Modern Windship

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Synopsis

Big potential for saving CO_2 and sulpher emissions by using Modern Windships for seaborn freight transport; Regarding green transport with Modern Windships, tecnical challenges and barriers.

Abstract

With a average fuel consumption of only 7 tonnes pr. 24 hours, a 50.000 dwt. bulk carrier designed as a modern windship is able to perform the same transportation as a similar sized, diesel-driven vessel having a daily consumption of 20-25 tonnes.

This is one of the main conclusions of a research project sponsered by the Danish Energy Agency and worked out by Knud E. Hansen (Pelmatic group), consulting naval architects and marine engineers in Copenhagen.

The research project shows that international sea transportation with modern windships, does not seem to run up against unsolvable problems regards to technic or safety. The economical analyses show that windship transportation, with today's oil prices, will be about 10% higher compared to the diesel driven transportation. Rising oil prices and/or environmental restrictions can, however, change this picture.

The paper is based on the repport “Modern Windship, Phase 1”, Knud E. Hansen, november 1996.

Background

Partly as a consequence of the implementation of more versatile energy supply systems following the oil crisis, the transportation market virtually has been the only growth sector for the oil industry over the past 20 years. The transportation sector being almost 100% dependent on oil, thus ranks among the fastest growing sources of greenhouse gas emissions. Transportation in 1990 world-wide consumed 60,000 PJ, accounting for about one-fifth of total final energy use and approx. 60% of all oil products consumed. In the future, the high growth of the transportation sector is
expected to continue.

The annual growth rates of global marine bunker consumption from 1993 - 2010 is by the International Energy Agency, IEA, estimated to be 2,8%, approximately 10 times as high as the historical growth rates, this being the highest growth rate of all primary energy sectors.

CO_2-emissions from global marine bunkers were 342 million tonnes in 1971 and 404 million tonnes in 1993. IEA estimates CO_2-emissions in this field in 2010 to be 572 million tonnes.

This development brings the transportation sector and the marine consumption in the focus of future global energy use. Burning of fossil fuels is also the main contributor to other emissions having a wide range of environmental impacts.

The Future of the Marine Consumption sector

The historically and expected unsurpassed growth in the world-wide energy consumption in the transportation sector and also the marine consumption sector will undoubtedly in time create more regulatory focus on the possibilities for reducing the use of natural resources in these sectors and their environmental impacts.

While many countries have implemented legislation regulating fuel quality e.g. content of sulphur, for land based transportation and emissions from power plants, the marine bunkers constitute a relatively unregulated sector with regard to fuel quality and emissions. In this field the International Maritime Organisation, IMO, has not yet succeeded in forming international agreements securing the same fuel-, emission- and efficiency standards as for the land based transportation and power plants.

Hence today the sea and our oceans to some degree function as “dumping grounds” for technology and fuel qualities not allowed for land use. As a consequence, there are very great potentials for reducing emissions of e.g. sulphur and CO_2 in the marine bunkers sector.

In addition, EU-regulation prohibits energy-taxes on air- and sea transportation in the EU-region. According to the Energy Action Plan “Energy 21” the Danish Government will work towards changing EU rules in order to make it possible to tax the energy consumption of ferries and airborne traffic.

Conclusively it is hard to imagine a “business-as-usual” scenario for the global marine bunkers sector. Marine bunkers presumably share a common destiny with the transportation sector in general being the most important single field of challenge for the future, if a sustainable development is to be achieved. There is already evidence that political and environmental focus is gathering more and more on transportation.

The enormous global environmental challenges in mind, it seems as only a question of time before the role of the international seaborne traffic, as an unregulated retreat, will begin to be radically changed.

Subsequently, activities and initiatives in this field will be needed. In this perspective this report looks into modern windships as a possibility, the driving force this time not only being saved fuel-costs, but very substantially environmental potential benefits from reduced emissions and energy consumption.

Modern Windships, phase 1

During the past 30 years, considerably efforts and resources have been spent in a number of shipbuilding countries on recent studies and projects, aiming at a modernisation and re-vitalisation of the sailing ship, whether as a “pure” sailing ship or as a sail-assisted vessel.

The project “Modern Windships phase 1” has had three main goals:

1. To collect all these studies and projects and evaluate them in the light of the progress that has been made over the recent years with regard to new technology and materials, in order to investigate if a symbiosis between experience and new knowledge would form a new platform for the feasibility of windships.

2. To identify cargo types and trades where modern windships could be economically employed and create an interest among people involved in the transportation of such cargoes - i.e. owners, shippers, financiers and charters.

3. To come up with a design proposal for a modern windship, a bulkcarrier in the handymax size of approx. 50,000. This is a type of vessel that both commercially and technically seems to be well suited for wind-driven propulsion.

Windships - an Envir onmental and Economical Challenge.

Previous studies and projects concerning the re-utilisation of the wind as a source of propulsion for vessels have to a very high degree focused on two main factors: To be able to safeguard the lines of supplies in a critical situation and an ability to compete economically on equal terms with diesel-powered vessels.

In other words, the availability of oil and the price of same, have always been the ultimate decisive factors, when judging the viability and prospects of such projects.

The big environmental benefits of using wind-powered vessels were more or less considered spin-off effects. The environmental awareness that has emerged over the past 5-10 years, has however completely changed this picture.

Although the economic viability is still a paramount factor, especially with regard to acceptance within the shipping industry, the main purpose today is to reach the positive environmental effects of a more widespread use of wind-powered vessels especially reduction of the emission of CO_2 and sulphur but also reduktion of other harmful pollutants and preservation of valuable fossil fuels are legal arguments.

All this plays a much bigger role in our society today than twenty years ago. In the western world, counting for 75% of the world's consumer spending, the so-called "green values" are now influencing all areas of society.

Despite higher prices, consumers demand for ecologically produced food now often exceeds production capacity. The same trend has only pourly been observed in the transport sector but there is no doubt, that "green values" also here will penetrate the barrieres sooner og later.

The modern windship fits well into this picture of future green trends. We furthermore believe that the time is now to look at this idea with fresh eyes. It is therefore our hope that the project will pave the road for further, practical developments in this important area.

The Availability of Cargoes, Suitable for Windships

Some cargoes like manufactured goods and frozen or chilled cargoes speed and punctuality are of paramount importance and service speeds in the 18-25 knots range are common. For this reason it is not realistic, in a anticipated future, to expect such cargoes (today being containerised) being transported with vessels having approximately half these service speeds.

Bulk cargoes, dry and wet combined, accounts for appr. 80% of the total, global seaborne cargo volume. The service speed for bulk vessels lies lower around 13-14 knots, so the expected service speed of a modern windship, appr. 11 knots, lies within the acceptable.

Wet bulk cargoes (45% of the total bulk volume) theoretically presents themselves as an ideally suited cargo for modern windships as there are no cargo handling problems. A very big part of this market, the transportation of crude oil is however to-day being transported with very big vessels, 300,000 DWT and above, leaving out wind driven vessels as an alternative.

Smaller units like product tankers and chemical tankers, which are being constructed within a broad range of sizes from 5,000 to about 50,000 DWT, offer good opportunities for winddriven vessels.

The dry bulk market is big business, vessels with a total of 415 million DWT are involved and the annual freight bill amounts to abt. 35 billion USD.

Regarding sizes of individual shiploads, there has since the early seventies been an increase. Shipments have got steadily larger as ship of the bulkcarrier class have been substituted for smaller, less efficient ships and exporters have sought to lower their freight costs. This is the main reason why less so-called “spot” cargoes comes on to the freight market in shiploads under 50,000 tonnes.

The vessel-size we concentrate on in this study, a 50,000 DWT vessel, is therefore placed well in the middle of the bulk market both with regard to overall economy and demand. And further, should a future demand arise in any sector below the 50,000 DWT range, it could for example be vessels trading mainly on smaller ports (developing countries), it is no problem to down scale the plans of the vessel.

The market is roughly divided into two main areas, the “Major bulks” and the “Minor bulks”. Of the major bulks, one important item, namely iron ore are today mostly transported in bigger vessels, the so-called “Cape sizers” (140-160,000 DWT) and these ore-cargoes are consequently not accessible for modern windships, their upper limit presently being around 50,000 DWT.

Coal is also generally transported in these big vessels, but abt. 25% of this also very important item, mostly steam coal, is still being transported in Panamax-sizes around 60,000 DWT.

The third major item, grain, and also bauxite/alumina plus phosphate rock are however also well suited cargo-types for windships.

Most of the minor bulks: agribulks, forest products, fertilisers, ore and minerals, iron and steel plus a number of other bulk cargo-types are also well suited cargo-types for windships.

The actual size of the seaborne dry bulk trade for both major and minor bulks and a forecast of its growth (2,3% per annum) until year 2000, measured in million tonnes, is shown in table 1. (ref. no 10) below:

Table 1. Forecast Growth of Seaborne Dry Bulktrade (million tonnes)

	1993	1996	2000
Major Bulks	994	1,090	1,198
of which:			
Iron Ore	352	383	394
Coking Coal	159	178	187
Steam Coal	203	237	318
Grain	205	209	224
Minor Bulks	616	616	703
Total	1,610	1,751	1,901

Source: Drewry Shipping Consultants.

Acording to the forecast - the total dry bulk market will increase with almost 20% from 1993 to the year 2000, which means that a larger bulk carrier fleet is required to cope with the increase.

It should however be remembered that bulkcarrier demand is not solely a function of the volume of bulk cargo entering seaborne trade, another important variable is the transport distance.

From the forecasts for seaborne traffic and the projected pattern of bulk shipments, it has been calculated - by multiplying tonnage shipments by the average haul distance in individual trades - that the shipping dry bulk cargo will be required to perform 9,800 billion tonne mile in year 2000 - an increase of almost 20% from the bulk demand of 1993.

In the minor bulk trades, the 3,300 billion tonne-miles will passed in year 2000, an increase of 400 billion, or 13%.

As mentioned, voluminous, low value, steady demand cargoes travelling long distances, offer the best market possibilities for modern windships.

It therefore seems to be a good idea to take a look at the last commodities which could be transported competitively by sail driven ships even in our century, as these should probably be the first commodities to be considered for the re-entry of sail power.

Grain is an excellent example of a cargo having a big potential for modern windships and a forecast of the international size and growth of this market until year 2000 is shown in table 2 below.

Table 2. Forecast Seaborne Grain Trade to 2000 (Million tonnes)

Year:	1993	1996	2000
Canada	23.0	24.5	28.0
USA	98.0	106.5	111.0
EU-12	26.0	21.5	24.5
Argentina	10.5	11.0	15.5
Australia	15.5	13.0	14.5
Others	32.0	32.5	30.5
World	205.0	209.0	224.0

Source: Drewry Shipping Consultants.

In the global grain market, the United States is easily the biggest player (abt. 45%), followed by Canada, Argentine and Australia. The main importing grain countries are China, the former Soviet Union countries, the Middle East and Africa.
Asia in general, having nearly 60% of the world’s population and the fastest projected income growth, is expected to offer the largest growth potential with regards to import of grain, the main import demand arising in countries along the Pacific Rim.

As illustrated, there exists a number of different bulk cargoes that are well suited for the transportation by modern windships - generally we talk about long haul, low value, low density cargoes with a steady demand.

For such cargoes a speed reduction from 13-14 knots down to 11 knots, or about 15-20% lower speed, is not a major problem because the vessels under way often acts as “floating warehouses”, loading and unloading their cargoes from/to big buffer-stores ashore.

With reliable and reasonably sized auxiliary engines, combined with modern information technology, voyage lengths and arrival times can be predicted with the same accuracy as a conventional vessel. Loading and unloading of such cargoes will not cause problems in general.

Design Criteria

For bulkcarriers, there seems to be an upper limitation to sail driven propulsion at about 50,000 DWT. This limit is mainly due to mast-height and length of ship (sail area) constrictions. A mast-height (air draught) exceeding 60 metres will make it impossible for the ship to pass through the Panama Canal and also limit its access to a number of North American ports, and the ship length has due to harbour (lock) restrictions and to strength/weight considerations limitations too.

The draught is another important aspect. A draught exceeding 12 meters will make it impossible for the ship to enter many ports and therefore also the majority of the handysize fleet (abt. 90%) have fully laden draughts between 10.5 - 12.0 metres.

The maximum permissible beam for passage through the Panama Canal is 32.3 metres. The maximum permissible length in the Canal, 274.3 metres, seems to be no limiting factor for our ship. An excessive ship length should for other reasons (port accessibility and costs) however be avoided.

The lay-out of the main deck has to be based upon a compromise between the best possible hatch arrangement (loading/discharge) and mast position/sail handling.

The safety aspect plays a very important role in the development of the auxiliary propulsion system's size and position, the manoeuvring lay-out, the sail handling system and the mast lay-out. Thus the vessel designed is fitted with a twin auxiliary propulsion system and with today's eyes, a rather unconventional sail plan.

With these aspects and limitations, the following design criteria for the projected ship, WindShip 1 (WS1) have been established:

Deadweight all told:	50.000 tonnes
Cargo stowage factor:	1,45 m^3/tonnes
Max. beam:	32 metres
Max. draught loaded:	12 metres
Max. air draught:	60 metres
Average service speed:	11 knots
Manning:	as a similar conventional ship

The criteria has been used very strictly as background in the work with developing WindShip 1.

Rigging

The rig that Phase 1 ended up with is a newly developed type, partly inspired by the Chinese junk rig and partly by the classic lugger rig. The six mast are, for cargo handling reasons, all placed off the port side off the vessel.

In selecting solutions for the modern wind propulsion system the design team has, instead of developing new sail types, based the proposals on a careful study of historical data and evaluated the possibilities of improving well-known sail types by using new technology.

The mast are equipped with acrane type of arm, which bears the 1500 square metre sail. the prototype mast will probably be made of high tension steel, but light composite materials (carbon fibre) are being considered - also for use of the upper yardarm.

Made of a newly developed, high strength material of the same type used in modern airships, the sails are furled down into boxlike booms, and fully automated, hydraulically operated sheeted system is positioned around the hatches.

Preliminary calculations show the developed type of rig is about 20% more efficient that previously developed types of rig.

Propulsion

The engine arrangement i quite novel. It is a diesel-elctric system with two medium speed engines each approximately 2,700 kW and each coupled to a 3,370 generator. In addition there are to smaller gentets, each of 500 kW/625 kVA.

All four generators can be connected to the propulsion engine, which are two thrusters turnable through 360 degrees, which can deliver the amount of prpulsion necessary to maintain a service speed of 11 knots. The two thrusters can be extracted when the vessel i driven by sail only. A bowthruster of 1,700 kW is place in the skeg of foreship.

The relatively high propulsion effect, slit up into three independent units, gives the vessel a very high degree of manoeuvrability and safety.

The ship can be held in positioned stationary ind wind exceeding Beaufort 8, and needs no tugs for harbour manoeuvres. The size of the auxiliary propulsion also guarantees that a service speed of 11 knots, measured as a voyage average, can always be maintained. Uncertainty of arrivals plus insufficient manoeuvrability in ports, as well as under difficult conditions, have been the main critisims levelled at earlierwindship projects.

Competitiveness

Despite the fuel savings, preliminary calculations show that a windship - with present oilpricees - cannot yet compete with a conventional ship. Transportation cost are approximately 10% higher. The main reason for this is that windship bulding costs are estimated to be approximately 20% higher than a conventional ship, resulting in correspondingly higher capital costs. The calculation is here based on a relativly short pay back time on eight years which off cause is favourable for the cheapest (the conventional) ship.

Economy calculations based on various forecasts of oilprices show that the competitivenessof the windship will probably be on a par with a conventional ship around the year 2000. Time is thus working for the windship.

Conclusion

Project Windship has, in contrast to earlier tests and projects, designed a bulkcarrier based on a complete evaluation of ecology, safety, economy and reasonable transportation speed.

A substantial part of the world's seaborne transportation of cargo is carried out with transportation speeds, where windships can be considered. Among areas where windships are not useably can be mentioned transportation of containers which typical operate with a much higher speed and require large deck cargoes.

The accumulated CO_2-emission from the potential market of windships is in the extent of 200 - 300 million tonnes and growing rapidly. As opposed to this is the Danish emission with about 60 million tonnes CO_2 from all sectors. Seen in this aspect, the environmental potentials are quite considerable.

The research project shows that international sea transportation with modern windships, does not seem to run up against any obstacles as regards safety. The economical analyses show that windship transportation, with today's oil prices, will be about 10% higher compared to the diesel driven transportation. Rising oil prices and/or environmental restrictions can, however, change this picture.

On top of this is the possibility that the company and consumers, at least for a period of time, will accept slightly increased transportation costs when using "green" transportation.

The further work

Three more phases of the study are planned, and are including further development and test of rig and hull in both water basin and wind tunnel. It is also planned to build a mast on land for testing rig and sail.

The financing of the following phases is expected to come from the Danish Energy Agency, the Danish Environmental Protection Agency and the Ministry for Industry as well as private companies.