ClassNK's Approach to Reducing Greenhouse Gas Emissions from Ships

- Implementation of EEOI appraisal services -

1. Introduction

Social interest on global warming issues has grown increasingly in recent years, and topics related to energy conservation and reduction in CO_2 emissions is omnipresent. Stringent demands for measures against global warming are being made in the international shipping arena also. Discussions are being held in the International Maritime Organization (IMO) related to reducing greenhouse gas emissions.

This article gives an introduction of the discussions that have been held at the IMO until now, as well as an overview of the Society's approach towards implementing EEOI appraisal services and joint R&D projects with the industry.

2. Trends in deliberations at the IMO

2.1 Discussions related to methods for reducing greenhouse gas emissions

Discussions related to reducing greenhouse gas emissions are being held by the Marine Environmental Protection Committee (MEPC) at the IMO. Methods for reducing greenhouse gas emissions discussed at the MEPC until now, and instruments for promoting these methods are first discussed in this section. CO_2 accounts for a major part of the greenhouse gases emitted from ships. For this reason, CO_2 has become a target for reduction in the international shipping arena. In this document, "greenhouse gas" is assumed to be the same as CO_2.

The emission of CO_2 from ships is proportional to the quantity of fuel actually burned on the ship and depends on the type of fuel used. Therefore, in order to reduce CO_2 either the amount of fuel used has to be reduced or the energy efficiency of the ship (fuel consumption per activity) has to be improved. Since the amount of activity is closely linked to the economic growth of the whole world, including that of developing countries, discussions are being held at the IMO with the focus on enhancing the energy efficiency of ships considering a proper balance between the reduction in CO_2 emissions and economic development.

"Technical measures", "operational measures" and "economic instruments" are being studied as methods for reducing CO_2 emissions according to recent discussions at the IMO. The technical and operational measures mentioned here are direct measures for improving the energy efficiency of a ship. The former are implemented by improving the ship's hardware (equipment), while the latter are implemented by improvements or innovations in the operation of the ship. In contrast, economic instruments are not meant to reduce CO_2 emission directly; they may be considered as instruments that offer economic incentives to promote implementation of the technical measures or the operational measures mentioned above.

2.1.1 Discussions related to methods for reducing greenhouse gas emissions

Technical measures aim to enhance the energy efficiency by hardware (equipment) improvements of the ship as mentioned earlier. Some specific examples of the technical measures are given below.

- Modified hull form (reduction in propulsion resistance)
- Modified propeller (enhanced propulsion efficiency)
- Energy-saving appendages on hull
- Increase in deadweight capacity by increasing the hull size
- Use of energy from exhaust heat recovery
- Use of renewable energy (wind power or solar power, etc.)

IMO has proposed the Energy Efficiency Design Index (EEDI) as the index for evaluating the technical measures. EEDI is an index expressing the energy efficiency of new ships, and is estimated by the equation below.

$$EEDI\ (\text{g/ton mile}) = \frac{\text{CO}_2\ conversion\ factor \times fuel\ consumption\ (\text{g/kWh}) \times engine\ output\ (\text{kW})}{Capacity\ (\text{ton}) \times speed\ (\text{mile/h})}$$

In the equation above, the EEDI is a value calculated taking design values as parameters, and it expresses the CO_2 emission reduction potential. EEDI is likely to be required to satisfy the IMO standard value (set according to DWT of each type of ship) for new ships to be built henceforth.

2.1.2 Operational measures

Operational measures aim to enhance the energy efficiency through improvements or innovations in the operation of the ship, as mentioned earlier. The operational measures are applicable to individual ships. There are various kinds of operational measures including those that go beyond the scope of efforts of individual ship management companies and necessitate coordination with relevant personnel. Specific examples of the operational measures are given below.

- Optimization of operational plan of individual ships and fleets
- Operation at reduced speed
- Weather routing
- Just-in-time entry into port
- Hull maintenance (for instance, reduction in propulsion resistance by cleaning the hull)
- Machinery maintenance

IMO has proposed the Energy Efficiency Operational Indicator (EEOI) and the Ship Energy Efficiency Management Plan (SEEMP) as tools for promoting the implementation of operational measures.

Of the two, the EEOI is an indicator expressing the energy efficiency of the ship in operation, and it is estimated by the equation below.

$$EEOI\ (\text{g/ton mile}) = \frac{\text{CO}_2\ conversion\ factor \times fuel\ consumption\ (\text{g})}{Actual\ cargo\ weight\ (\text{ton}) \times actual\ voyage\ distance\ (\text{mile})}$$

The EEOI also expresses the CO_2 emission rate of the ship, similar to the EEDI. However, it differs from the EEDI in that it is calculated from values measured during an actual voyage (the EEDI is calculated from the design value, as shown in 2.1.1). As seen from the equation above, the EEOI readily varies according to the difference in operation (route, load, etc.), and thus it is not appropriate generally to use the obtained value for comparison with the EEOI values of other ships. It should be used as an indicator to evaluate energy efficiency improvement in the same ship.

On the other hand, the SEEMP is a management plan that should be used for implementing improvements in energy efficiency by operational measures. The plan to implement operational measures appropriate for one's own ship is described here.

The EEOI and SEEMP are both effective tools that can be voluntarily used by ship operators to improve the energy efficiency of their ships (that is, reduce specific fuel consumption). During the actual implementation of the operational measures, each ship monitors the energy efficiency of the ship, that is to say, self-monitors the EEOI, and implements the planned operational measures according to the SEEMP.

2.1.3 Economic instruments

Economic instruments offer economic incentives to promote the implementation of the technical measures or the operational measures as mentioned above. Several different methodologies have been proposed by IMO for the economic instruments; they may be broadly divided into two groups.

(1) Fuel pricing system (proposed by Denmark)

(2) Emissions trading system (proposed by Norway, Germany, and France)

A fixed amount is charged and automatically collected when purchasing fuel oil in the fuel pricing system. The collected fund is used for projects for reducing greenhouse gases in developing countries and so on. Based on the fuel pricing system, Japan has proposed that a part of the fund collected be reimbursed to ships in which excellent efficiency improvements have been made, so that the incentive for making efficiency improvements will be further strengthened. On the other hand, the total CO_2 emission amount for the maritime industry is regulated in the emissions trading system. From this total, the difference in the credit and the actual CO_2 emission amount assigned to each ship will be traded with other ships or other sectors.

2.2 Flow of introduction of regulations

The measures to reduce CO_2 emissions, namely the technical and operational measures, and the economic instruments are likely to be incorporated gradually in the IMO's regulatory framework in the future. Although the specific timing for introduction of regulations in the future is not decided, the flow shown in Table 1 is generally expected to take place.

Table 1 Flow of expected introduction of regulations

First generation regulations	Mandatory EEDI requirements: Newbuildings will be required to satisfy the provisional rules set for each ship type or ship size.
	Mandatory SEEMP requirements: Ships will be required to prepare and possess an SEEMP
Second generation regulations	Introduction of economic instruments

2.3 Recent trend of deliberations

Guidelines and guidance mentioned below related to the technical and operational measures were adopted at the MEPC59 held in July 2009.

(1) Interim guidelines on the method of calculation of the EEDI (MEPC.1/Circ.681)
(2) Interim guidelines for voluntary verification of the EEDI (MEPC.1/Circ.682)
(3) Guidance for the development of a SEEMP (MEPC.1/Circ.683)
(4) Guidelines for voluntary use of the EEOI (MEPC.1/Circ.684)

At the MEPC60 held in March 2010, discussions were held on the mandatory requirements for the EEDI and the SEEMP. Studies began on the proposal to amend the provisions of MARPOL ANNEX VI. Meetings attended by experts were held to evaluate the impact of the economic instruments on the maritime industry and the possibilities of implementing the methods proposed until now.

3. Improvement in energy efficiency by operational measures

Although a reduction in CO_2 emissions of ships has not yet become mandatory as of this moment, the voluntary implementation has deep significance not only from the viewpoint of environmental protection but also from the aspect of reducing fuel consumption, that is to say, reducing the operational costs. The improvement in energy efficiency by the operational measures does not accompany improvement in the hardware (equipment) aspect as in case of the technical measures; therefore, many measures can be adopted not only for new ships but also for existing ships. An overview of the procedure for improving energy efficiency by the operational measures according to the “Guidance for the development of a SEEMP” (hereafter called “SEEMP Guidance”) is described in this section.

3.1 Energy efficiency improvement cycle using the SEEMP

The items shown in Table 2 form one cycle. By implementing these items repetitively, energy efficiency can be improved according to the SEEMP guidance (this repetitive procedure is called the “energy efficiency improvement cycle” hereafter). Fig. 1 shows a model of the energy efficiency improvement cycle (voluntary reporting and review in the figure are described later in Sec. 3.2).

Table 2 SEEMP based procedures for improving energy efficiency

Item	Overview
Planning	Decide energy efficiency improvement measures after understanding the use of energy in the present state of the ship, and set the energy efficiency improvement goal. Decide the procedures and person in charge of implementing the energy efficiency improvements, and establish these as a system.
Implementation	Implement the energy efficiency improvement measures according to the plan.
Monitoring	Monitor the energy efficiency of the ship quantitatively. Monitoring must be performed continuously using a consistent method.
Self evaluation/improvement	Evaluate the impact of the energy efficiency improvement measures that have been implemented based on the monitored results. Feed back the evaluated results to the next energy efficiency improvement cycle, and aim for further improvement in efficiency.

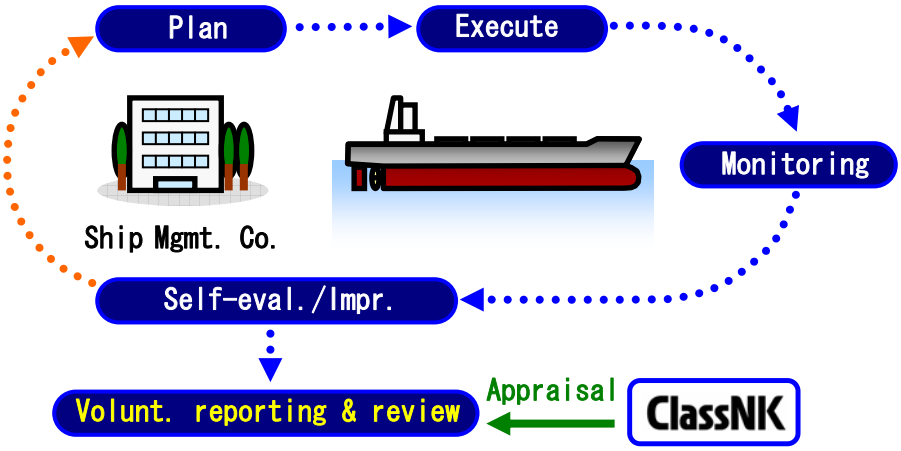


Figure 1 Energy efficiency improvement cycle

The SEEMP is a management plan for implementing the items shown in Table 2. The following items are to be written down according to the plan. These items are to be studied at the “planning” stage.

(1) Energy efficiency improvement measures deemed appropriate for each ship
(2) Description of monitoring tool
(3) Goal (measurable energy efficiency improvement goal)
(4) Self-evaluation procedure

Best practice guidance for (1) the energy efficiency improvement measures mentioned above, is included in the SEEMP guidance. Typical examples are given below. Table 3 shows examples of energy efficiency improvement measures mentioned in the SEEMP.

Table 3 Examples of energy efficiency improvement measures mentioned in the SEEMP

Efficiency improvement measure	**Implementation method (including day of start)**	**Responsible Person**
Weather routing	Conclude a contract for the use of weather routing system with service provider A. Start using the system from 1 July 2012.	Master is responsible for selecting the optimum route based on the information from service provider A.
Speed optimization	Planned speed (85 % MCR) is 19.0 knots, but the maximum speed is set at 17.0 knots. Start from 1 July 2012.	The Master is responsible for maintaining the speed. Entry in the log book to be checked daily.
⋮	⋮	⋮

Comprehensive examples for items (2) to (4) have not been given in the SEEMP Guidance; however, examples using EEOI as evaluation indicator are given as a (2) monitoring tool. The measurement method, frequency, person in charge and so on, related to data measured for monitoring (cargo quantity, fuel consumption, voyage distance, and so on) should be clearly indicated. Detailed values related to the goal in (3), such as annual mean EEOI, should be entered. Detailed procedures related to the evaluation procedure in (4) should also be entered, including validation of effects of energy efficiency improvement measures and evaluation of the realized goal.

By “implementing” the energy efficiency improvement measures sequentially according to the planned schedule in the energy efficiency improvement cycle, and by referring to the “monitoring” results of EEOI, the realization level of the set goal can be “self-evaluated” finally. However, in practice, it is preferable to validate the effects of the implemented efficiency improvement measures and the effects due to the operation by analyzing the monitored results periodically even during one cycle. The factors for variation in energy efficiency can be confirmed visually and easily by plotting the EEOI for each voyage as a trend graph, as shown in Fig. 2 for instance, in case of periodic

monitoring. In the example shown in Fig. 2, the said effect can be confirmed by superimposing the period of implemented energy efficiency improvement measures (hull cleaning) and the EEOI trend.

EEOI varies easily because of the effect of cargo volume or sea conditions. Therefore, the "Interim guidelines on the method of calculation of the EEOI" also touches on the use of a rolling average value for a fixed period as an evaluation indicator. In the example of Fig. 2, the EEOI per voyage varies considerably depending on the effect of the load index at that time. The rolling average for every 3 voyages evens out this effect, however, and makes it easy to understand the trend of the energy efficiency, as seen from the figure

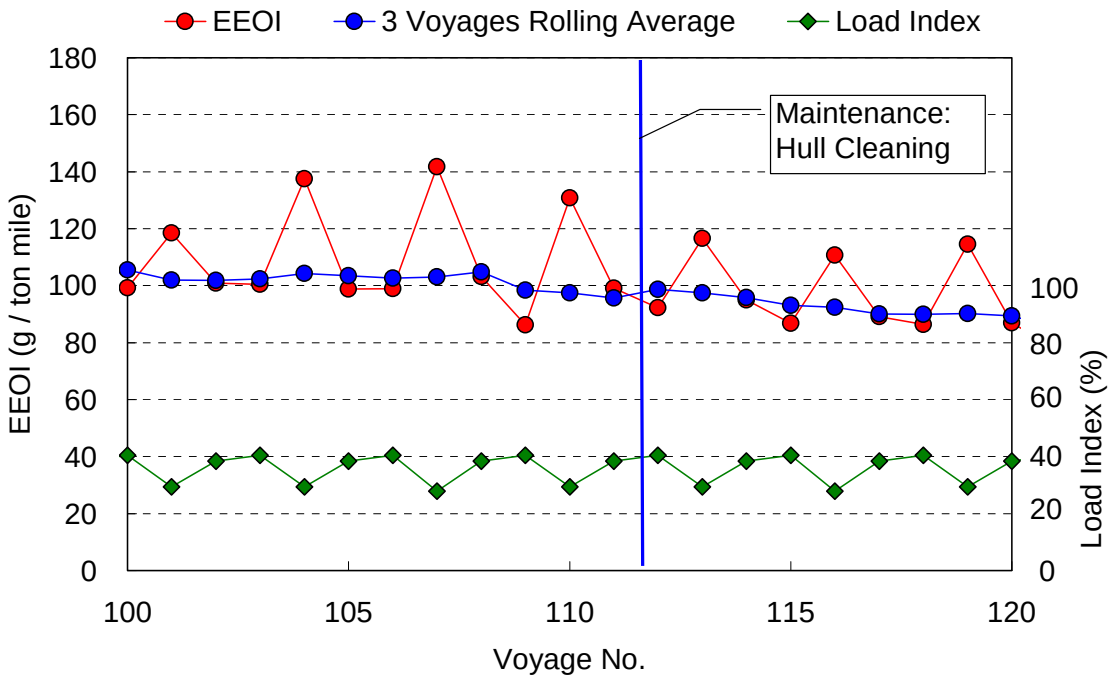


Figure 2 Example of trend graph of the EEOI (values are theoretical values)

3.2 Publishing the results of self-evaluation

The SEEMP Guidance mentions voluntarily publishing the self-evaluation results of the improvements achieved in the energy efficiency improvement cycle (voluntary reporting and review). This is suggested bearing in mind the various benefits received by the ship because of the Society's approval of ships with high energy efficiency. For instance, favorable treatment in port usage charges may be set for ships with high energy efficiency, that is to say, for ships that are environmentally friendly, especially in ports and harbors. A similar example is that recently, in some of the ports, measures have been adopted to reduce the port entry fees for ships with very little emissions of NOx or SOx. Moreover, because of the heightened interest of the society toward environmental protection, transportation means that give adequate considerations to the environment is likely to be demanded when companies manufacturing consumer products carry their products to the market.

In view of this background, it is preferable that a third party verify the results of published energy

efficiency. ClassNK has started therefore to offer partial appraisal services related to the energy efficiency indicator as typified by the EEOI. The approach of ClassNK to appraisal services is given in the following section.

4. Implementation of EEOI appraisal services

To offer more complete EEOI appraisal services, ClassNK is planning to offer a support system for calculating, analyzing and preparing reports related to EEOI. The development of this system has already started.

The data required for EEOI calculation is being accumulated in the Society's server either by input of data from the ship through Internet or by connecting to the existing electronic ABLOG system used by ship management companies. The calculated results can be output when required. The conceptual system configuration is shown in Fig. 3.

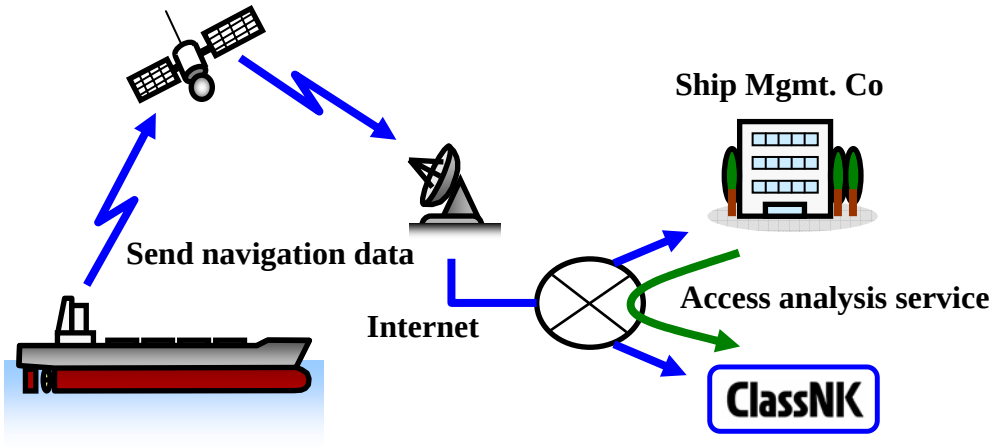
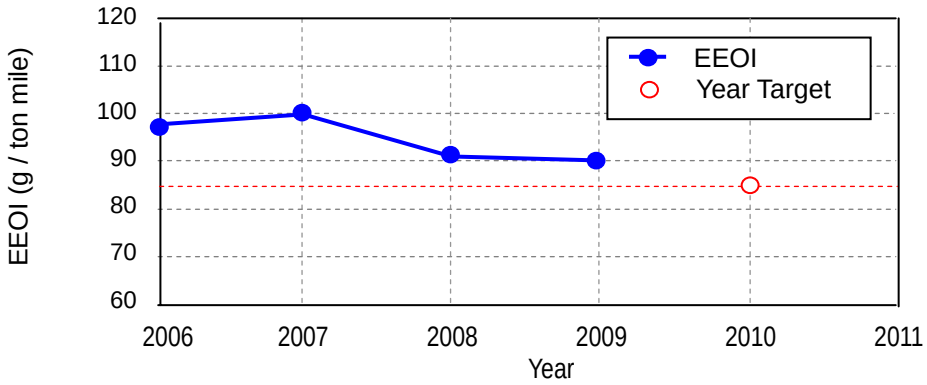


Figure 3 Conceptual diagram of system configuration

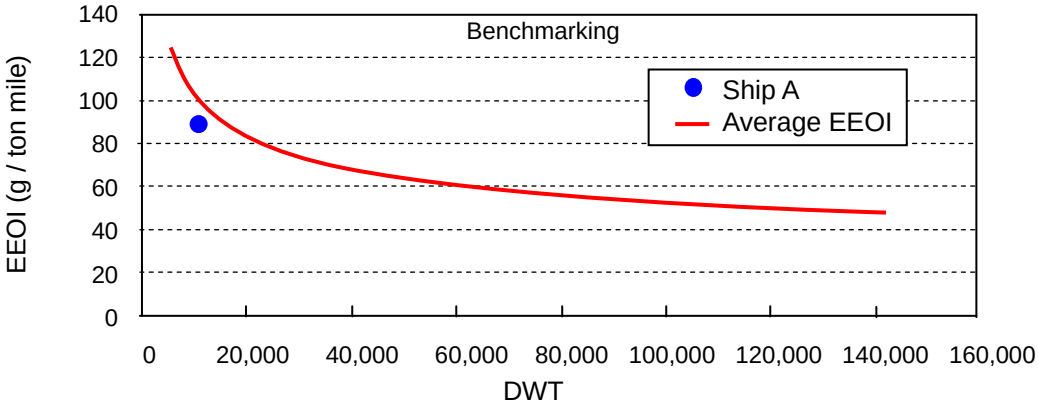
Procedures required for appraisal services can be simplified, and faster services can be offered by using this system. Various support functions for implementing energy efficiency improvements to the system are planned to be added. In addition to the EEOI calculation functions in Version 1, other functions scheduled to be added are as follows:

- EEOI trend graph display
- Support for setting energy efficiency improvement goals
- Benchmarks (comparison with mean values within the same ship type group)
- EEOI comparison within fleet
- Support for preparing various reports, etc.

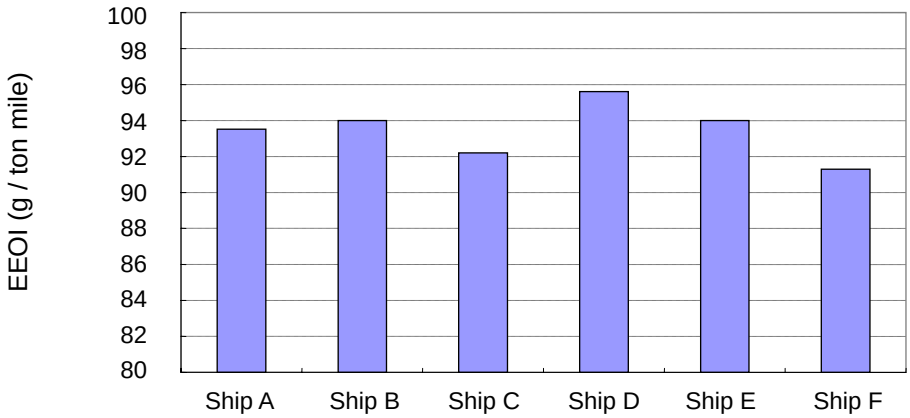
Fig. 4 shows the illustration of the output screen for a part of the functions. Functions for analyzing causes for the variation in EEOI are likely to be added henceforth. The system will be designed such that it can be used as a more effective support tool for implementing improvements in energy efficiency.



(a) Support for setting energy improvement efficiency goals



(b) Benchmarking



(c) Comparison of EEOI within fleet

Figure 4 Illustration of output screen of EEOI calculation system (Example)

- Joint R&D projects with industry on technical developments to reduce GHG -

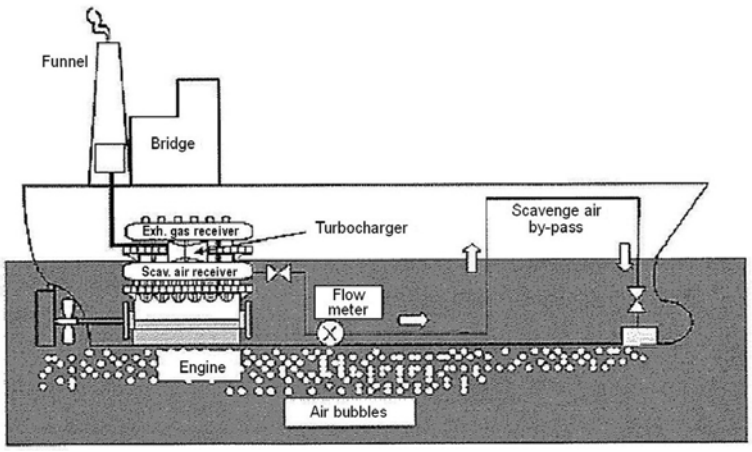
ClassNK has been implementing many R&D projects jointly with the industry. The Society has also been participating in many projects such as those related to the "Support for Technology Development for Curtailing CO_2 from Marine Vessels" (four-year program that started from 2009), meant for assisting the Ministry of Land, Infrastructure, Transport and Tourism. The said support project is classified as shown in Table 4 and extends over a wide range of fields. The Society is participating in 19 of the 22 projects. Table 5 gives an overview of these 19 projects.

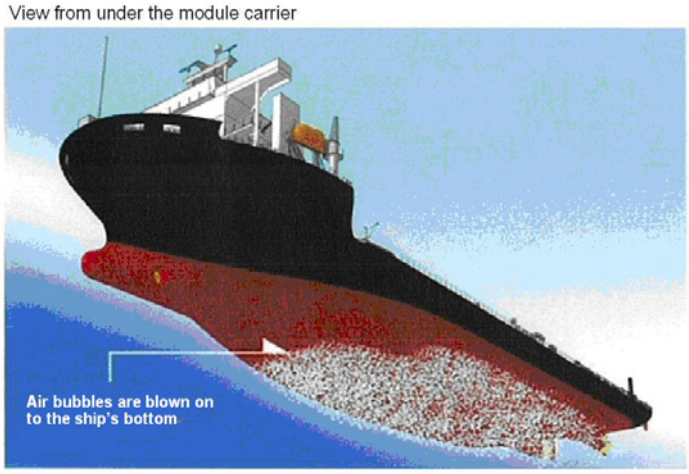
Table 4 Support for technology development for curtailing CO_2 from marine vessels and number of projects with ClassNK participation

Technical Field	No. of projects	No. of projects with ClassNK participation
(1) Development of hull form with minimum resistance and high propulsion efficiency	4	2
(2) Development of technology to reduce frictional resistance of hull	3	3
(3) Improving propeller efficiency	3	3
(4) Improving the efficiency of diesel engine, exhaust heat recovery	4	4
(5) More efficient operation and manoeuvring of ships	5	5
(6) Development of hybrid propulsion system	3	2
Total	22	19

Table 5 Overview of "Support for Technology Development for Curtailing CO_2 from Marine Vessels"
(only projects with ClassNK participation)

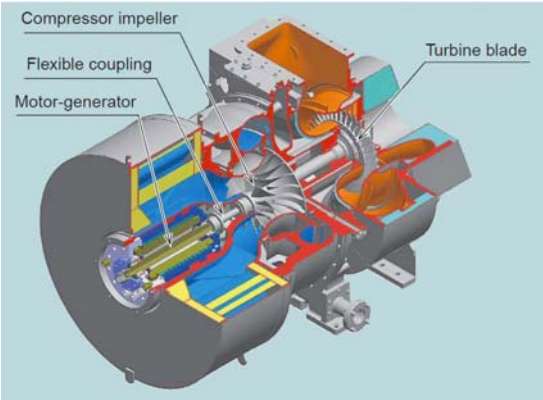
No.	Project Name
	Implemented by ("Co., Ltd." or "Inc." omitted)
	Overview
①-1	Research and development of hull forms suitable for CRP for reducing GHG
	IHI MU, IHI
	Contra-rotating propeller (CRP) has significant energy saving effects. This project aims to develop duct and hull form for enhancing the effects of CRP.[1)]

①-2	Research and development of mega container carrier capable of saving energy and reducing GHG
	IHI MU, IHI Diesel United
	In recent years, mega container carriers having very high engine output are anticipated to conserve energy and reduce fuel consumption (reduce GHG). The aim of this project[2)] is to develop an energy-saving container carrier capable of conserving energy more significantly than in the past through prototype testing and performance checks of twin-skeg hull forms, basic studies on high efficiency main engines, and studies on exhaust heat recovery technology.
②-1	Research and development of energy-saving technology for ocean-going ships by air lubrication method
	Oshima Shipbuilding, IHI MU, Imabari Shipbuilding, MTI, Kawasaki Shipbuilding, Sumitomo Heavy Engineering, Tsuneishi Holdings, Mitsui Engineering and Shipbuilding, Mitsubishi Heavy Industries, Universal Shipbuilding
	This project aims to validate the application of air lubrication method to ocean-going ships as effective energy-saving technology, and to establish a design method for ships using the air lubrication method. Together with the development of the air lubrication method, a design support system (design tool) for ships is to be developed using the same technology. An air supply system (gas scavenging system) using a turbocharger as the main engine is also to be developed. Individual technical topics are to be selected for realizing the air lubrication method and solutions for this method are to be studied.[3)]  Source: Kaiji Press 12 Nov. 2009

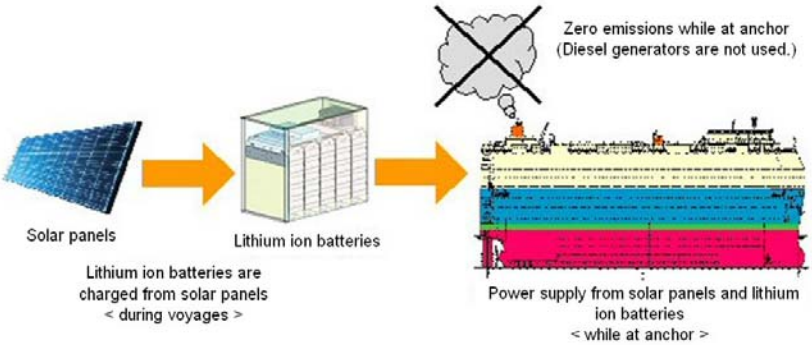
②-2	Tests to demonstrate the technology to reduce frictional resistance of large shallow draft twin-screw vessels
	Mitsubishi Heavy Industries, NYK, MTI
	In this project, tests are to be conducted to demonstrate the air lubrication system by blowing air on to the ship's bottom using blowers. For the first time, this system will be permanently installed on a ship, and CO_2 emissions are expected to reduce by approximately 10 %. The tests are to be conducted on a module carrier. The main features of the module carrier are wide beam and shallow draft among large ships. Thus, the water pressure is comparatively small, and the amount of power required by a blower to send air to the ship's bottom is small. Since the ship's bottom is flat and its width is large, air is likely to reside at the bottom part of the ship. The effect of reduction in CO_2 emissions can be validated easily through demonstration tests.[4)]  Source: MHI News Release, 24 Feb. 2010
②-3	Research and development of anti-fouling paint for bottom leading to very low fuel consumption
	Nippon Paint, Nippon Paint Marine, Mitsui OSK Lines
	The evolving type low-fuel consumption bottom anti-fouling paint "LF-SEA" developed by Nippon Paint and Nippon Paint Marine will be further developed and promoted in this project. The CO_2 emitted from a ship is because of fuel consumed during voyage. A major part of the fuel is consumed when frictional resistance is generated when the hull is in contact with sea water. Frictional resistance with sea water accounts for 50-80 % of the total resistance of a ship when underway. Reducing the sea water friction will directly contribute to reducing the fuel consumption. The aim is to reduce CO_2 emissions by more than 10 % compared to that of conventional anti-fouling paints through the development of very low-fuel consumption type bottom anti-fouling paint in which the low friction properties (low fuel consumption) of "LF-Sea" have been further improved and developed. The effects on ships in service will also be analyzed at the same time.[5)]

③-1	Research and development of limited small blade-area non-hub vortex (NHV) propellers
	Nakashima Propellers
	According to recent research, if the blade shape near the blade tips is designed properly, the blade surface area can be reduced and at the same time, cavitation erosion and increase in stern vibrations can be avoided. Such conclusions have been obtained from the results of model tests. Moreover, the non-hub vortex (NHV) propeller has been developed already, which leads to a reduction and elimination of hub vortex cavitation because of improved propeller efficiency. "Small blade area NHV propeller" will be designed after theoretical calculations and model tests for demonstrating the energy-saving effects of both small blade surface area and NHV when fitted to four ships for the purpose of verification in this project. After manufacture and conversion of actual propellers, comparative tests will be conducted on propellers fitted on actual ships to demonstrate that the new propeller has about 3 % energy-saving effect compared to the existing high performance propeller.
③-2	Research and development of energy-saving appendages using effects of interference between blades
	Shin Kurushima Dockyard
	Existing energy-saving appendages have been developed with the purpose of energy conservation by recovering the propeller rotational energy. However, in this project, development is being carried aiming to enhance propeller efficiency by mutual hydrodynamic interference effects between propeller blades and appendages. This kind of technology is being actively pursued for improving lift using the effects of interference between blades in the aeronautical field, such as by using a blade with flap. The number of blades in an energy-saving appendage is the same as the number of propeller blades. The diameter is assumed to be about 50 % that of the propeller diameter, and it is secured to the propeller boss by bolts. The propeller efficiency is increased by fitting the appendage and by reducing the propeller torque (increase in propeller thrust). The target is energy savings of about 3 %.[6)]
③-3	Development of load fluctuation stabilizer for periodic disturbance from weather and sea conditions
	NYK, MTI, Terasaki Electric, Kawasaki Heavy Industries
	The fuel consumption of a ship varies due to the main engine being affected by weather and sea conditions. The project aims to reduce fuel consumption of the main engine by equalizing load fluctuations, and developing a new control system for variable pitch propellers and shaft motor generators.[7)]

④-1	Research and development of CO_2 reduction technology for large low-speed marine diesel engines
	Mitsui Engineering and Shipbuilding
	CO_2 emissions are usually reduced using an exhaust heat recovery system combined with a high and low temperature exhaust separation system for large low-speed diesel engines (electronically-controlled engines). More specifically, 4-cylinder test engines (cylinder inside diameter: 500 mm) will be manufactured and various tests carried out. The new engine is likely to be similar to the actual engine, and have similar specifications as those of manufactured 15 years earlier.[6)]
④-2	Research and development of exhaust heat recovery system in marine diesel engines
	Yanmar
	The exhaust heat recovery system in large diesel engines is already in use on land and on ships. Steam is generated from the exhaust heat of the engine, and power is recovered by a steam turbine. However, in small engines, the efficiency of the steam turbine drops considerably, and cost also increases; so such a system has not been practically used in small engines. Research and development of highly efficient and economical steam expander and exhaust heat recovery system will be carried out in this project for use in small diesel engines used as auxiliary engines for power generation and as main engines in coastal vessels. The aim is to reduce the amount of CO_2 generated in the engine (amount of energy consumed) by approximately 6 %.[6)]
④-3	Research and development of next generation dual fuel engines for ship propulsion
	Niigata Power Systems
	European manufacturers have already developed the marine dual fuel (DF) diesel engine. Such engines have been used for power generation in large LNG ships, but have not yet been used in general cargo ships. The engine to be developed as part of this project is mainly for coastal vessels in which fuel tanks (gas) are ensured. The target is to manufacture medium speed engines with output up to 10,000 HP. Compared to conventional engines; the target is to reduce CO_2 by approximately 15 %.[6)]

④-4	Development of hybrid turbocharger technology applicable to marine vessels
	NYK, MTI, Universal Shipbuilding, Mitsubishi Heavy Industries
	The project involves equipping a Capesize bulk carrier (to be completed in 2011) with a hybrid turbocharger power generating system and proves its effectiveness. This power generating system consists of a small high speed generator and a power frequency converter within the turbocharger, which is installed on a low speed diesel main engine. The system can supply all the power needed on the ship during a normal voyage. The diesel power generator need not be operated during a normal voyage; therefore, reduction in CO_2 emissions may be anticipated.[7)]  Source: MHI Report Vol.44, No.1 (2007)
⑤-1	Research and development of voyage support system with the aim of reducing CO_2 emissions by optimized operation
	Universal Shipbuilding
	The voyage support system “Sea-Navi” that searches for the optimum route of a ship has functions to search for the optimum route for a voyage with the shortest distance and smallest fuel consumption, based on the sea and weather data, and based on the features of the hull and the main engine. An energy-saving effect through CO_2 reduction of 5 to 8 % approximately may be anticipated. Besides the above, it also contains a monitoring function that collects data of voyage conditions of the ship, a function to analyze the fatigue strength of the hull from the voyage data, and maintenance and management functions to estimate the structural life of a ship. The development of this software is almost complete, but demonstration tests will be carried out as part of this project by installing the system on many more vessels.[8)]

⑤-2	Development of international navigation control system
	NYK, MTI
	Efficient navigation is a prerequisite for reducing CO_2 emissions. In this project, development has started of a worldwide time-reservation system for berth window and canal passage. The introduction of an international port control system will enable vessels to further reduce their time at ports and to navigate at lower speeds. This project will also make use of international services when the system is implemented, and propose future roles for international navigation controls.[9)]
⑤-3	Research and development related to operational performance of vessels as they increase in size
	NYK, MTI, Japan Marine Science
	Currently, most pure car carriers in Japan have an overall length below 200 m. However, by making these vessels larger, the CO_2 emissions per car (CO_2 emitted for transporting a single car) can be reduced. In this project, the ability of pure car carriers of length above 200 m to navigate by keeping out of the way of other vessels (ability to avoid collisions) will be validated using simulation technology. Based on this research, the project will propose requisite technologies for large vessels so as to achieve the same level of operational performance as that of conventional vessels.[9)]
⑤-4	Research and development of “navigation support system”
	Oshima Shipbuilding, Kyushu University, Fluid Techno, Oshima Engineering
	This project aims to give support to the navigator for selecting the optimum route based on weather and sea data. At the same time, a navigation support system is to be developed to support optimum navigation in rough seas and in restricted areas.[10)]
⑤-5	Development of a system for monitoring ship performance
	NYK, MTI, NYK Trading, Kawasaki Technology
	A navigation monitoring system that will become the basic system for effective navigation featuring comprehensive integration between vessels and land operations will be developed in this project. This system accurately monitors the current conditions of the vessels from land, and suggests an appropriate speed for the vessel based on a specified standard. The project also aims to measure waves and ship motions more accurately, and to estimate their effects on the propulsion performance of ships.[7)]

⑥-1	Research and development of application technology for secondary batteries on ocean-going vessels using large-capacity nickel hydrogen batteries
	Kawasaki Shipbuilding, Kawasaki Heavy Industries, NYK, MTI
	This project aims to develop a hybrid power supply system by combining an existing diesel power generator and a new type of large capacity nickel hydrogen battery (Gigacell ® by Kawasaki Heavy Industries). Verification test devices will be installed on car carriers and tests will be carried out in the actual plying area.[7)] Source：Kawasaki Heavy Ind.　WEB SITE Gigacell ®
⑥-2	Research and development of CO_2 emissions reduction technology by hybridization of power systems in car carrier
	Mitsui OSK Lines, Mitsubishi Heavy Industries, Sanyo Electric
	This project aims to develop a hybrid power supply system formed by combining a solar power generating system and lithium ion batteries. The aim is to use natural energy more effectively, accumulate the electricity generated in the solar power generating system during voyages in the lithium ion batteries, and use these batteries while the ship is at anchor, so that the diesel engine can be stopped resulting in zero emissions while at anchor. The “hybrid car carrier” equipped with this system will be constructed (scheduled to be completed in 2012), and the effects of CO_2 emissions reduction will be validated and assessed by actual operation, with the aim of establishing effective CO_2 reduction technology in the future.[11)]  Source: Mitsui OSK Press Release，14 Jan. 2010

ClassNK is also participating in several joint R&D projects with the industry besides the support projects of the Ministry of Land, Infrastructure, Transport and Tourism. Table 3 shows the typical projects.

Table 6 Examples of joint R&D projects with the industry
(Other than the support projects of the Ministry of Land, Infrastructure, Transport and Tourism)

Name
Implemented by (“Co., Ltd.” or “Inc.” omitted)
Overview
Wind Challenger Project (Research and development of motor assisted wind driven vessel with large vertical sails)
University of Tokyo, Mitsui OSK Lines, NYK, Kawasaki Kisen, Oshima Shipbuilding, Teijin and others
This project aims to develop large area, high-lift flexible sails made of composite materials. Research and development of large motor-assisted wind driven merchant ship using such sails and its navigation method will be carried out with the aim of reducing the fuel consumption to one-third that of conventional merchant ships, and thereby contribute to low-carbon transportation of materials by sea.[12)] Source: “Conceptual design of wind-driven vessel aiming for low-carbon society”, Ouchi, Uzawa, JFOES, JASNOE, 21st Ocean Eng. Symposium, Aug. 2009

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(1) The Nippon Foundation website>List of projects>Research and development of hull forms suitable for contra-rotating propeller for GHG reduction 1-2 (in Japanese)

(2) The Nippon Foundation website>List of projects>Research and development of mega container ships conserving energy by GHG reduction 1-3 (in Japanese)

(3) Kaiji Press, 12 November 2009

(4) Mitsubishi Heavy Industries, Ltd., News Release, 24 February 2010 (in Japanese)

(5) Nippon Paint, 2010 News, January 25

(6) Kaiji Press, 30 November 2009

(7) NYK Line, News Release, 21 December 2009

(8) Kaiji Press, 11 December 2009

(9) NYK Line, News Release, 15 June 2009

(10) The Nippon Foundation website>List of projects>Research and development of navigation support system 1-4(in Japanese)

(11) Mitsui OSK, Press Release, 14 January 2010
(12) University of Tokyo website>Information>Press Release >Interview “Development of new motor assisted wind driven vessel for low CO_2 operation and inauguration of the Wind Challenger Program”