1. EffShip- Efficient Shipping with low emissions (Effektiv sjöfart med låga utsläpp)

2. Summary

The EffShip project is based on the vision of a sustainable and successful maritime transport industry – one which is energy-efficient and has minimal environmental impacts. Specific project goals to achieve this include improving the efficiency of the ship machinery, introducing alternative marine fuels, using wind energy as a complementary propulsion force and developing applicable technology for reducing the emissions of CO_2, NO_x , SO_x and Particulate Matter. The project will result in solutions with respect to maritime fuels, energy efficiency and emission reduction technology that will contribute to the fulfillment of EU's and the Swedish Government's climate goals of 20% more efficient energy usage, 40% reduction of green house gas emissions, a minimum of 10% renewable energy in the transport sector in year 2020 and to fulfill and exceed upcoming international rules. In the project, there will be full scale tests of some of the developed technologies as well as a complete ship design including functional design of the best technologies. A state of the art ship design has been made available to the project to act as the platform for further development. The project results will be disseminated and exploited through the eight partners of the project consortium consisting of research organizations, ship design companies, suppliers of power and emission reduction solutions and heating systems.

3. Project areas

The project addresses the area "Efficient energy use" for shipping, and also the area "Sustainable use of natural assets". The project is a combined Research, Technological development and Demonstration (RTD) project.

4. Project content

The work will be structured in nine Work Packages. Each WP focuses on a specific task but will be carried out in close co-operation with the other WPs (details in Sec. 8):

WP1. Project Management: Leading of the project activities, monitoring of the overall progress, co-ordination of the liaisons between the project partners, and reporting to VINNOVA.
WP2. Present and Future Maritime Fuels: The purpose is to identify present and possible future fuels for maritime use. An overview level report discussing short term, medium term and long term perspectives for present and future maritime fuels will be compiled. Logistic and risk aspects of the supply and storage of the fuels are also included in this work package.
WP3. Exhaust Gas Cleaning: The purpose is to identify and evaluate existing methods and techniques under development for exhaust gas cleaning, especially with regards to NO_x, SO_x , CO, VOC (Volatile Organic Compounds) , PM (Particulate Matter) and methane slip. Internal engine methods as well as external methods will be studied. Possible interactive relations between the methods will be observed. Areas for future development will be identified and described.
WP4. Energy Efficiency and Heat Recovery: The purpose of this WP is to identify and establish an overview of existing methods and techniques under development for improving energy efficiency (i.e. minimizing energy consumption) of the machinery, accommodation and outfitting systems as well as identify the potential of heat recovery from exhaust gas and cooling water energy. Areas for potential future development will be identified and ways to achieve this will be described.
WP5. Energy Transformers: The purpose is to identify, describe and evaluate technologies suitable to serve the heat recovery methods described in WP4. Examples of transformers are Rankine machines, boilers, coolers and heat exchangers. Alternative use of recovered energy (electricity generation, propulsion, auxiliary, etc.) is to be investigated and the potential described. An Organic Rankine Cycle (ORC) demonstration power plant will be built at Högsbo CHP plant in

Göteborg and appropriate tests will be carried out. Areas for future research and development will be identified and described.

WP6. System Impact when Using Wind, Wave and Solar Energy: In order to reduce fuel consumption and thereby emissions, attempts have been made in recent years to use wind as a complementary propulsion force. The wind energy can be used either as a direct propulsion force or to generate electricity. The former is probably the most efficient way of using wind energy on a ship. At present there are two methods using this alternative that are being explored by different companies and organizations: Kites and Flettner rotors. Both methods will be investigated, especially with respect to the significant unloading of engines and propellers.

WP7. Logistic System Analysis: This work package analyses logistic aspects of the waterborne transport system, and deals with how to design and operate a greener and more efficient maritime system.

WP8. Demonstration of Findings: A key part of this project is applicability. In order to ensure this the state of the art Mk III roro vessel, as put at the disposal of the project by the Swedish Orient Line, will be used as a benchmark and test bench for the proposals resulting from the WPs.

WP9. Final Reporting, Dissemination and Future Projects: The findings from the EffShip project will be summarized in a Final Report and the results will be disseminated in appropriate journals and conferences, and a special EffShip seminar will be organized. Reports from each of WP2-WP8 will be produced and the Final Report will be formulated within WP9.

5. Environmental potential

Implementation of the results from EffShip will significantly reduce the energy use per transport distance (at constant speed) for ships as well as significantly reduce the emissions (CO_2, NO_x, SO_x and PM) from marine transportation.

6. Project relevance

Aim: The aim of the project is to focus on ways to improve the efficiency of the propulsion engine, to use alternative marine fuels, to use wind energy as a complementary propulsion force, and to reduce the emissions of CO_2, NO_x, SO_x and PM in maritime transportation.

Need: There is a broad international need to reduce emissions leading to global warming and all transport modes should work to reduce their impact (IPCC- Intergovernmental Panel on Climate Change). The need for clean and efficient marine transport systems is also clearly expressed by both the Swedish Government and EU. In addition to the tougher requirements from society in general there are specific international rules coming that will mandate a radical reduction in NOx and SOx emissions in ship operations.

-From 2015, ship operations in the Baltic Sea and the North Sea down to and including the English Channel must comply with the SECA requirement of SO_x emissions equivalent to operation on <0.1% sulphur fuel

-From 2016 the NO_x emission level for diesel engines will be reduced by 80% from today's level. Currently the International Maritime Organisation, IMO, is working on an Energy Efficiency Design Index, EEDI, which will require future ship designs to become significantly more energy efficient than today**.**

Goal: The goal of the project is to present solutions with respect to maritime fuels, energy efficiency and emission reduction technology in order to significantly reduce the CO_2, NO_x, SO_x and PM emissions in shipping and to fulfil and exceed requirements from upcoming rules. Some of the solutions will be demonstrated and validated in test bed and onboard experiments.

7. Project quality

In the maritime world – as well as in the transport industry at large – substantial efforts are being made to make transport more energy efficient, to reduce the emissions from the energy used and to

make them less harmful to the environment. From society regulations are set forth or upcoming regarding what is tolerable in terms of CO_2, NO_x, SO_x and PM. The emissions of CO_2 are in proportion to the consumed energy, which in turn is directly in proportion to the energy efficiency of the transport system.

Cleaner and more efficient sea transport systems can be achieved by working within four major areas: Operational efficiency and economy of scale, Efficient hull and propulsion lines, Efficient and clean engines and engine systems, and Suitable fuels.

Two of the most clean and energy efficient sea transport systems presently operating in Europe are the StoraEnso "Base Port" (2000) and the "NETSS" (2006), which annually transportsome three million tons of forest products from Sweden/Finland to the Continent, with 3+3 ships in an intermodal system.

An MKIII version of the StoraEnso ships has been developed by ScandiNAOS together with Imperial Shipping in Gothenburg. This version has a propulsive efficiency (hull form and propulsion line) which reduces the fuel consumption by about 20%. Imperial Shipping has put this ship concept at the disposal of this project to be used as a template upon which the various proposals of the project can be tested and evaluated. The above means that the state of the art of operational efficiency and hull/propulsion line efficiency are already integrated parts of the project. The EffShip project will thus focus on ways to improve the efficiency of the propulsion engine and systems and on reduction of CO, NO_x, SO_x and PM emissions.

The major engine makers have extensive development programs for efficient and clean engines and engine systems. The efficiency of a maritime diesel engine (about 49%) can be further improved by using heat recovery systems that vary in efficiency and complexity. Waste heat (exhaust and cooling water) is used for electricity production and for heating. The emission problem is dealt with by engine technologies, e.g. Exhaust Gas Recirculation (EGR), Humid Air Motor (HAM) and by Selective Catalytic Reduction (SCR) and SO_x scrubbers, filters.

Despite all well intended ongoing work one problem is that some promising technologies are dealt with "stand alone" without considering possible combinations or synergies and some technologies are simply just neglected.

The most common reasons for this are:

- The engine makers are working within the limits of the company sphere and use the technologies accordingly.
- Technologies from outside the maritime sphere (power industry, etc.) are neglected or considered troublesome and costly to adapt to a maritime standard.
- Limited - or rather non-existing – research on maritime engines at our universities.
- Traditional thinking.

8. Project approach

The partners in the consortium carrying out the work in the project "EffShip" represent the state of the art expertise within their fields of activities:

SSPA Sweden AB (SSPA) is an independent, limited consultancy and research company owned by the Foundation Chalmers University of Technology. See www.sspa.se . In EffShip SSPA will act as Project Manager and assist the Technical Manager, and lead WP6 and WP7. SSPA will also carry out research within WP1, WP2, WP3, WP8 and WP9.

ScandiNAOS is a Swedish company specialised in ship design, cargo handling and sea transport system design. ScandiNAOS will be Technical Manager. The key personnel of ScandiNaos have 20 to 40 years experience of extensive and qualified projects of both commercial and scientific nature. ScandiNAOS will lead WP8 and WP9 and participate in all other WPs.

Wärtsilä enhances the business of its customers by providing them with complete lifecycle power solutions. When creating better and environmentally compatible technologies, Wärtsilä focuses on the marine and energy markets with products and solutions as well as services. See www.wartsila.com . Wärtsilä is the leading provider of ship power solutions including ship design, engines, generating sets, reduction gears, propulsion equipment, automation and power distribution systems as well as sealing solutions for the marine industry. Wärtsilä is leading WP2 and WP5, and participating inWP1, WP3, WP4, WP6, WP8 and WP9.

S-MAN AB, a company within the Euroboilers group, specializes in turn-key heating systems for cargo and bunker heating. For more than 50 years S-MAN has served as a leading supplier of thermal oil, steam and hotwater systems tailor made for virtually any type of ship. S-MAN was also the company introducing thermal oil within Scandinavia already in the 1960s. See www.s-man.se . S-MAN is leading WP4 and participating in WP1, WP5, WP8 and WP9.

D.E.C. Marine AB (DEC) is a leading supplier of NOx reduction solutions for diesel engines since the early 1990s. D.E.C. Marine specializes in marine applications and has a solid knowledge requirement of the SCR Technology, as well as the design, manufacture, installation and service of complete SCR system. See www.decmarine.com . DEC is leading WP3 and participating in WP1, WP2, WP8 and WP9.

Chalmers, Shipping and Marine Technology (Chalmers). At the department, training and research support processes in the genesis of the ship, as well as processes in its handling, management, and operation. The resource use and environmental impact of shipping as well as environmentally sustainable energy supply and use are important research issues. see http://www.chalmers.se/smt/EN/ . Chalmers participates in WP1, WP2 and WP3.

StoraEnso AB is a global paper, packaging and forest products company producing newsprint and book paper, magazine paper, fine paper, consumer board, industrial packaging and wood products. The majority of the StoraEnso products and raw material is dependent on efficient marine transportation systems. In the last ten years StoraEnso has been leading the development for short sea transportation and are today operating two of the most clean and energy efficient sea transport systems in Europe. See www.storaenso.com . Stora Enso participates in WP5 and WP8.

Göteborg Energi is Western Sweden's leading energy company. We provide our customers with energy services, broadband, district heating, cooling, natural gas and the electricity supply network. Göteborg Energi is an energy company with an outspoken ambition to work for long-term sustainable energy solutions in the society. Due to this ambition, Göteborg Energi has identified a number of core areas where we are active, primarily: (1) The need for the transportation sector to evolve from the use of fossil fuels, (2) The need for more efficient use of energy, and (3) The need for more renewable electricity. Website: www.goteborgenergi.se . Göteborg Energi participates in WP5.

The EffShip project is planned to start 2009-12-01 and to finish 2013-03-31 with delivery of the Final Report. The total project time thus is 40 months. Below is a Project Plan for the project (WP-leader in bold):

WP1. Project Management (**SSPA**, ScandiNAOS, Wärtsilä, S-MAN, DEC, Chalmers)