Ullmann's Encyclopedia of Industrial Chemistry, Wiley-VCH Verlag, Electronic Release, 2002

[9] Biofuels and their effect on the Shipping Industry- 2008- Richard Sadler CEO Lloyd's Register

fuel is in transport should all be considered when transporting B100 to ensure that the fuel does not freeze.[10]

3.2.3. Vegetable fats and oils (palm, soya oil, rape)

Vegetable fats and oils are lipids that are extracted from oilseeds or the oil fruits of plants. The most important plants for the production of vegetable oils are soy, rape (canola), sunflowers and oil palms. Subsequently the most important vegetable oils are soybean oil, rapeseed oil, palm oil and sunflower oil. As fats and oils have a high heating value (36,000 to 40,000 kJ/kg) they easily can be used as renewable fuel for transport and for producing renewable energy in power plants.

Vegetable fats and oils contain ~ 97% triglycerides (trimesters of glycerol with fatty acids) that contain at least two different fatty acid groups. The chemical and physical properties of fats and oils are determined mainly by the molecular structure of the triglycerides, or more precisely by the type of fatty acid groups and their distribution over the triglyceride molecules. The melting point generally increases with increasing proportion of long chain fatty acids or decreasing proportion of short chain or unsaturated fatty acids. Fats with a low proportion of unsaturated fatty acids are solid at ambient temperature whereas oils are liquid at ambient temperature because of their high proportion of unsaturated fatty acids. The melting point of vegetable oil ranges between -15 to -8°C in the case of soybean oil and 36 to 40°C in the case of palm oil.

Handling during transport and storage has a decisive influence on the quality of the vegetable fats and oils. Therefore some precautionary measures have to be observed. Impurities (seed particles, cell fragments, proteins) should be removed by sedimentation, filtration or centrifugation to avoid hydrolisation and the growth of micro organisms. The crude oil should be dried to less than 0,2% moisture and the storage temperature should not be more than 10 to 15°C above the melting point. Frequent pumping should be avoided to prevent saturation of the oil with air and consequent autoxidation. As fully refined oils (raffinates) often have lower oxidation stability than the crude oils, they have to be protected from air, but also from light, moisture, relatively high temperatures and trace metal prooxidants if they are to be transported for long distances or stored for long periods.[11]

3.2.4. Bio-oil

Bio-oil (pyrolysis oil or wood oil) is a dark-brown, free flowing liquid fuel that is derived from plant material. It is not "oil" like a petroleum oil because it contains about 25% water. It can be stored, pumped and transported like petroleum products. It has a density of 1.2 kg/litre, and heating value 16-19 GJ/tonne, giving it approximately 55% of the heating value of diesel on a volumetric basis and 45% on a weight basis

Bio-oil is not dangerous but it is acidic, with pH 2.2-3 compared with diesel at pH5. It is combustible but not flammable, ignites and burns readily when properly atomized, and once ignited burns with a stable, self-sustaining flame[12]. It is flammable at extremely high temperatures. Bio-oil is very stable but is not a homogeneous liquid. If left standing for long periods (months), lignin will eventually precipitate into a viscous bottom layer, however it can be stirred back into the bulk with slow-speed agitation.

[10] "Biodiesel Handling and Use Guide (Fourth Edition)", National Renewable Energy Laboratory, 2008
[11] Alfred Thomas: "Fats and Fatty Oils", Ullmann's Encyclopedia of Industrial Chemistry, Wiley-VCH Verlag, Electronic Release, 2007
[12] Overview of Applications of Biomass Fast Pyrolysis Oil- Jan 2004, S. Czernick and A.V. Bridgwater

With a pour point of -15°C bio-oil can be stored below freezing, but recommended storage is with frequent agitation, insulated, and heated to 10°C. The acidic and thus corrosive nature of bio-oil means that physical enhancements are required for storage and transportation. Storage vessels and piping should be Stainless 304, 316, HDPE, EPDM, PVC, Teflon or like substance. Layering of bio-oil is not an issue for short-term transportation and storage. Neither trucks, nor rail, nor shipping are required to have mixing capability. Mixing capability in customer storage tanks is easily arranged with existing tanks. To prevent contamination, shipping vessels should have specialized compartments.

Bio-oil transportation has an advantage over fossil fuels. If a ship containing fossil fuel sinks or otherwise causes a spill, petroleum will spread over water in a thin layer over a wide area with major environmental consequences. Bioil does not spread, but separates into a very heavy organic fraction that will sink and is largely inert[13], and an aqueous fraction that will be diluted and is very bio-degradable.

4. CURRENT BIOMASS SHIPPING LANES

The chief biomass energy products shipped by ocean include wood pellets, wood chips, ethanol, and palm oil. Wood pellets are shipped primarily from Canada, the US and the Baltic countries to western and northern Europe; raw wood chips are shipped from the Baltic to Western Europe for energy (and Brazil to Canada for pulp); ethanol is shipped from Brazil to the US, Europe, and the Far East; and palm oil is shipped from Malaysia and Indonesia to Europe, as shown in Fig 4.1

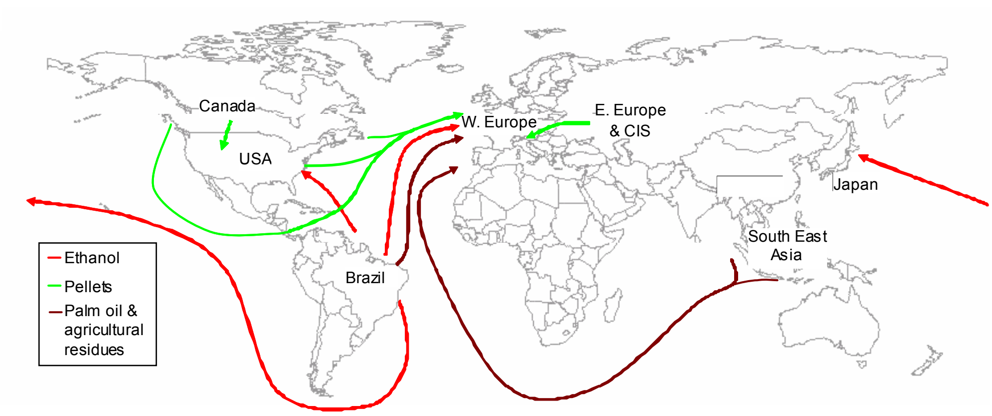

Fig 4.1 World Biomass Shipping

4.1. Wood pellets

Wood pellet trade data is notoriously hard to find and is often inaccurate. The latest year of available data is 2007, though 2007 is not regarded as a normal year because of spill over from the shortage of supply in 2006. In 2007, 8.78 million tonnes[14] of wood pellets were produced worldwide; 6.15 million tonnes in Europe, 1.4 million tonnes in Canada, and 1.2 million tonnes in the US. Europe consumed approximately 7.0 million tonnes. Much of European production was either used in the country in

[13] Dr. Tony Bridgwater, Aston University, Birmingham
[14] John Swaan- Executive Director Wood Pellet Association of Canada- Ottawa Oct 2008

which it was produced, or was transported by land routes. Approximately 2.4 million tonnes of wood pellets were shipped by ocean freighter.

- Canada exported 740,000 tonnes; 500,000 tonnes to Belgium, Netherlands, Sweden & Denmark and 110,000 tonnes to Japan
- Latvia exported 300,000 tonnes, and since most Latvian pellet plants are owned and operated by Swedish companies, most went to two Swedish companies with good port facilities with minor amounts likely to the Netherlands and Belgium
- Estonia exported 212,000 tonnes, probably all to Denmark since most of the Estonian capacity was owned by Danish stakeholders
- Finland exported 186,000 tonnes[15]; 78,000 to Sweden, 39,000 to Belgium, 30,000 to Denmark, 30,00 to the Netherlands
- Sweden exported 130,000 tonnes, some bulk exports to the UK from plants in northern Sweden, and some bagged in southern Sweden and shipped to Denmark.
- Lithuania exported 110,000 tonnes, probably to the Netherlands and Belgium
- Russia exported 47,000 tonnes to Sweden
- Norway exported 30,000 tonnes to Sweden in bagged form for small scale use

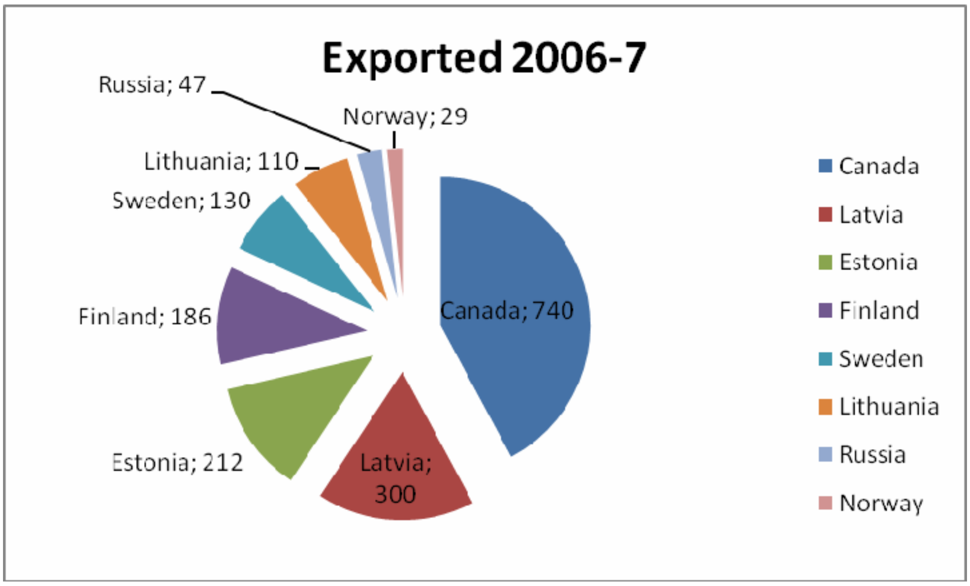

Figure 4.2- Pellets Exported 2006-07

Major ports and destinations for wood pellets include;

Vancouver to Antwerp-Rotterdam-Sweden: In 2007 Canada produced 1,485,000 tonnes of wood pellets from 26 plants. 495,000 tonnes were exported to the US, primarily by train, and 740,000 tonnes were exported by large ocean-going vessels to Europe; 500,000 tonnes to Belgium, 100,000 tonnes to the Netherlands, 130,000 tonnes to Sweden, and a small amount to Denmark. All 740,000 tonnes came from the port of Vancouver in BC through the Panama Canal. This is a well established shipping lane. There is a 100,000 pellet mill in Nova Scotia that exports to Europe from the port of Halifax, but the pellet mill shut down for some months in 2007 following the closure

[15] Finnish Country Report 2008

of the adjacent sawmill. Enligna of Germany bought the mill in 2008 and has renewed exports.

Vancouver to Japan-China-Korea: Canadian pellet producers shipped 110,000 tonne pellets to Japan in 2007, and expect exports to reach 400,000 tonnes. Owing to shortage of coal to make power to support the tremendous growth in Chinese industry, many private Chinese energy companies are interested in securing pellets as an alternative fuel.

Panama City (Florida, US) to Antwerp-Rotterdam: In 2006 the US had 60 pellet plants producing 800,000 tonnes pellets, essentially for domestic use. New pellet plants are now being built in the US South East for export. Green Circle Bio Energy completed a 560,000 tonne mill in Cottondale Florida and began production in May 2008, 2 years later than plan. Production is expected to reach capacity in spring 2009. Green Circle plans to build more such plants, but only if prices are projected to be high enough, since the feedstock is now more-costly roundwood rather than the free sawdust originally envisioned. It exports by the deepwater port of Panama City Fl. Customer data is confidential, but none goes to Sweden, in all likelihood going to Belgium and Netherlands.

St. Petersburg and Archangel to Swedish ports: Uncertain statistical information reports that Russia produced 500,000 tonnes pellets in 2007. 47,000 tonnes were exported to Sweden by way of St. Petersburg. However, despite its potential as a pellet producer, Russia has proved a most unreliable exporter. Russian ports have not had investments required to support efficient loading, nor have plants received the investment to keep costs competitive. Russia will not be a pellet export actor unless drastic changes in these basic conditions occur.

Finnish ports to Sweden-Antwerp-Rotterdam: Exports from Finland peaked at 195,000 tonnes in 2006, of which 78,000, or 40%, went to Sweden. The remaining exports were likely to be fairly evenly split between Denmark, Netherlands and Belgium. Since 2006 exports from Finland have declined to approximately 186,000 tonnes, though the destination is unknown.

Latvia-Estonia-Lithuania to EU: In 2006 these three countries exported approximately 620,000 tonnes pellets, of which 150,000 went to Sweden. These countries are suffering from reduced supply of wood and exports will fall accordingly.

4.2. Wood chips and other raw biomass

Wood chips and particles are traditionally used for the production of pulp and paper. With increasing demand for bioenergy, a larger proportion of wood chips are likely to be used for energy purposes. Canada is the world largest producer of wood chips and particles, followed by China, Russia and Australia. As shown in Table 4.1, Australia is the world's largest exporter of wood chips, followed by South Africa, Chile and US. Japan is by far the largest importer. Table 4.1 shows the production, import and export quantities of the main actors in 2006.

Table 4.1 Production, export and import and wood chips and particles 2006 in 000 m^3 roundwood equivalents. Source: FAO Stat (http://faostat.fao.org)

Country	Production	Exports	Country	Import
Australia	16,613	10,610	Japan	19,011
South Africa	12,950	5,822	China	3,285
Chile	7,681	4,690	Finland	2,287
United States	3,000	3,533	Canada	1,993
Germany	3,320	3,253	Italy	1,794
Latvia	3,215	2,676	Sweden	1,555
China	24,008	1,273	Austria	920
Canada	75,363	1,222	United States	897
Russia	20,400	1,150	Germany	744
France	5,690	671	Spain	635
Sweden	12,500	548	France	469
Austria	4,897	401	Latvia	26
Thailand	2,080	322	Russian	3
Finland	9,321	139	Australia	1
Italy	530	1	South Africa	1
Japan	4,435	1	Chile	0
Spain	3,919	1	Thailand	0
Total Above	**209,922**	**36,313**	**Total Above**	**33,621**
World	230,889	45,959		40,149

As seen by Table 4.1, the major importer of wood chips and particles is Japan with about 50% of the trade. Table 4.2 shows countries exporting to Japan, China and Finland.

Table 4.2 Major trade flows for wood chips. Source: FAO Stat (http://faostat.fao.org)

To Japan from	Australia	South Africa	Chile	Viet Nam	United States of America	China	Malaysia	Uruguay	Canada	B
	9 500 100	2 311 300	2 099 818	974 711	892 126	737 748	716 605	698 725	631 903	560
To China from	South Africa	Viet Nam	Australia							
	1 428 830	656 262	636 972							
To Finland from	Russian Federation	Latvia	Estonia							
	783 264	668 044	621 710							

4.3. Vegetable oils

4.3.1. Palm Oil

Palm Oil is shipped largely as a food product, but some is shipped for energy. Indonesia and Malaysia together are the largest producers and exporters in the world. In 2007-08, 12.7 million tonnes palm oil were shipped from Malaysia and 13.6 million tonnes from Indonesia[16]. 5.5 million tonnes went to China, 4.9 million tonnes to the EU, 4.1 million tonnes to India, and 11.6 million tonnes to other countries. The Netherlands imported 840,000 tonnes for co-firing in coal power plants in 2006[17]. However, following concerns about sustainability of palm oil production the Dutch government withdrew significant feed-in-tariffs for power production from bio-oils including palm oil and in 2007 palm oil imports for energy collapsed. Essent, for example, imported 400,000 tons in 2006, none in 2007-08, and now palm oil is not in their fuel portfolio. In 2007-08 the price of palm oil almost tripled from a low of $500 US/ton starting in 2007 to reach $1300 US in 2008, effectively making palm oil uneconomic for energy. Prices have dropped to the $500 level again, however this is near the breakeven point for palm oil for energy in the Netherlands. It is projected that less than 150,000 tons will now be imported by the Netherlands for energy.

Palm Oil export ports include Port Klang, the designated hub port in Malaysia, and Pasir Gudang, the largest palm oil port in Malaysia.

4.4. Liquid biofuels

4.4.1. Ethanol

Brazil dominates world trade in ethanol, as shown in Table 4.3. Of 3.75 billion litres (Bl) in exports in 2006, Brazil exported 3.51 Bl. By destination, in 2005 Brazil exported 2,598 million litres (Ml); 500 Ml to the EU, 414 Ml to India, 318 Ml to Japan, 261 Ml to the US, 75 Ml to Korea, and over 1000 Ml to other destinations.

Most ethanol is exported from the ports of Santos (state of São Paulo; smaller vessels), São Sebastião (state of São Paulo) and from the terminal Ilha D'Água (state of Rio de Janeiro). The last two terminals are operated by PETROBRAS. There are also regular shipments from Paranaguá (state of Paraná) and Maceió (state of Alagoas, in Northeast). Some Brazilian ports cannot operate with large crude oil tankers and in this case MR1 and MR2 ships are mostly used (up to 55,000 DWT). Santos, the main Brazilian port, isn't deep enough for large vessels and smaller tankers will be used there for many years. There are two terminals close to the main ethanol producer area in which Suezmax and VLCC (very large crude carriers) can be fully loaded, and in this case the capacity varies between 130,000 and 300,000 DWT.

Currently, there are investments taking place in ports and ducts. For instance, PETROBRAS, the Brazilian oil company, is making investments and intends to have and operate ships exclusively for ethanol.

[16] FAPRI
[17] Netherland Country Report 2008

Table 4.3 Ethanol Trade (million litres)

				Brazil Exports
Net Exporters	**2006**	**2007**	**2008**	**2005**
Brazil	3,511	2,450	2,722	2,598
China	158	29	20	
ROW	88	66	58	
	3,757	**2,544**	**2,799**	
Net Importers				From Brazil 2005
European Union-25	-268	-469	-489	-509
India	-447	-576	-556	-414
Japan	-649	-744	-790	-318
South Korea	-282	-319	-339	-75
United States	-2,571	-896	-1,084	-261
	-4,217	**-3,004**	**-3,258**	**-1,577**

4.4.2. Biodiesel

Table 4.4 outlines biodiesel trade in 2007[18]. The largest net exporter was the US at 416 Ml, with Indonesia exporting 325 Ml and Argentina 227 Ml. The largest importer was the EU at 451 Ml, with 255 Ml going to Japan.

Table 4.4 2007 Biodiesel Trade (Million litres)

Net Exporters		**Net Importers**	
Argentina	227.2	European Union	451.1
Brazil	-1.5	Japan	254.7
Indonesia	325.5	ROW	398.5
Malaysia	137.5	Net Imports	1,104.3
United States	415.6		
Net Exports	1,104.3		

4.4.3. Pyrolysis Oil

Pyrolysis oil is not currently shipped by ocean transport. Ensyn and Dynamotive Energy Systems of Canada transport all production overland by truck and rail to both Canadian and US customers. Several European power producers are interested in Pyrolysis oil as a fuel, and ocean transport routes are surmised from Ontario and Quebec to the UK, Rotterdam, and Germany.

[18] Food and Agricultural Policy Research Institute -2008

5. SHIPPING CAPACITY

5.1. Current shipping capacity

As shown earlier, world shipping volumes have grown at a more rapid pace than world economies. World shipping capacity increased almost 5% annually 2004-07, however even this capacity growth was not sufficient to handle demand. In 1990, 9.7% of capacity was surplus to needs, as shown in Table 5.1. However, surplus tonnage had slipped to 2.2% of the fleet by 2000, and to 0.7% by 2004-05, indicating that world shipping was operating at essentially full capacity. Under these conditions, prices tend to spiral out of control, which they did in 2006-7 as shown in Section 7.

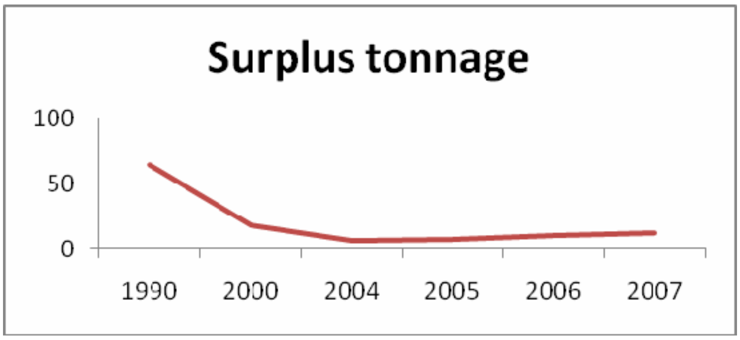

Fig 5.1. Surplus tonnage- World Shipping

Table 5.1. Tonnage Oversupply in the World Merchant Fleet- Selected Years

	1990	2000	2004	2005	2006	2007
World Merchant Fleet	658	808	896	960	1042	1118
Surplus tonnage	64	18	6	7	10	12
Surplus % of total	9.7%	2.2%	0.7%	0.7%	1.0%	1.1%

Based on 5 years of booming manufacturing and shipping, considerable planned new shipping capacity was put on the order books. The order book for container ships now is half of the container-shipping fleet[19]. 2008 began an unprecedented collapse in shipping demand. While in early 2008 an article branded the shipping industry as not prepared for a biofuels future[20], by year end capacity far exceeded demand. DVD Bank predicts a surplus of over 500 Panamax tankers by 2011[21], assuming that all vessels over 25 years (290 ships) will be scrapped over the next four years and that 19% of the Panamax order book will be cancelled. In its market outlook DVD Bank states that with an estimated 16% fall in utilization between 2009 and 2011, freight rates will hover around $10,000 per day, well below breakeven for ship owners that bought their assets in boom years. For a $20 million Panamax bought in 2002-03, breakeven is about $11,000 per day, assuming 100% financing for 15 years at 6%. Ship owners that are faced with considerable losses may scrap older tonnage[22].

[19] DVD Report, Tradewinds, Article 531825
[20] “Shipping industry not prepared for a biofuels future”, Karen Remo-Listana, Emirates Business 247
[21] “Bulker Bulge”- Tradewinds- Article 533406
[22] UNCTAD press release- 2008-44

5.2. Obstacles and barriers to shipping biomass

5.2.1. World Demand for shipping

In the 2006-08 period manufacturing growth in developing countries such as China, and the subsequent demand for ships to move raw materials to these countries and manufactured goods from these countries caused shipping prices to spiral out of control. For short distance transport, such as from the Baltic to Sweden, sharp increases in prices may not be a major factor. However, for long-distance transport, such as from Canada to Europe or Australia to China, where shipping is a major component of landed cost, major shipping price increases may be sufficient to cause a source of biomass supply to drop completely out of the market. In BC, many exporters were only able to sustain exports by having already arranged 3-5 year fixed shipping price contracts[23].

5.2.2. Reliability of Biomass Supply

A major obstacle to growth in trade is reliability of supply, for example pellet exports from Russia, Chile and the US. Russia, despite its huge supply of biomass in the northwest region, suffers from a number of drawbacks that together result in a production and trade malady: a large, difficult-to-understand bureaucracy, a stumbling business structure, lack of investment, language problems, safety and comfort in business dealings, 6-month winter, lack of trust in normal business dealings etc. All these prevent Russia from becoming a major factor in trade of pellets[24]. Russia also implemented a massive tariff increase on the export of sawlogs to Northern Europe that caused a reduction of 10 million m^3 to sawmills around the Baltic Sea[25] and a shortage of pellet raw material. As a result a large portion of the pellet production capacity in Estonia and Latvia has gone bankrupt[26].

5.2.3. Port inadequacies

Many prospective ports lack the upgraded port facilities needed to keep costs down and make long-distance trade possible. For example, both St. Petersburg and Archangel in Russia lack the investment needed for cost-efficient handling and loading. This issue combined with other supply chain difficulties result in no new production coming out of Russia. Supply is undependable.

Chile has plans to be a producer of 2-3 million tonnes of biomass annually, targeting Japan and China as markets, but low profitability in pellet manufacture has slowed interest in investing in the handling and port facilities needed to accommodate these volumes.

Vancouver is a major port that recently added the new Kinder Morgan pellet terminal to complement the existing Fibreco terminal. The new terminal can accommodate 1 million tonnes pellets and is expandable to 2 million tonnes. It has advanced systems for removing pellet dust in loading, but does not have a movable shipper-loader, so the ship must move to even the load. Fibreco added wood pellet handling to its business in 2005 and over 3 years constructed pellet storage silos, installed tripper-style conveyors with a full length enclosure, and modified the ship loader to allow more effective delivery of pellets to vessels. However, despite port

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[23] John Swaan, President Wood Pellet Association of Canada
[24] Anonymous Swedish biomass traders
[25] Comments
[26] Bo Hektor, First Energy, Stockholm

improvements to handle the growth in BC pellet manufacturing capacity, many transportation issues can yet be improved. For example[27]:

- The rail system is a monopoly and is currently at capacity. Pellets sometimes wait days to get into the terminal
- In BC grain cars are used to transport pellets, but are not optimized for pellets. Inability to spread the load often results in 20% open space in each car, raising the cost of transport.
- The port is heavily unionized and human tasks suffer accordingly. Union members will walk off the job to attend a meeting
- Vancouver is a rainy city, and you cannot load in the rain
- When conveyors break down ships will often not wait, even for minor repair
- There is often a lack of necessary communication between ships and loading staff

While the UK has not been a wood pellet importer in the past, new project development by power companies such as EOK-UK and Drax will result in the UK joining other companies as major pellet importers. Some of the ports that serve the power companies cannot handle Panamax ships, and smaller ships will mean higher cost delivered pellets. Only a few utilities in Europe can be directly served by Panamax ships.

5.2.4. Lack of efficient back haul

Competitive shipping rates often depend on shipping companies arranging 2-way flow of products. This is often impossible and ships return empty, thus placing the costs of a 2-way trip on one cargo.

5.2.5. Idiosyncrasies of the shipping business

The shipping business does not always lend itself well to optimized biomass transport. For example, pellet quality product is critical to buyers, yet shippers are sometimes more concerned about loading fast and getting out than preserving quality. Sometimes quality suffers due to poor instructions, training and control[28]. Despite the best estimates of arrival times, there are many factors, such as heavy weather or late departures from previous ports that play havoc with loading and shipping schedules. Despite an era of computerized manufacturing optimization programs, shipping remains largely a manual business[29]. Shipping tends to have a floor price, below which it is more profitable to scrap an old ship than keep it running, thus reducing shipping capacity. For example, the shipping cost for pellets Vancouver-Rotterdam has fallen from $100/tonne to $35/tonne. The floor price for scrapping, not including fuel and staffing cost, is $21US/tonne[30].

5.2.6. Uncertainty of biomass feedstock costs

Pellets have traditionally been manufactured from sawmill and pulp mill residues that are a by-product of lumber and pulp manufacture, and could be acquired at virtually no cost. In the last 2-3 years increases in bioenergy development, and major reductions in lumber and pulp production in many regions, such as Canada, the US, and South Africa, have resulted in formerly free residue becoming a rare commodity commanding significant prices. The next lowest cost feedstock is usually forest harvest residue and standing energy wood, both of which cost significantly more

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[27] Bas Verkerk, Control Union, Vancouver, BC
[28] Bo Hektor, First Bioenergy, Stockholm
[29] Bas Verkerk, Control Union, Vancouver BC
[30] Bo Hektor, First Bioenergy, Stockholm

than mill residue. For example, the US South-East has been planning major investment for the pellet export market, estimated at 2 million tonnes, but the collapse of low-cost mill residue availability has caused many projects to be delayed. Feedstock is now almost totally more-expensive roundwood. Approximately 500,000 tonnes of pellets are projected to be exported in 2008, but other projects await higher pellet prices and higher oil prices. Slower development may mean that pellet production will be drawn to domestic markets instead of exports.

5.2.7. Product characteristics

Pellets are not dense and thus are lighter per unit volume than other commodities. Panamax ships designed for ore will not take a full load of pellets as it affects ship handling. Of 7-10 holds per ship, only 3-5 will be filled with pellets with the rest filled with heavy products. The remaining pellets must wait for the next ship. Special ships designed for grain and pellets do not pose this problem.

Pellet manufacturing plants sometimes run at overcapacity to meet demand, and in some cases pellet quality deteriorates. Pellets crumble more easily, increasing the risk of pellet dust, which occasionally causes fires in conveyor systems. Dust capture systems are required.

Pyrolysis oil (BioOil) is acidic and requires non-corrosive materials for tanks. It has yet to be transported on ocean ships, though it is successfully being transported by truck and rail. Chemical transport ships will suffice, but they tend to be small and thus more costly. BioOil is twice as energy dense as wood pellets, but if it is to be successful as a long-distance ocean-transport biofuel and competitive with pellets, a way must be found to transport the product in larger ships.

6. FUTURE BIOMASS SHIPPING

6.1 Major exportable biomass sources

6.1.1. Canada

Canada has one of the largest forestry industries in the world and thus is one of the largest sources of woody biomass. In addition, the Mountain Pine Beetle infestation has resulted in the Province of BC releasing vast amounts of wood for energy. Canada resembles the US in its market-oriented economic system and it has a reputation for ease of doing business. There are few of the obstacles that one finds in biomass supply in developing countries. Despite a major downturn in the US housing market caused by the sub-prime crisis, there is still substantial available biomass. There are two potential zones for biomass exports; the west coast and the St. Lawrence River on the east coast.

The west coast of BC serves the BC interior with the ports of Vancouver and Prince Rupert. As a result of the BC government raising annual allowable cuts to exploit Mountain Pine Beetle wood before it deteriorates, BC has almost 9.3 million BDt of harvest residues and 1.7 million BDt of standing MPB timber available annually. After recovery of the US housing market, BC will have 550,000 BDt of mill residue also. The total available in BC is 11.5 million BDt annually. Perhaps 5 million BDt will be used for domestic heat and power, and 6.5 million tonnes will be destined for export.

Overseas exports of pellets are projected to grow from 740,000 tonnes in 2007 to 2 million tonnes by 2010-11.

The St. Lawrence River has the ports of Quebec City and Saguenay. The export zone has 577,000 BDt of mill residue long term, 2.2 million BDt of hog fuel in heritage piles, 2.9 million BDt harvest waste, mostly sitting at roadside, and 5.8 million BDt standing non-commercial timber. The total available is 11.5 million BDt annually, perhaps 4.0 million BDt destined for domestic heat and power, and 7.5 million BDt for export.

6.1.2. US

The US South East is making a major move to be a pellet supplier, led by Green Circle. This company has built the world largest wood pellet plant with a capacity of 560,000 tonnes. The plant is located in Cottondale Florida, 93 km from the deep-water port of Panama City. The plant began production in April 2008 and is expected to reach full production in 2009. The feedstock is Pine wood from sustainable plantations in South Eastern USA. Additional plants are being planned.

In the US South all wood residuals are currently used. There are an estimated 30 million tons (27 million tonnes) of forest slash, however practical volumes are estimated at 3-5 million tons p.a.[31]. Only 1% of this is used now. New pellet plants are projected to use other slash or pulp wood.

6.1.3. Brazil

Brazil is the world leader in both ethanol and sugar cane production. About half of Brazil's sugar is used to manufacture ethanol, and half is for sugar production. As shown in Table 6.1, in 2006 205 million tonnes sugar cane was used to make 18 billion litres of ethanol, of which 3.5 billion litres was exported. Sugar cane production for ethanol is projected to increase 24% by 2012, and 45% by 2016. Ethanol exports are projected to reach 4.8 billion litres by 2016.

Table 6.1. Brazil Biomass Availability

	2006	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2016**
Cane (M tonnes)[1]	205	213	219	227	236	245	254	298
Ethanol Production (Bl) [1]	18.0	18.8	19.5	20.4	21.4	22.4	23.5	28.5
Ethanol Export (Bl) [1]	3.5	2.4	2.7	2.9	3.2	3.6	3.8	4.8
Bagasse (M BDt) [2]	7	15	25	25	26	27	27	
Trash (M BDt) [2]	26	27	31	32	32	33	33	

1. Food and Agricultural Policy Research Inst- 2007
2. European Market Study for BioOil Dec 2006

In sugar cane 30% of the chemical energy is in the sucrose, 35% is in the residue from processing cane (bagasse) and 35% is in the leaves and tops left in the field (trash). Both bagasse and trash are biomass sources for energy. Bagasse production in 2005 was 117.6 million tonnes at 50% moisture, and trash 69 million tonnes at 15% moisture. Most of the bagasse is burned in sugar and ethanol plants to provide heat for industrial processes, however it is burned inefficiently. Through ordinary actions on steam savings and investments in efficiencies it is possible to achieve a surplus of 20-30% of the bagasse. Combined with the increases in sugar cane production, and

[31] Peter J. Stewart, Forest2Market Inc., North Carolina

estimated 27 million BDt bagasse and 33 million BDt trash could be available for energy by 2012[32], though this would have to be densified for long-distance transport.

6.1.4. Rest of Latin America: Argentina, Chile, Paraguay, Bolivia

Argentina has a sizable sawmilling industry. In 2002 there were 1.1 million hectares of plantation forest and 32 million ha of native forest, with 2,230 sawmills processing 94 million m^3 of wood[33]. Using industry conversion factors, this processing volume yields approximately 4-5 million tonnes of wood waste, completely unused in 2002. It has been recently estimated that there are several million tonnes of waste forestry biomass on rivers within barging distance of major ports. It is possible that Argentina can become a major exporter of wood pellets or bio-oil now, or when 2nd generation biofuel technologies proliferate; they may become major exporters of bio-ethanol and biodiesel.

Chile has a major forest products industry and is South America's most export oriented forest industry. Pulp & paper is the more important sector, but sawmills consume most of the roundwood. Chile intends to build an export-driven pellet industry using fast growing plantations as a feedstock. Andes Bio Pellets commissioned a 40-60,000 tonne plant in 2006. In 2007, Chilean production was 60,000 tonnes but only 20,000 tonnes were exported[34]. The selling price of pulp and the existing transportation infrastructure support pulp exports even though the state of the ports is poor. However, it is not currently economic to manufacture pellets and export great distances without newer port facilities. Chile may become a source for biofuels when 2nd generation biofuel technologies become more commercial.

Paraguay and Bolivia have also been earmarked as suppliers of ethanol and biodiesel in the future[35].

6.1.5. South Africa

In 2006 South Africa had an estimated 8.8 million BDt of sugar cane residue and bagasse available for energy and 1.7 million BDt of bark and sawdust from the forest industry[36] in the two provinces closest to the port of Durban. South Africa set a renewable energy target of 10,000 GWh, and a subsequent framework set targets for power production from IPPs and the state energy company Eskom, excluding cogen. However, progress was slow due to lack of financial enabling mechanisms. In 2007 a Pilot National Cogeneration Program (PNCP) inaugurated a call-for-interest to produce power from cogeneration, and by Jan 2008 there were 5000 MW proposed, but whether these projects would be built is in question. In Dec 2008 a Feed-in-tariff was proposed[37] but power generation from biomass was excluded since it was part of the PNCP. It is likely that opportunity exists for development of exportable biofuel products

6.1.6. Malaysia and Indonesia

Already the world's largest palm oil producers, these countries are projected to achieve major increases in production; Malaysia 27% over five years, and Indonesia

[32] European Market Study for BioOil 2006
[33] The First Hewsaw to Argentina, Dario Rodriguez
[34] Global Wood Pellet Markets- IEA Bioenergy 2007
[35] "Biofuels and their Effect on the Shipping Industry"- Stanley Grey Lecture, April 23, 2008
[36] European Market Study for Bio-oil (Pyrolysis Oil)-2006, Douglas Bradley, Climate Change Solutions
[37] Nersa consultation paper- Dec 2008

21%[38]. Indonesia already exports to over 100 countries, mostly as a food. In Malaysia there is vast development in the regions of Sabah and Serawak. In Indonesia the producing regions are Sumatra, Kalimantan, Sulawesi and Papua. Malaysia's largest markets are China (25%), EU (13%), Pakistan (8%) and the US (7%), trans-fatty acid labelling in the US since 2006 continues to spur a major increase in palm oil usage in the US and this will continue to develop as a trade route.

In the future, sales in Western Europe may face a serious obstacle as the EU will require crude palm oil (CPO) to be certified sustainable as of 2010. To be certified CPO must pass an environmental test to prove whether or not it can reduce GHG emissions by as much as 35%. To-date only one of approximately 300 lists producers has passed the test.

6.1.7. Russia

The Russian federation has 23% of the global growing stock of forests and 50% of the coniferous forests. Annual fellings account only one quarter of allowable cut. Even if lack of infrastructure limits the share of economically accessible timber, Russia exported 49 mill cubic meter of wood in year 2007 (roundwood and chips) and in 2007 was the world largest net exporter of wood (FAOSTAT 2009). To encourage foreign investments, Russia increased export duties that limit the economic feasibility of wood export. The implementation of increased duties has however been postponed. Russia is likely to be an important exporter of biomass and biofuel in the future.

6.2. Important Future Shipping Routes

6.2.1. Wood Pellets

Vancouver to UK: The UK has not been a major importer of wood pellets, but incentives by the UK government to develop renewable power have caused major power companies both to increase co-firing and also to plan 100% biomass power plants to use a number of different biomass feedstocks. An example is EON-UK's Lockerbie power station, which will need 500,000 tonnes biomass[39]. Drax also looks to increase co-firing at it's Selby power station, with the import point being Immingham on the Humber, near to Selby. It is anticipated that volumes of pellets in the range of 1 million tonnes annually with be needed in the UK.

Quebec ports to Europe: In Canada, investors in the province of Ontario have signed agreements to build 6 new pellet plants to produce 1 million tonnes of pellets by 2011, but this will not likely be exported. To comply with a deadline to stop producing power from coal by 2014, Ontario Power Generation issued a notice indicating a need for 2 million tonnes of biomass to replace coal in three power stations. It is anticipated that Quebec will see 1 million tonnes of pellets manufactured by 2012. The domestic residential market for pellets will continue to grow, but slowly. Some may be sold into the New England States, but with bioenergy incentives in the EU it is likely that 1.5 million tonnes will be destined for the EU. The most likely port will be the Grande-Anse terminal at port of Saguenay, a 13 metre deep year-round port on the Saguenay River used by the pulp & paper industry, which can handle 100,000 tonne vessels. There is also the port of Quebec, and smaller ports at Trois-Rivières and

[38] FAPRI
[39] Philip Wallace, EOK-UK, presentation Warwick UK, Sept 2008

Rageneau. Since these ports will handle only smaller ships, it is likely that the prime destination will be the UK, where northern ports cannot handle super-large ships.

Vancouver to China: China has not been a pellet importer until recently. Due to the huge demands for power in the burgeoning economy, private power producers which have had difficulty acquiring consistent shipments of coal are now considering pellet imports, not so much as a renewable energy source, but an available energy source. As the Vancouver-Japan route has been established, Vancouver-China will likely follow.

Chile to China and Japan: Chile is a major softwood pulp producer and had plans to develop into a pellet supplier also. They have 3 plants, but there have been management difficulties and feedstock supply problems. There is the potential for 2 million tonnes of pellets for export, likely destined for China or Japan. There is a need for specialized handling and storage facilities, which need investment.

Brazil to Europe: While this route will continue and expand for ethanol, pellets are not a topic amongst planners, despite the biomass conversion opportunities in bagasse and trash. This will only become a pellet route if pellets are in short supply in Europe.

Australia to China: Three pellet mills are planned near Eucalyptus plantations in Queensland, with the intent to manufacture pellets for China. This could develop into an important trade route. During the recent economic boom in China, energy companies were unable to get assured supply of coal, and thus were interested in acquiring biomass[40].

Russia to Europe: Russia claims to have production of 500,000 tonnes pellets and has large potential for volume increases for a hungry European market. Whether Russia can develop these resources, manufacture a quality pellet, and deliver it competitively to Western markets is still open to question.

Norway to Europe: A pellet plant with annual capacity of 450 000 tonnes is under construction at the west coast of Norway. The raw material will be woody biomass and the production is for export to Europe.

6.2.2. Wood chips

Traditionally, roundwood that does not meet the standard for pulpwood ends up as woodfuel.
Recently, this distinction has begun to change. The combination of rising woodfuel prices and falling
pulpwood prices has resulted in broadly similar price levels. Wood chips for energy production are currently being exported from Russia and the Baltic states to Scandinavia, a new trend caused by falling demand for pulpwood, lower shipping rates and increasing demand for energy wood.

A likely scenario is that a larger share of the production of roundwood, wood chips and residuals currently used for pulp and wood-based panels will be used for energy production in the future. The European panel industry is already confronted with wood supply problems due to increasing competition with the biomass energy

[40] Bo Hektor, First Bioenergy, Stockholm

sector. The current production of wood chips and particles is more than ten time the production quantity of wood pellets in terms of dry tonnes. Increased use of wood fuels in countries with limited forest resources is creating new trade, which will continue in coming years.

Trade in wood fuels depends on the economic viability of low transport costs; ship transport will therefore be the dominant means of transport in an integrated pan-European wood fuels markets. Dependence on low transport costs will probably limit the trade in wood fuels to mainly coastal areas for large-scale energy production.

The rapid growth in Russian and Baltic wood supplies is likely to come to an end due to raw material constraints. The most accessible Russian forests have been high-graded, and fires have taken their toll as well. Rising costs of fuel and infrastructure development will also make it difficult to extend harvests into more remote areas. Furthermore, better governance and forest management are likely to play a role in more judicious harvesting.

Estimates suggest that about 30% of current industrial roundwood needs are sourced from planted forests. According to the latest FAO data, the world's forest area was 3.95 billion hectares, of which 150 million were plantations. Investment in timber plantations is continuing around the world, but the growth rate in plantation areas has been slowing. The key issue is whether high-yielding plantations will comprise a significant part of future biomass supply. Plantation wood already provides a large share of the world's needs for industrial wood. Because of high growth rates on some plantations, large increases in these areas could yield substantial volumes of wood for harvest that could cause an important shift in global demand-supply balances.

The demand for wood fuel will be decided by political development. Wood chips and solid wood products will have to play a major role in future biomass supply if the increase in bioenergy is going to be substantial, as the availability of residuals are limited. Major trade flows will be from plantation forests in Australia and New Zealand, Chile, Uruguay and Brazil and South Africa, as well from traditional wood sources like Canada, the US, Russia and the Baltic states.

6.2.3. Vegetable Oils and Ethanol/Biodiesel

Two major drivers can combine to significantly affect biofuel shipping volumes and routes in the medium and long term: policy targets for biofuel use in Europe, the US and Asia; and breakthroughs in technologies for 2nd generation biofuels. The first driver will sustain growth for several years, but long term targets will be more difficult to achieve unless 2nd generation biofuels become economic and widespread. A study was made on the shipping and trade route impact to 2030 as a result of these drivers, shown in Table 6.2[41]. The study projects volume of transportation biofuel demand in 2015 and the shipping required to transport it, and then projects volumes and ships needed by 2030 based on breakthroughs in the commercialization of 2nd generation biofuel technology.

[41] Biofuels and Their Effect on the Shipping Industry- Stanley Gray Lecture April 23, 2008

Table 6.2 Biofuel consumption and shipping capacity needed 2015-30

	Ethanol and Biodiesel Use		Tankers	
	M tonnes			
	2015 Plateau	2030 Breakthrough	2015 Plateau	2030 Breakthrough
US	33	80	32	115
Europe	30	55	80	145
Asia	18	58	50	140
Total	81	193	162	400

The major producers of ethanol are the US, estimated at 42.3 Ml in 2008, and Brazil, at 22 Ml in 2008[42]. The US consumes more than it produces and is a net importer, while Brazil produces more than it consumes and is a net exporter. Brazil is by far the largest exporter of ethanol.

The US Renewable Fuel Standard is the key driver of biofuels consumption in the US. Due to the popularity of cars supported by ethanol-based fuel solutions, it is projected that demand for ethanol will reach 33 million tonnes pa by 2015. To meet this demand imports, largely from Brazil, will have to increase from 8% of consumption to 15%. To achieve this import level will require 32 additional Handysize ships, as shown in Table 6.2. Due to progress in 2nd generation ethanol technologies, a breakthrough case is surmised whereby the limitations of ethanol production by corn will be bypassed by the availability of ethanol from lingo-cellulosic sources. With this assumption the US is projected to need 80 million tonnes of ethanol by 2030, and that an additional 115 Handysize ships will be needed. Exports would be expected to come from Brazil and possibly Bolivia and Paraguay.

In the EU, consumption of biofuels is projected to reach 30 million tonnes by 2015; half ethanol and half biodiesel. Imports are projected to be about 50% of demand. According to the Stanley Grey study, demand for biofuels will reach 30 million tonnes in 2015 and 55 million tonnes in 2030, necessitating 80 Handysize ships in 2015 and 145 in 2030, higher than the US because of the higher proportion of imports. Vessel sizes are anticipated to be Handysize with some Panamax due to longer voyage distances and also Aframax (80,000-120,000 DWT). A major trade route could be from the East Indies. For example, a vessel could carry palm oil through the Malacca Straits to Europe, then ballast to Argentina, carry soybean oil from Argentina to China, and then make a short ballast run to the Malacca Straits where the pattern begins again.

By 2015 biofuel demand in developing South East Asia is projected at 18 million tonnes; half biodiesel and half ethanol. Half diesel would require would require large scale increases in vegetable oil production. 30% of biofuels supplies are projected to come from within national borders, 40% from within the SE Asia region, and 25% from South America. With a technological breakthrough in 2nd generation biofuel technologies, consumption could reach 58 million tonnes biofuels requiring 140 Handysize-equivalent; some Handysize, some Panamax and Aframax for longer

[42] Fapri

voyages. Indonesia and Malaysia are already investing in ports that will allow large Handysize and Panamax vessels.

Thus a fleet of 162 vessels will be required by 2015 and 400 by 2030. Shipping routes are outlined on Fig 6.1[43]. South East Asia (Malaysia and Indonesia) is expected to be a major supplier of biofuels to China, India and Europe. South American countries (Brazil, Argentina, Paraguay, Bolivia, Chile) are expected to supply the US, Europe and China.

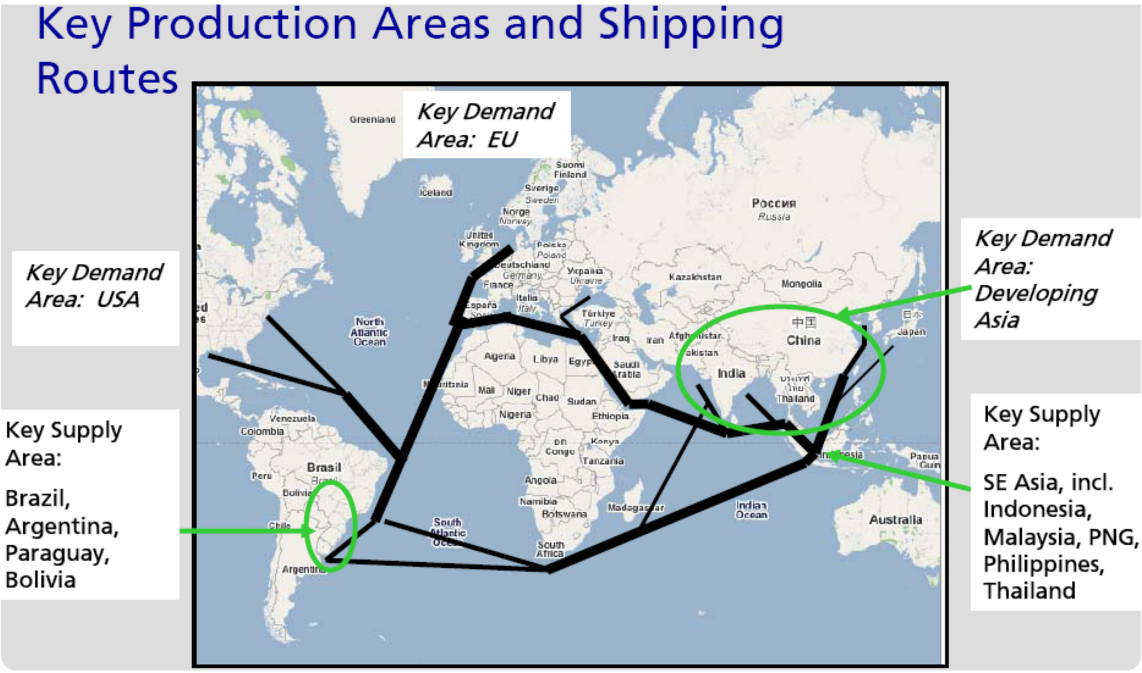


Figure 6.1 Production areas and shipping routes

6.2.4. Pyrolysis Oil

Quebec to UK-Netherlands: While pellet plants will be built in Quebec, Pyrolysis oil is twice as energy dense as pellets. As forest residue supply chains develop, BioOil plants could develop into a meaningful supply to the EU, in particular the UK where interest has been expressed in BioOil as one of a mix of fuels in biomass power plants. Quebec and Saguenay are year-round ocean ports, while Trois-Rivières is an 8.2 metre St. Lawrence Seaway port. Ensyn Energy is already preparing for up to 1 million tonnes BioOil production in this area.

Argentina, Uruguay, Columbia to UK: These countries have meaningful amounts of biomass from forestry operations. While Brazil's focus is on ethanol, these other Latin American countries can develop into suppliers of pellets or pyrolysis oil.

[43] "Biofuels and Their Effect on the Shipping Industry- Stanley Grey Lecture April 23, 2008

7. SHIPPING PRICES

As the historical development of freight rates shows, the charter market is highly competitive. Freight rates can change dramatically over a short period of time. When there is a shortage of transport capacity freight rates rise, and when there is an oversupply of ships freight rates can plummet. Generally, the cost of shipping is determined by the supply-demand balance of ships and goods. In "Maritime Economics" Martin Stopford gives a typical supply curve for sea transport (see Fig.7.1). It shows the transport capacity (btm = billion ton miles) that shipowners supply at each freight rate. When there is low demand (point A), the least efficient ships are not able to cover their operating costs and move into lay-up. The rest of the fleet reduces speed to conserve fuel. With an increase in demand (point B) all ships are back in operation and freight rates increase marginally. To meet increasing demand and to earn the maximum possible revenue transport capacity is actually expanded without the addition of ships by running the fleet at full speed (point C). When no further sea transport capacity is available freight rates skyrocket (point D).

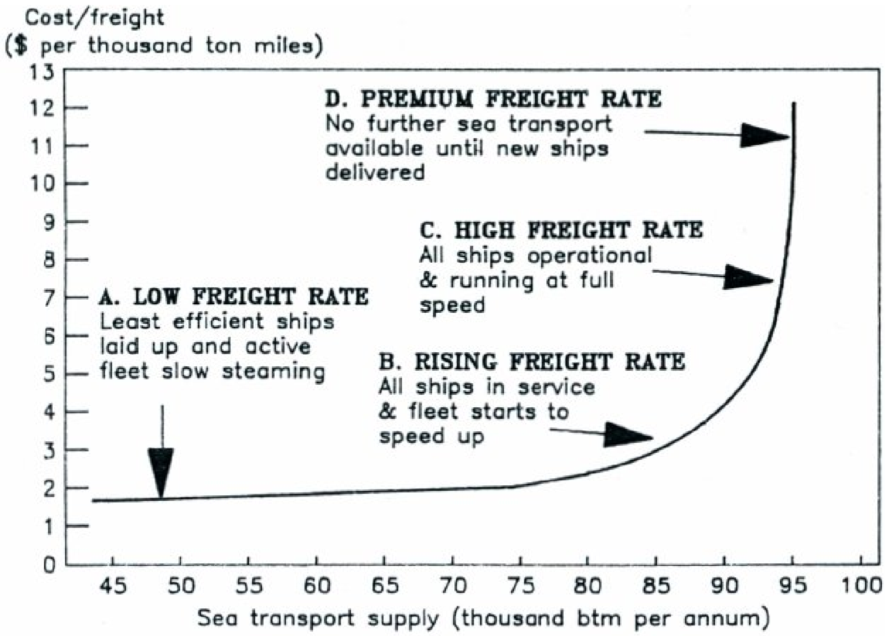


Fig. 7.1 Typical supply curve for a given size of fleet; Source: Stopford 1993

The following graph (Fig 7.2) shows the development of the average time charter rates for Capesize, Panamax and Handymax ships. As shown, shipping rates for dry bulk stayed fairly constant in 1999-2002. As a result there were few ships coming online, only enough to replace capacity being scrapped. In 2002-05 demand for shipping by the booming Chinese manufacturing sector drew considerable capacity from other routes. By 2006-07 much manufacturing formerly in the traditional developed countries had moved to China and India. Since goods that were formerly made in the countries where they were consumed were now manufactured offshore, more shipping was required to bring these goods to the major consuming regions. Orders for ships were placed, but because ship building take years, ships could not comeoff the line fast enough to match demand. The shipping shortage caused prices to rise considerably. For example, the Capesize rate rose from $4000 per day in 2004 to $20,000 per day in 2008.

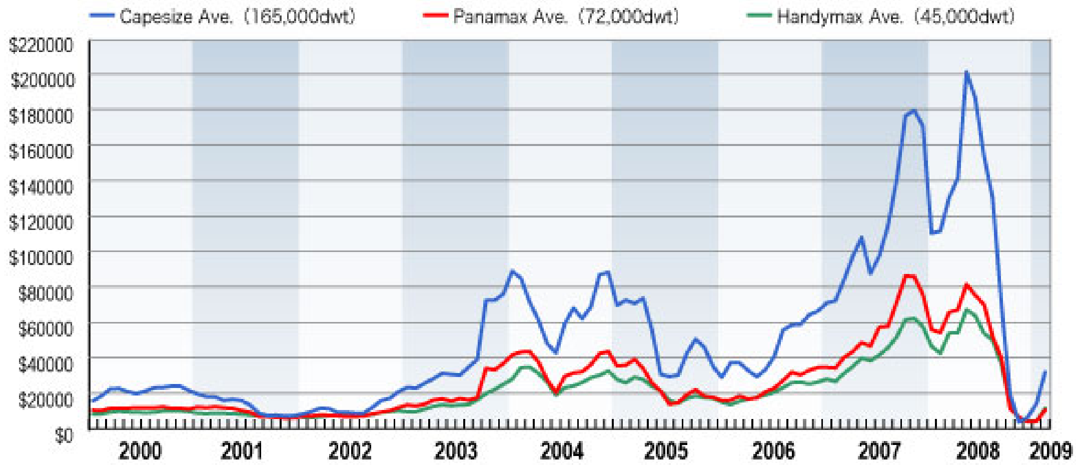


Fig. 7.2 Dry Bulk Market Trends, time charter rates in US-$/day, Period: January 2000 - February 2009; Source: NYK Researched

The current world financial crisis, which has lead to the common recessionary factors of falling demand and over-supply of inventories, as well as collapsing oil-prices, has caused a free-fall in shipping prices. At the moment the pacific panamax rates have slumped and are showing little chance of a quick revival as few cargoes enter the market and the tonnage list gets longer by the day. Refering to (Wallis 2009) the Baltic Exchange average time charter rate March 23, 2009 is near $11,900. The following table gives the 5-year maxima and minima of the charter rates for the following types of vessels: Capesize, Panamax, Supramax and Handymax.

Table 7.1 Maximum and minimum charter rates; Source: Seasure 2008

Type of ship	Charter rate 5 year high (US-$/day)	date	Charter rate 5 year low (US-$/day)	date	Movement of prices (%)
Capesize	233988	05/06/08	2316	03/12/08	-99
Panamax	94997	30/10/07	3537	12/12/08	-96,3
Supramax	72729	30/10/07	4065	19/12/08	-94,4
Handysize	49397	22/05/08	3948	12/11/08	-92

The BALTIC DRY INDEX (BDI) is an index that measures the cost to transport dry bulk materials by sea. The index is a weighted average of different routes and vessel sizes, it is a composite of the Capesize, Panamax and Handymax Indices. It came into operation in 1999 and is the successor to the Baltic Freight Index (BFI). In this index the inflation is not taken into account. The BDI is the most important price index for dry bulk cargoes.

Shipping with tankers is a completely different market than shipping of dry bulk products. Therefore for tankers there are other price indices: There is the Baltic Dirty Tanker Index for crude oil tankers and the Baltic Clean Tanker Index for tankers that are transporting refined products like gasoline, kerosene and ethanol. The Baltic Exchange has recently also launched an index for palm oil - the BPOIL1, based on - 35/40000mt Palm oil Straits to Rotterdam.

Table 7.2 Five years maxima and minima of the Baltic wet indices; Source: Seasure 2008

Baltic Wet	5 Year High	Date	5 Year Low	Date	Movement of prices (%)
Dirty Index	3194	17/11/04	619	16/09/07	-81
Clean Index	1929	24/10/05	746	20/09/07	-61

For tankers there is a unified system of establishing payment of freight rate for a given oil tanker's cargo: Worldscale (WS).

The development of both indices (BDI for dry and WS for wet) since 1999 is shown in Fig. 7.2. It shows that the market for tankers did not show the tremendous rise and fall of prices as did the dry bulk market.

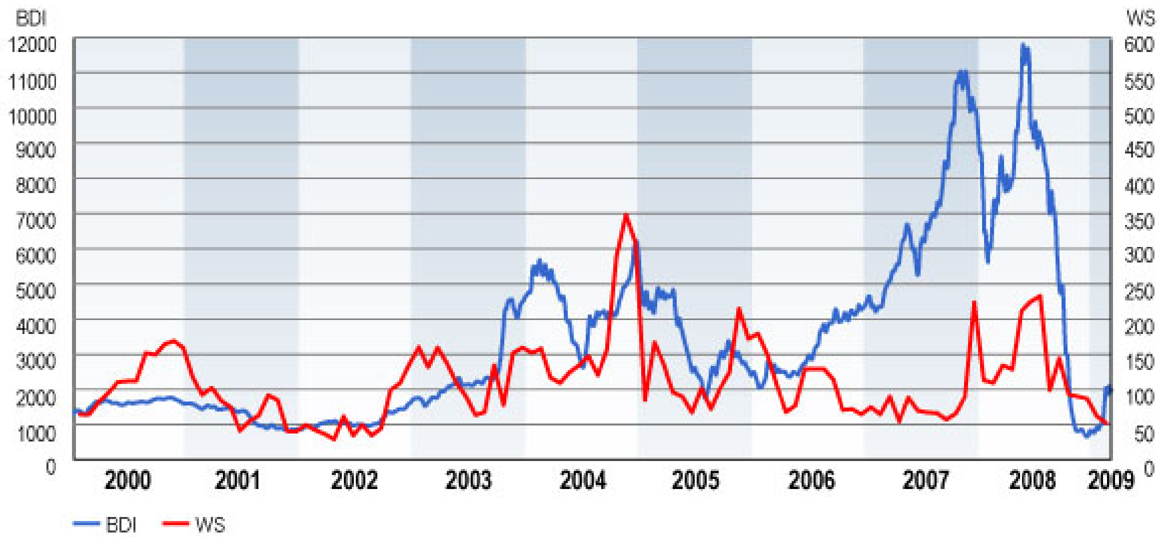


Fig. 7.2 Trends of Freight Index (BDI/WS), Period: January 2000 - February 2009; Source: NYK Researched

Besides freight rates bunker costs play an important role for the overall costs for shipping cargo. The following graph is showing the development of the Cocket Bunker Price Index (Cocket 2009), that represents the global price movement of bunkers. This global figure, which is published in Lloyd's List, is calculated each day using volume and grade weighted price figures from 39 top World bunker ports. This index was started on January 1st 1986 at 1,000.

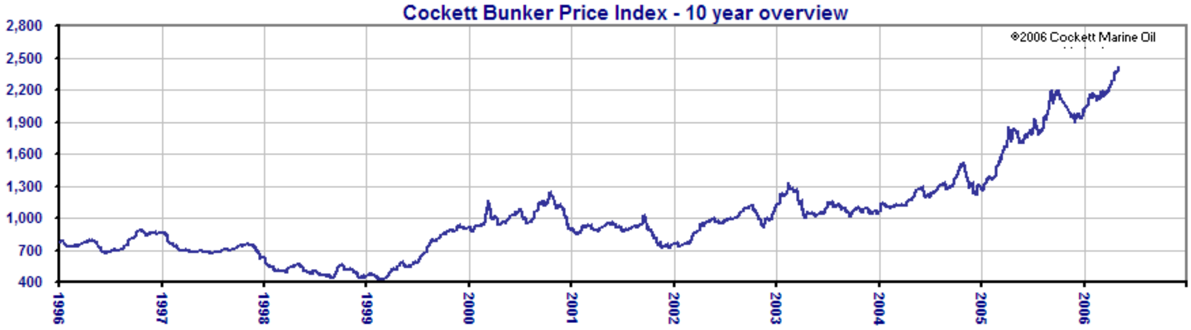


Fig. 7.3 Development of the Cockett Bunker Price Index (Historical World Bunker Price Index); Source: Cockett Marine Oil Ltd. Homepage (www.cockettgroup.com/bindex.htm)

Although high oil costs have been important in driving ocean freight costs higher over the past two years, they have not been the primary reason for the large increases. Some analysts suggest that only about 15-25% of the increases in ocean freight rates are due to higher fuel charges and that capacity shortages have been a much more important factor in driving rates higher.

Quotes for transporting goods are very much affected by what shipping contracts are already in place. The lowest cost is achieved when a ship is always full of goods. If a ship travels one way full and returns empty, the one contract must bear the cost of the empty return trip. If a shipper can find a back-haul product, the cost of both trips can be considerably reduced.

The cost of transport also is very dependent on whether a port is on a common route or is out of the way. For example, a considerable volume of pellets is moved 14,000 km from Vancouver through the Panama Canal to major European ports of Antwerp and Rotterdam. A very-much smaller volume of pellets are moved from Halifax to Europe, yet the cost is almost the same between the two routes. Halifax to Europe is not a common route, and ships are considerably smaller. In order for biomass to be shipped long distances at low cost, it must be on an existing route with many ships, or there must be sufficient volume of biomass to warrant establishing a major route in its own.

The following is a typical calculation for estimating the freight rates of shipping bulk cargo from A to B. The overall cost is $40 US/MT.

Table 7.4 Sample calculation for estimating the freight rates for 22 000 mt pellets by bulk cargo from A to B; Source: Michael Wild

Time charter: daily rate of ship (charter)	US-$	10 000
Cargo (metric tons)	mt	22 000
Loading (metric tons/day)	mt/day	3 500
Unloading (metric tons/day)	mt/day	2 500
Duration/travel time (days)		
Ballast voyage (travelling to A)	days	3
Duration (travelling from A to B)	days	21
Duration loading	days	6
Duration unloading	days	9
Over all duration	days	39
Costs of bunker		
IFO 380 - fuel oil (dzt.: 210 - 242US-$	US-$/mt	200
MDO - marine diesel (dzt.: 535-830US-$)	US-$/mt	350
Over all bunker requirements		
IFO 380	mt	879
MDO	mt	169
Costs (US-$)		
Harbour dues	US-$	60 000
Costs of 1st unloading	US-$	60 000
Costs of 2nd unloading	US-$	0
Bunker costs IFO	US-$	175 800
Bunker costs MDO	US-$	59 150
Fees for suez canal	US-$	120 000
Assurance	US-$	3 740
In lieu of holds cleaning	US-$	3 080
Misscelaneus	US-$	2 200
Comission	US-$	9 771
Overall charter rate	US-$	390 857
Overall costs US-$	**US-$**	**884 598**
Freight rate US-$	**US-$/mt**	**40**
Exchange rate	US-$/€	1,27
Overall costs €	€	696 534
Freight rate €	€/mt	31,7

By varying the daily charter rate, the bunker prices and the duration for loading and unloading of the vessel, the influence of different cost-factors on the freight rates can be shown. Fig. 7.9 shows the results by varying cost-factors by -50% to +100%. This analysis reveals that the daily charter rate is of prime importance to the freight rates. For example, a variation of 100% of the charter rate results in a variation of 45% of the freight rate. An increase in bunker prices of 100% results in an increase of freight rates of 27%. In this context the impact of the speed of ships on fuel consumption is important too. Referring to Stopford 1993 the amount of fuel used in a year can be halved by slowing down from 14 knots to 11 knots. Additionally in this analysis the duration of loading and unloading is the least important part of the shipping costs.

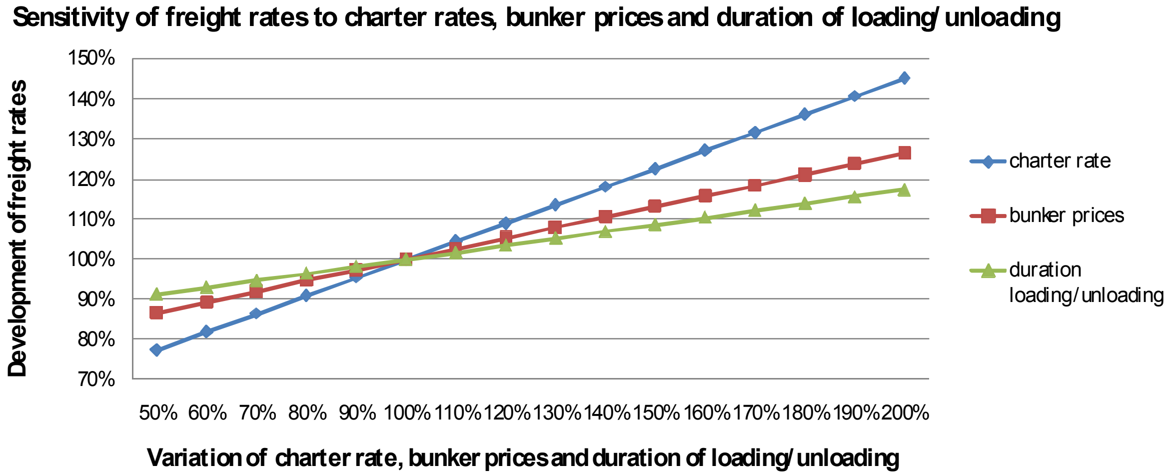


Fig. 7.4 sensitivity analysis for the freight rates of transporting goods by ship

In ports exporters are on the "first come, first serve" principle. If they are lucky and their contracted ships are the first in the dock, loading can be fast and costs kept low. But due to the vagaries of ocean travel, even factors such as weather conditions; it can happen that ships will be at the end of a long queue. Costs for shipping can easily skyrocket. For example, an exporter may charter a ship for 40 days (4 days to get the ship to the harbour (ballast voyage), 8 days for loading, 21 days shipping from A to B, 7 days for unloading) for $10,000$/day equals $400,000. If weather delays an empty ship by even one day, there may be a 3-4 day delay sitting in harbour even before loading. Similarly a late departure may result in delays waiting for harbour space at the unloading end. The risk of weather is always on the owner of the ship, but harbour risk is always with the charterer. In another example loading/unloading may not be possible because of rain, but a charterer does not have to pay for these days. Compared to daily charter rates, bunker prices and the duration of loading and unloading, the costs for harbours, insurance, salaries are less important.

Generally, the size of ships plays an important role in unit costs. There is a negative correlation in the size of vessels and the freight rates. The bigger vessels are, the lower are the specific freight rates. The economies of scale for bulk shipping are presented in Fig. 7.5. Increasing ship size from 40 000 to 120 000 dwt results in a reduction of the specific transport costs (cost per dwt) of 50%. The reason is that the number of crew members and the fuel consumption that is necessary for running bulk carriers and tankers does not increase to the same degree as the size.

Table. 7.5 Economies of scale in bulk shipping; Source: Stopford 1993

Ship size (dwt)	Operating cost (1000 US-$)	Bunker costs (1000 US-$)	Total cost (1000 US-$)	Cost per dwt (US-$ p. a.)
40 000	1 315	1 890	3 205	80
65 000	1 540	2 295	3 835	59
120 000	1 780	3 051	4 831	40
170 000	2 120	3 780	5 900	35

Using larger ships reduces unit costs, but it also reduces the number of ports that are accessible. Fig 7.6 shows the reduction in accessible ports based on ship size.

Table 7.6 relationship between ship size, draught and port access; Source: Stopford 1993

Ship draught (metres)	Average size (dwt)	Standard deviation (dwt)	Percentage of world ports accessible (%)
7,6-9,1	16 150	3 650	73
9,2-10,7	23 600	3 000	55
10,8-11,6	38 700	5 466	43
11,7-13,4	61 000	5 740	27
13,5-15,2	89 200	8 600	22
15,3-16,7	123 000	9 000	19

8. OUTLOOK AND SHIPPING NEEDS

8.1. Impact of Economic Downturn

The recent financial collapse and subsequent spiral into global recession has fundamentally changed shipping demand and supply. In 2007 the Chinese economic juggernaut drew all excess world shipping and drove shipping rates to an all-time high. By 2008 falling demand for manufactured and other goods caused factories to reduce production or shut down. Production sits in ports with no one to buy. Prices for shipping have collapsed. The drop in prices leaves the way open to secure growing biomass routes, and establish new ones.

Hopefully, recession will not hold up progress on bioenergy development. Even with the collapse in world oil prices, companies continue to plan bioenergy projects knowing that eventually fossil oil prices will rise back to trend levels. However, the financial meltdown has severely reduced the availability of both equity and debt funding. Projects simply can't find the money to proceed.

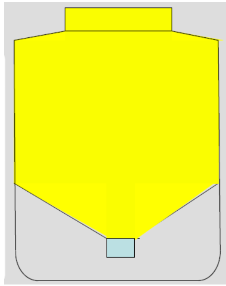
The recession will probably delay major investments in port facilities, such as in Chile. This outcome suggests that biomass exports, such as pellets and Bio-Oil, will grow first in those countries with excess biomass AND good ports, such as Canada and the US South to UK, Belgium, and the rest of Europe. Anticipated growth in ethanol production in Brazil can achieve major inroads to the EU market as feedstock costs and low shipping costs combined with European demand favour a growing trade pattern.

8.2. Types of Vessels

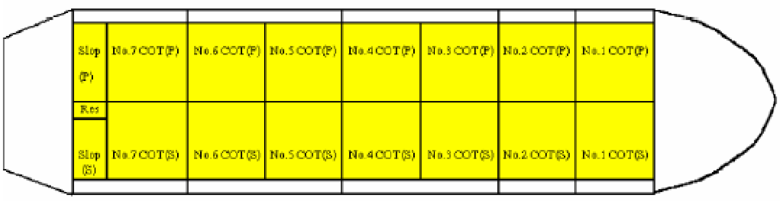
The size of vessel is critical to economies of scale. To ship a cargo from SE Asia to Europe would cost \$89 per ton on a 30,000 DWT vessel, but only \$41.20 per ton on a 95,000 DWT vessel. Since making bioenergy economic is fundamental to its development, it is clear that biomass should be shipped in the most efficient and largest possible vessel that the route can handle. Ships size must be determined by the constraints of the route, such as capability of passing the Malacca Strait, or going through the Panama Canal.

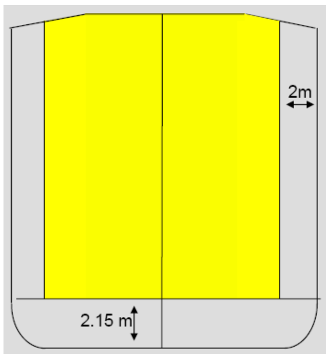
A large number of ships are projected to be required for biofuels (Section 6.2.3), but different biofuels have different shipping requirements. First generation biodiesel is IMO2 classification, hazardous goods requiring stainless steel with heating capability. Vegetable oils are IMO cargoes needing a double hull IMO3 configuration. Ethanol requires chemical tankers, but it is not clear what configuration will be required by 2nd generation ethanol. Therefore, flexible designs are needed that control initial costs while allowing subsequent modification at reasonable cost when needed[44].

For example later generation biofuels start of as solid cargoes, and then are processed into liquid. For coastal shipping of waste wood cargo we may see a new generation of 5,000 DWT dry cargo vessels with a V-shape and conveyor systems at the bottom. If volumes become large and journeys long, more design would have to be added to address condensation, ventilation and fire fighting.



Another example is to improve design for bulk liquid biofuel, starting with the basic design of a Panamax oil tanker, but with the option of Chemical tanker capability in the future. The mid ship section would require a double bottom of height 2.15 m, and side protection to "Marpol Annex 1" of 2 m. A vessel with 84,000 m^3 in cargo space designed with 7 cargo tanks along the length would enable future modification to simply divide the tanks in half resulting in 3000m3 tanks that are within the current maximum size for Type 2 ships.





8.3. Need for Port Facilities

The success of opening up new shipping routes depends on a number of interdependent actions. There has to be: sufficient volume of biomass to warrant development; transportation infrastructure to get the biomass to port; modern port facilities to cost competitively load biomass; and sufficiently large port facilities to warrant large ships to visit frequently. For example, large volumes of vegetable oils in Malaysia and Indonesia are resulting in port improvements to handle larger ships. Even Brazil, the largest ethanol exporter, still has ports that cannot handle the size of ship needed in the future. Much of Africa has large amounts of biomass, but it lacks

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the entire infrastructure to gather and transport it. But what must come first? The volume? The port?

8.4. How to find the Investment Needed in Infrastructure

There are domestic equity funds in many countries. For equity funds, many biomass investments are still regarded as risky and often only project proposals with the most iron clad contracts for purchase of feedstock and sales of bio-product warrant attention by investors. What is needed is to reduce the risk of individual projects that fit a wider supply chain. A viable solution is the formation of a large Biomass Equity Fund that can be used not only to proliferate successful 2nd generation biofuel technologies, but open up new large biomass sources for long distance transport to markets. The equity fund could invest in port facilities and biomass conversion projects in the same region. The fund would require guarantees of markets. The fund could itself invest initially in efficient ships for the products. The guarantees for the supply chain would draw shipping routes, and more biomass

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