One-day International Workshop on Sustainable Transportation and Energy
- Leading-edge technologies and Policies –

Session 2: Policies for International Transportation
(2) Policies for Marine Transportation

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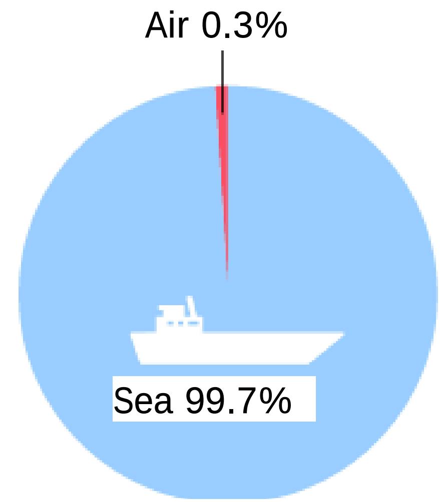
Contents

Maritime Transportation in Japan

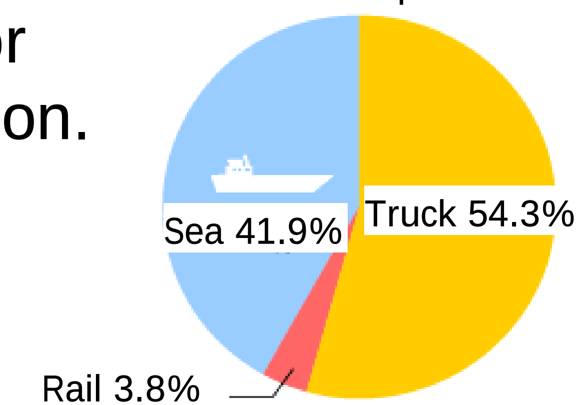
- More than 99 % of import and export cargo are transported by ship (in terms of ton)
  - Import is 800 million ton
    →about 26ton/sec, 6.5ton/year/citizen
  - 15% of world maritime trade volume

- Maritime transportation accounts for 40% of domestic cargo transportation. (in ton-km)

● Maritime transportation in import and export



● Maritime transportation in domestic transportation

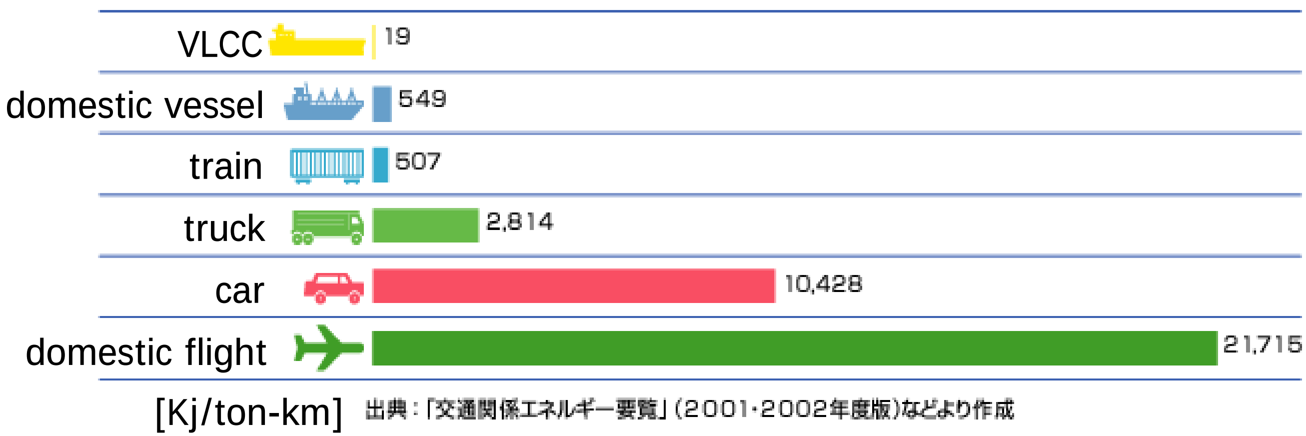


Source:日本船主協会 http://www.jsanet.or.jp/

Environment-friendly transportation

- Long-distance Mass transportation
  - The energy to transport cargoes per unit weight is low.
  - CO_2 emission is relatively lower than other transportation modes.

Necessary energy to transport 1 ton of cargo 1km (1999)



- Route maintenance is unnecessary, unlike for road, rail, etc.

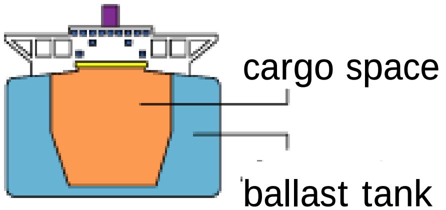
→ Environment-friendly transportation

Source:日本船主協会 http://www.jsanet.or.jp/

Environmental problems in shipping & shipbuilding industries

- Influence on the atmosphere
  - Global warming by CO_2 emission.
  - Atmospheric pollution by NO_x・SO_x emissions
- Oil spill in accidents at sea
  - Example： Exxon Valdez (1983), Nakhodka (1997)
- Bilge with hazardous liquid
- Discharge of polluted water and wastes to ocean
- Endocrine disruption from organotin antifouling paint on ship
- Bacterial carriage with ballast water
- Wastes resulting from ship scrapping
  - Asbestos , PCB materials, coating materials, lead, etc.
- Disposal of FRP ship

●Ballast water



Source :日本船主協会 http://www.jsanet.or.jp/ 他

Future prospect

- Assumption: Intergovernmental Panel on Climate Change's (IPCC) A1B scenario

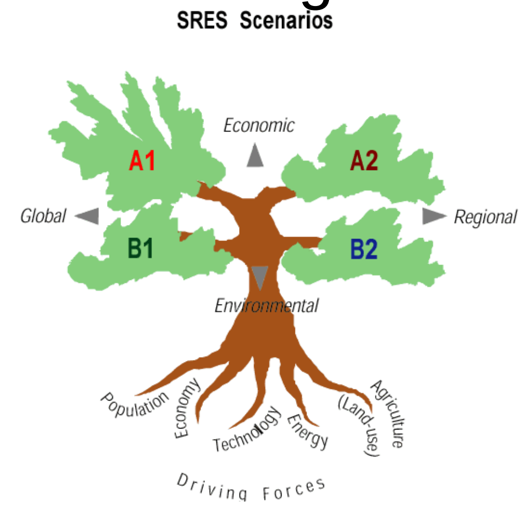
•The most probable scenario

A1. After rapid economic growth continues, world population achieves a peak in the middle of 21st century, and new and highly efficient technologies are rapidly introduced. This scenario is subdivided into 3 scenarios: fossil energy source-oriented (A1FI), non-fossil energy source-oriented (A1T), all energies' source balance-oriented(A1B).

A2. This scenario focuses on divergence of regional economic development. Economic growth per person and innovation progress are not the same with each other and are more gradual, as a whole than, other scenarios.

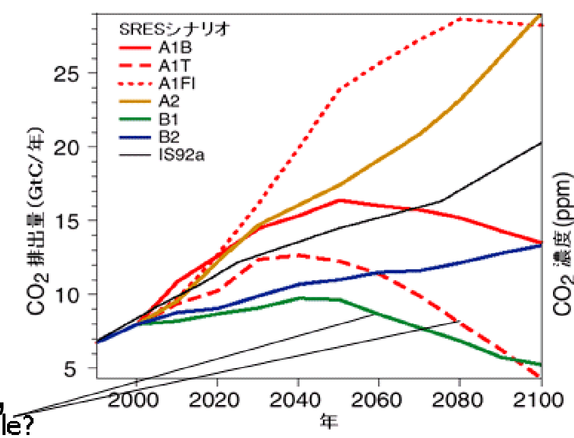
B1. Regional gap becomes small. Economic framework rapidly changes to service and information-based economy. Materialism is reduced and clean resource-saving technologies are introduced.

B2. This scenario focuses on regional measures to secure sustainability of economy, society, and environment. World population increases at a slower rate than A2 scenario and economic development stays at the moderate level.



Emission Scenario, 2001 IPCC Report (SRES 2000)

- OPRF model: A1B scenario
  - Models which are based on IPCC's A1B scenario, of forecasting models made by Ocean Policy Research Foundation (OPRF)



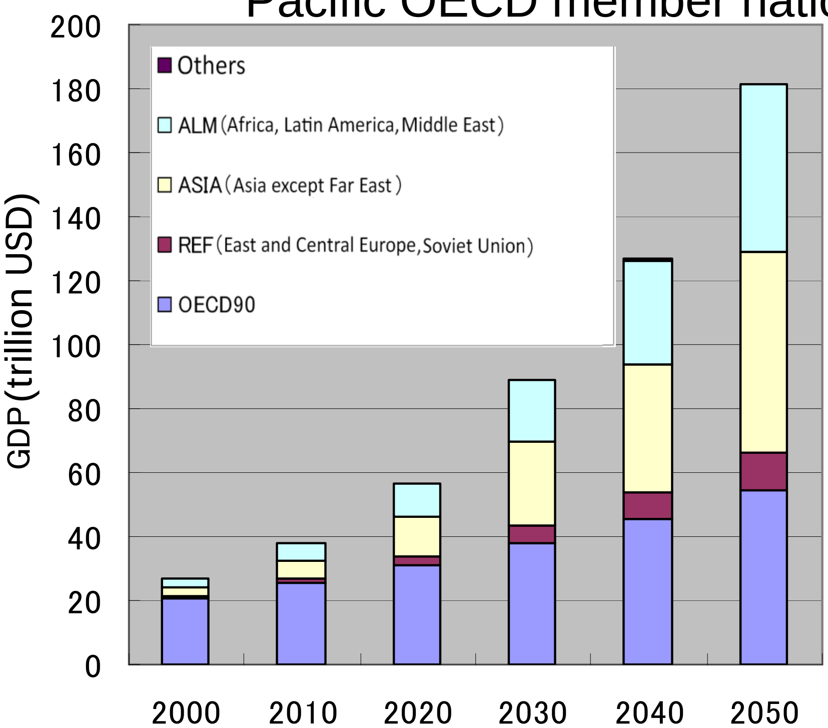
Acceptable?

CO_2 emission Forecast by each scen

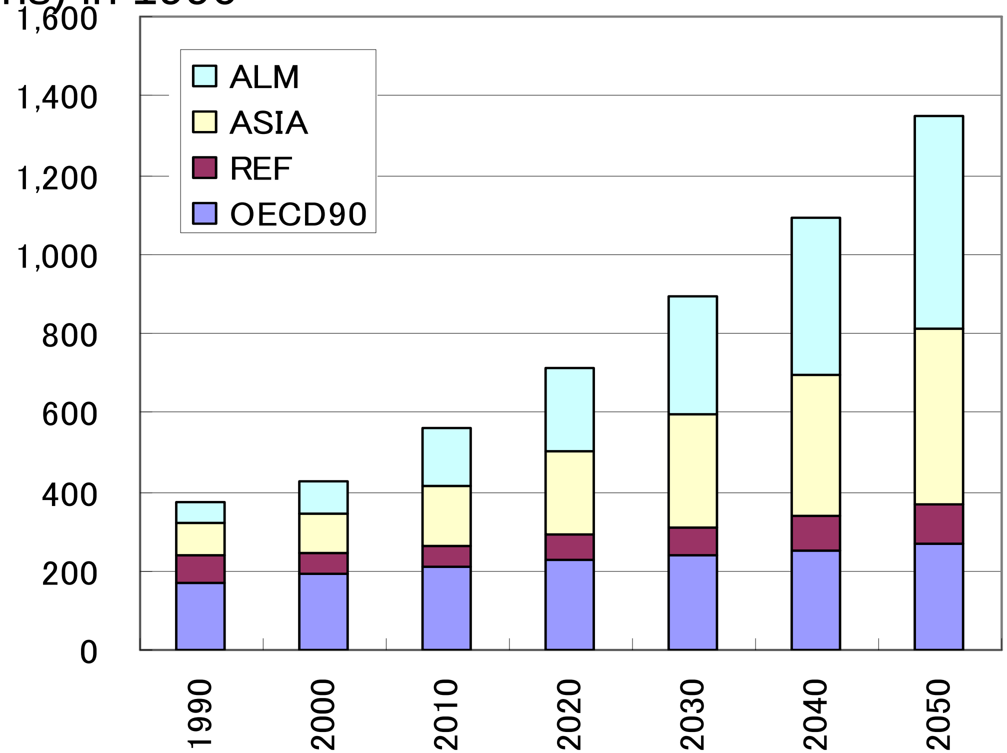
2. Future of Shipping & Shipbuilding Industries

Future prospect

- World GDP and energy forecast
  - Forecast of IPCC's A1B scenario
    - Note：OECD90：OECD member nations (North America, Western Europe, Pacific OECD member nations) in 1990



Regional GDP transition forecast

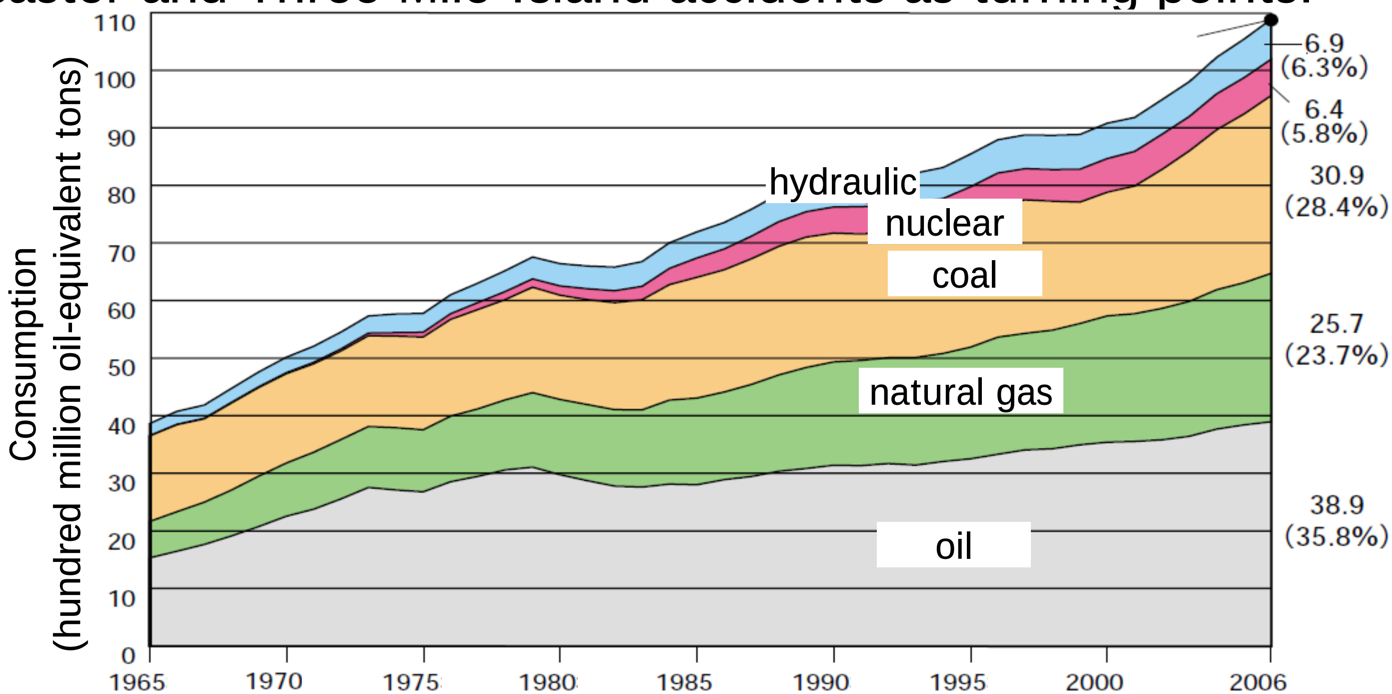


Regional energy demand transition forecast

Source :海洋政策振興財団、平成19年度 世界における海事産業の変革ビジョンに関する調査研究報告書

Future prospect

- Transition of world's production of primary energy
  - In recent years production of electricity by nuclear power is moving sideways because of rising anti-nuclear movement with the Chernobyl disaster and Three Mile Island accidents as turning points.

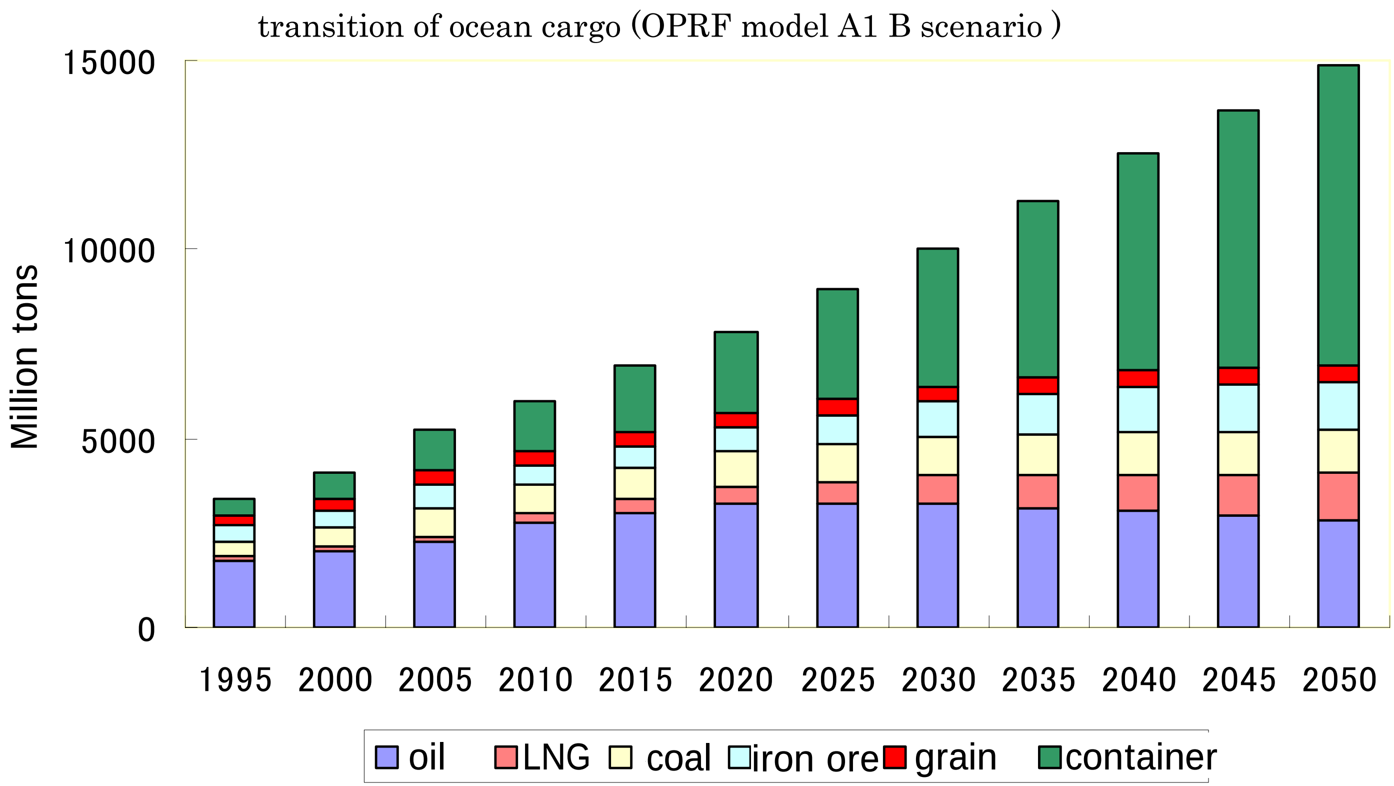


Transition in world's primary energy production

Source:電気事業連合会 原子力・エネルギー図面集2008年版

Future prospect

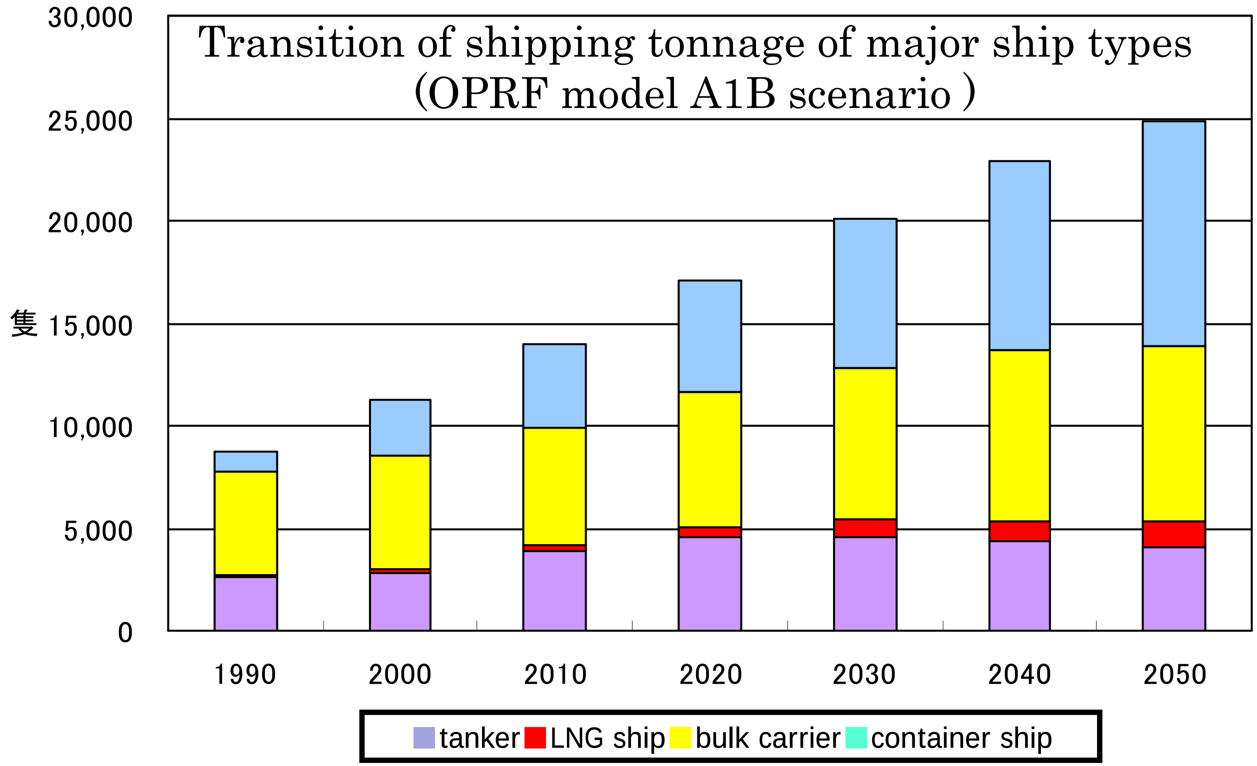
- Global prospects of maritime cargo amount
  - Resources and energy transport does not increase because of finite reserves. Container shipping volume continues to rise because it is presumed that ”GDP growth rate = container cargo volume growth rate”.



Source :海洋政策振興財団、平成19年度 世界における海事産業の変革ビジョンに関する調査研究報告書

Future prospect

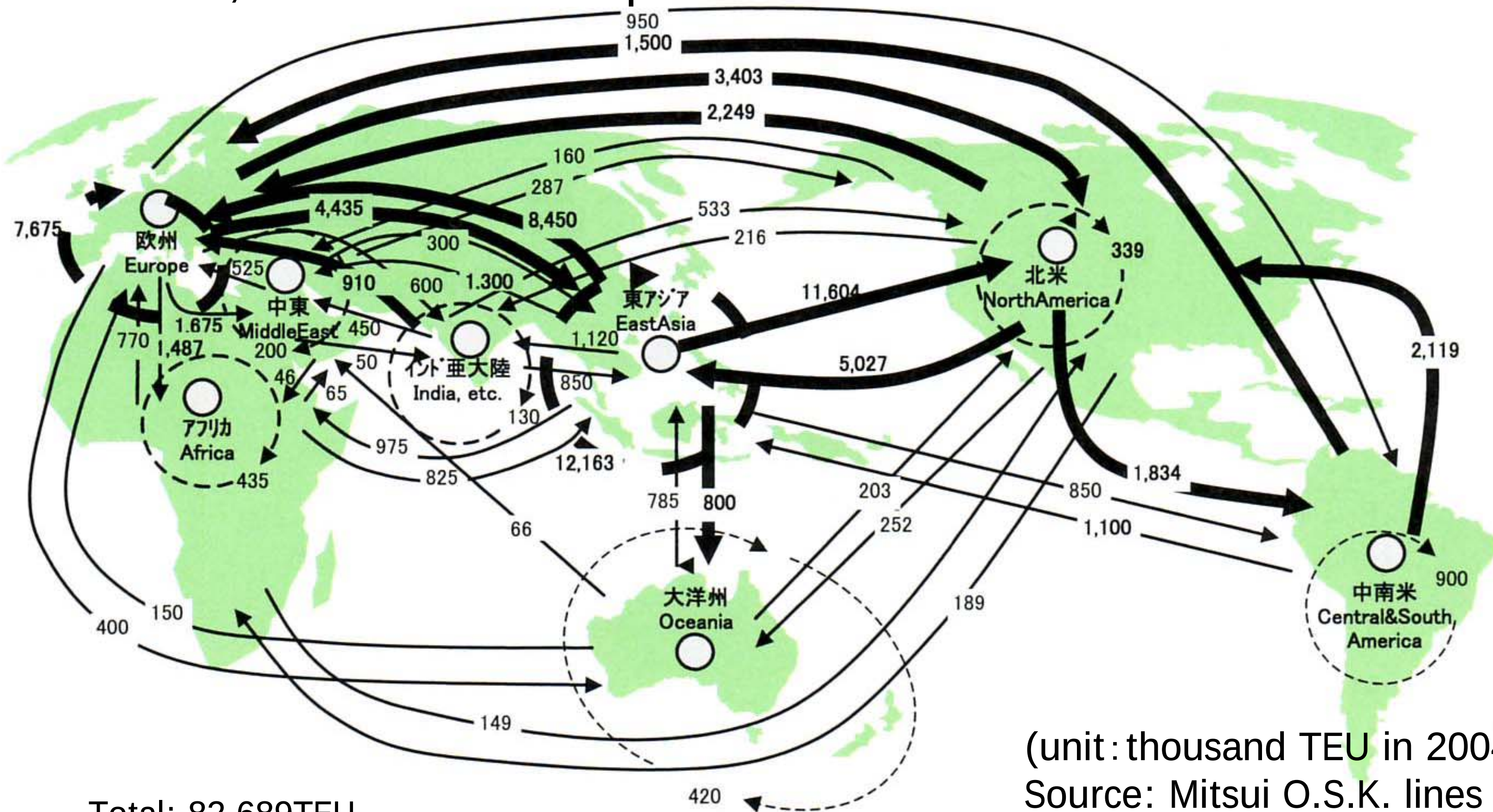
- World's shipping tonnage demand prediction
  - Transportation volume and travel distances are considered
  - Type of ship will be estimated from correlation between cargo amount (TEU) and average DWT



Source :海洋政策振興財団、平成19年度 世界における海事産業の変革ビジョンに関する調査研究報告書

Movement for the future

- Global movement of containers
  - How will transportation system shift due to changes in OD locations, traffic volume, and canal development?

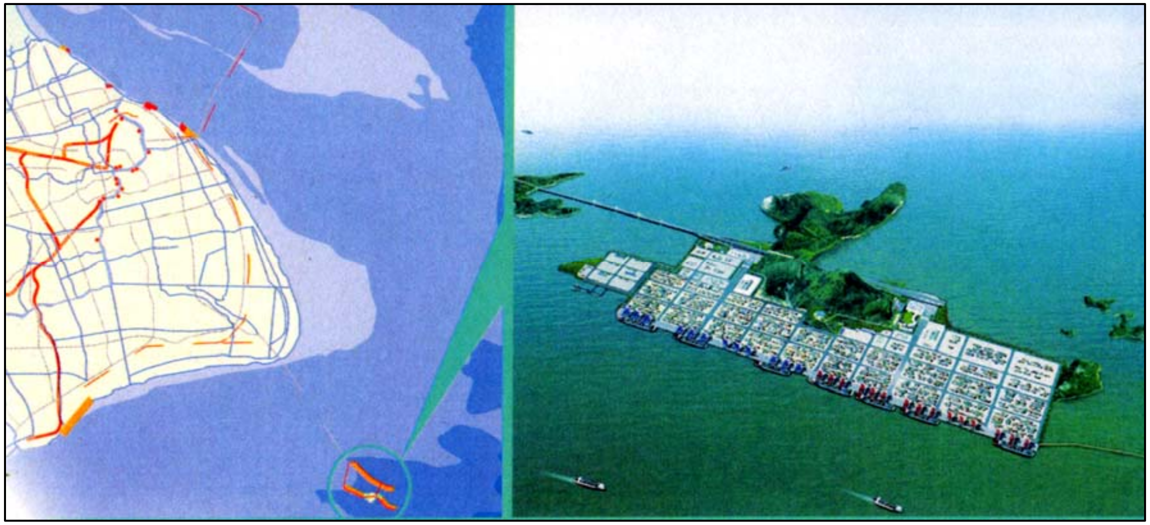


(unit：thousand TEU in 2004)
Source: Mitsui O.S.K. lines

Total: 82,689TEU

Movement for the future

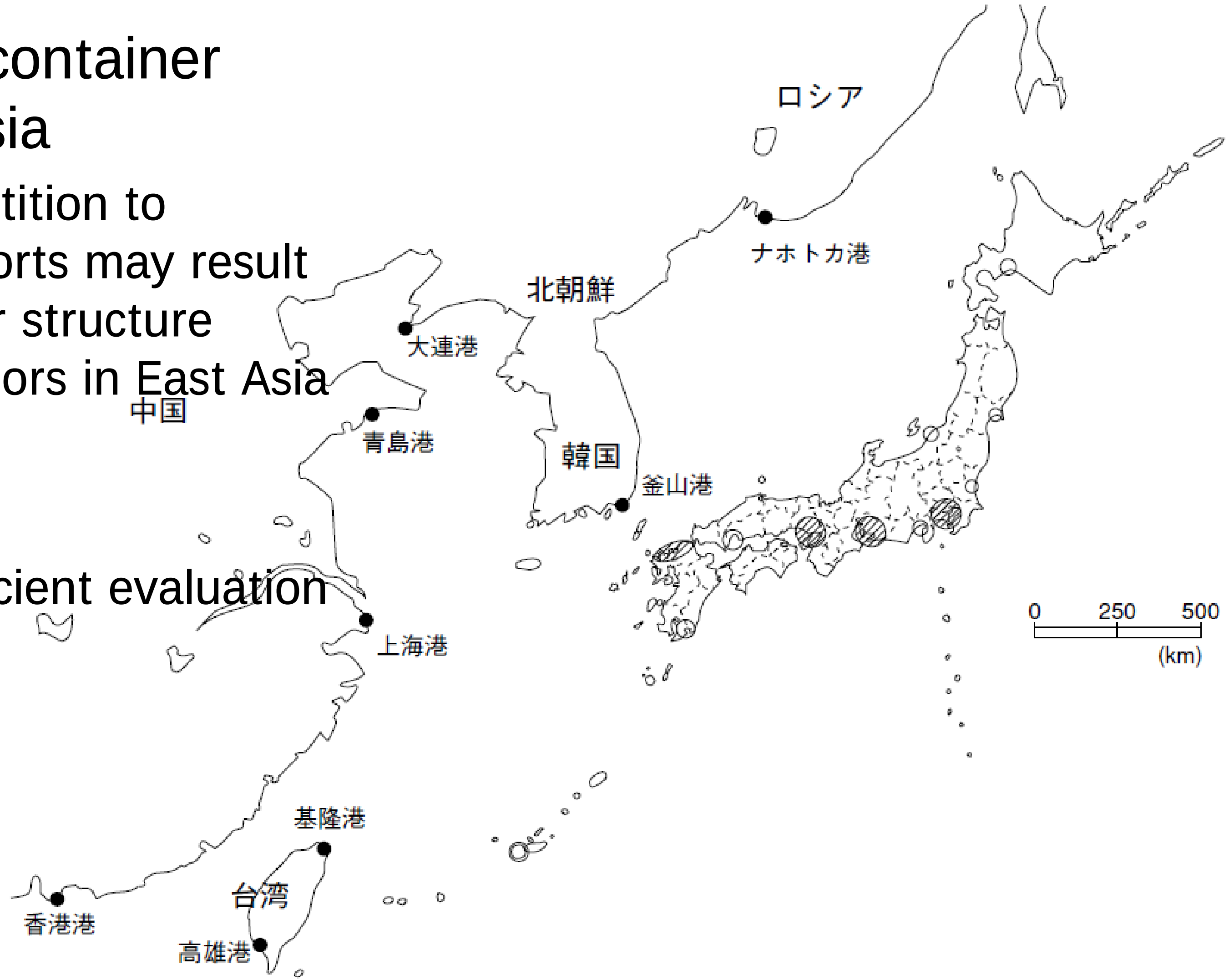
- Yangshan Port (Shanghai)
  - Large container port located 30km off the coast of Shanghai. Port is connected to mainland China by a 30-km long bridge
  - Built starting from 2002, aimed to be a main hub-port of East Asia.
  - If completed in 2020, this port can handle 25M TEU/year.
    - Note: Total number of containers that all Japanese ports handle in 2005 is 16M TEU.



Source :上海国際港務有限公司（SIPG）パンフレット

Movement for the future

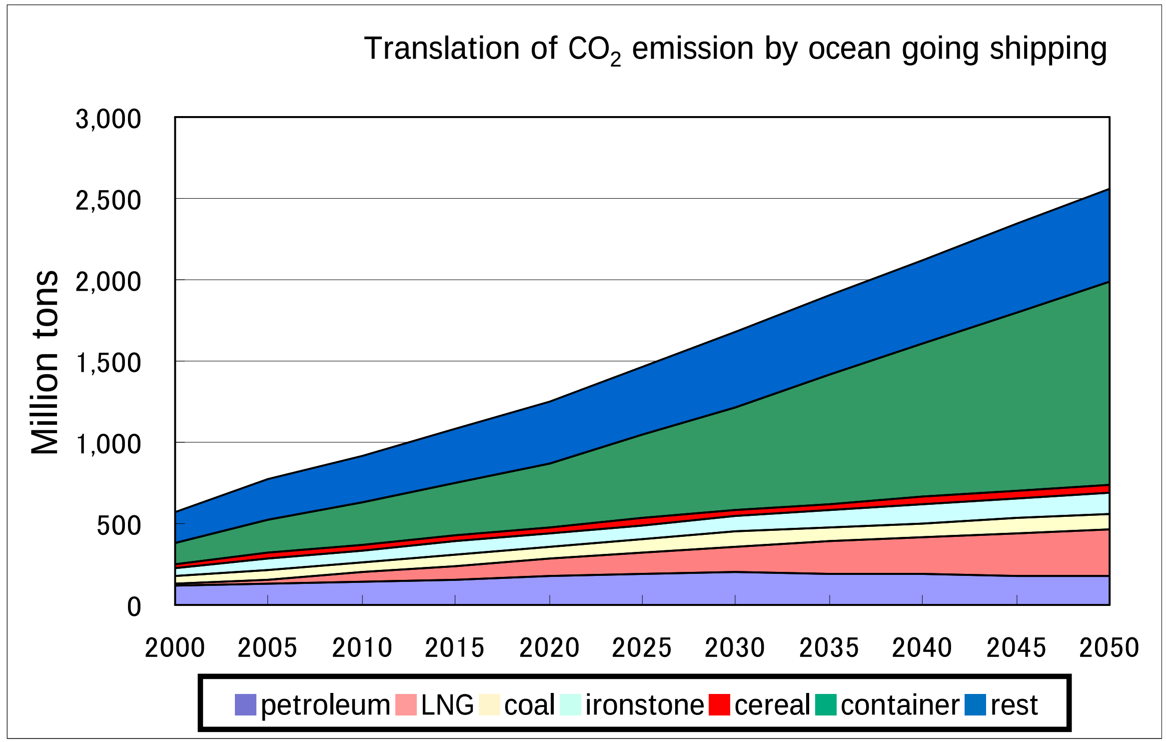
- Main ports for container ships in East Asia
  - Intense competition to become hub ports may result in major power structure change in harbors in East Asia
  - However, sufficient evaluation is still needed.



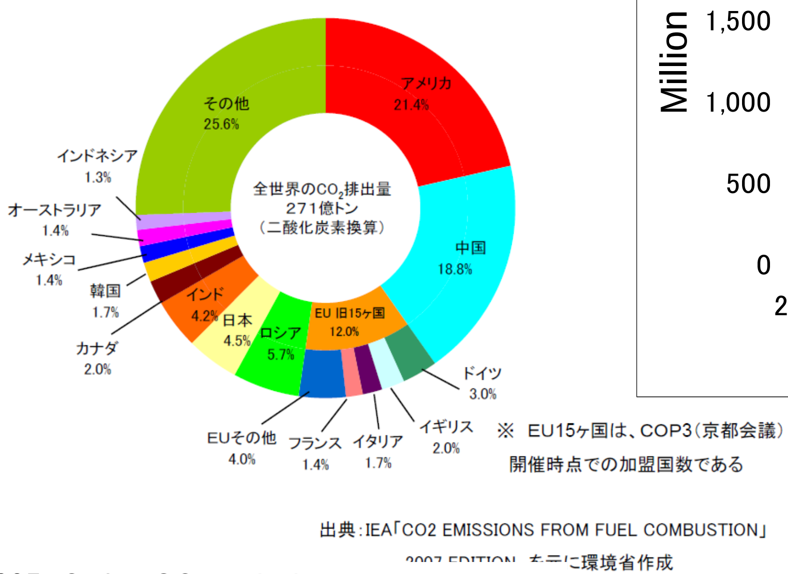
（資料）「大交流時代を支える港湾」運輸省港湾局

CO_2 emission by Ocean-going Vessels

- About 800M tons CO_2 emission of ocean-going vessels (2005)
  - 3% of total emissions
  - 2.6B tons in 2050; more than 80% abatement needed to reduce by half



Estimation of CO_2 emission（A1B scenario）



2005 Global CO_2 emission

Source：海洋政策振興財団、平成19年度 世界における海事産業の変革ビジョンに関する調査研究報告書

CO_2 emission by Domestic Vessels

- **The proportion of transport sector** is about **20％**
  → proportion slightly increasing
  - Breakdown of transportation: car = 90%
    ship = 3.1%

CO_2 emission in domestic Japan

単位；10^3t-CO_2

Fiscal year		1990	1991	1992	1993	1994	1995	1996
1A Fuel combustion								
1A1 Energy industry		77,449	78,491	79,608	78,966	83,215	82,695	82,582
1A2 Manufacturing		455,647	452,381	441,981	435,865	454,921	455,163	461,877
1A3 Transportation		213,780	223,251	228,317	230,127	241,368	248,547	254,815
1A4 Private & Primary		297,292	306,692	318,989	311,868	332,297	338,462	335,707
1A5 Others		8,792	11,946	16,314	7,570	21,498	13,284	17,183
Total		1,124,532	1,147,845	1,162,314	1,143,794	1,213,940	1,220,218	1,234,904
1A3 composition	Road	90%						91%
	Sea	3.2%						3.1%
	Air	1.1%						0.9%
	Rail	5.7%						5.1%
Reference info.								
Bunker oil		30,806	33,036	34,095	36,688	37,494	37,328	32,420
Oceangoing (in 200NM)								6,022

日本国政府；IPCC 第二回通報、第三回通報などより作成

Source :シップ・アンド・オーシャン財団,船舶から発生するCO_2の抑制に関する調査研究,1999

Physical unit of CO_2 emission

- Ship CO_2 emission calculation

$$CO_2 emission\ (kg) = \frac{FCR}{\rho} \times NCR \times t \times ER$$

FCR : Fuel consumption rate (0.125kg/hp.hr)
ρ : Density of heavy oil (0.96kg/l)
NCR : Normal consumption rate
(0.85-0.90% of max engine performance)
t : Voyage time (hr)
ER : CO_2 emission rate (kg/l)

CO_2 emission rate of different fuel types

Energy	ER	Unit
Gasoline	2,320.9	kg-CO_2/kl
Kerosene	2,464.0	kg-CO_2/kl
Light oil	2,623.0	kg-CO_2/kl
Bunker A	2,709.4	kg-CO_2/kl
Bunker B	2,847.6	kg-CO_2/kl
Bunker C	2,987.8	kg-CO_2/kl
LPG	3,004.6	kg-CO_2/kl
Electric power	0.3471	kg-CO_2/kWh

Source :経済産業省「CO2 排出削減量の算出方法について」

International trend for global warming

Trend of UNFCCC

＜Outline of COP 13＞

- Made a consensus to determine new framework in COP15 (will be held in 2009)
- Set the AWG to promote discussions and make the "Bali roadmap"
- Shipping is not to be incorporated in the roadmap, because of the differences in recognition between developed countries and developing countries' toward "Common but Differentiated Responsibility. "

＜Stance of each country＞

- **EU**: Needs a UNFCCC's leadership, not considering preceding with the deliberation in IMO since 1997
- **US**: Opposes to sum total control
- **China**: Should be compliant with "Common but Differentiated Responsibility" criterion
- **Oil countries**: Go on ahead, need discussions for Co_2 emission reduction of developed countries

UNFCCC

- COP13 2007/12 @: Indonesia
- COP14 2008/12 @: Poland
- COP15 2009/12 @ Denmark Consensus for new framework
- 2010～2012 Acceptance period for new treaty
- 2013～ New framework for post Kyoto protocol

Progression report at IMO

Progression report at IMO

IMO

- MEPC57 (2008/3)
- GHG mid conference (2008/6)
- MEPC58 (2008/10)
- MEPC59 (2009/7)
- General convention (2009/11)

Trend of IMO

＜ Decision in 23rd Assembly meeting (2003) ＞

① Set the criteria year to discuss reduction in the amount of emission

② Deliberations for reduction method by means of technical, operational and economical treatment

By decision of COP14, begin the substantial deliberation for reduction package by IMO

Developing countries (China etc)

IMO should make an effort to reduce CO_2 but should be compliant with the "Common but Differentiated Responsibility " criterion

EU

In case where there is no proceedings in IMO by 2009, give suggestions on approaches to the emission trade scheme towards a ship which enters the region.

UNFCCC: United Nations Framework Convention on Climate Change, COP: Conference of Parties
IMO: International Maritime Organization, MEPC: Marine Environment Protection Committee

Source: 国土交通

Envisaged Schedule

		2009	2010 onwards
1st Pack	EEDI SEMP	**Non-Mandatory Instruments** ◆ **EEDI Guidelines** (incl. verification guidelines <Japan + Norway 59/4/36>) ◆ **SEMP Guidelines** <Japan + U.S. 59/4/33> **Trial** → ◆ **Draft Legal Text for reference** <Japan + Norway 59/INF.26>	**Discussion on mandatory application**
2nd Pack	MBI	**Discussion on various proposals** ◆ **ETS** <France, Germany, U.K.> ◆ **International GHG Fund** <Denmark> and **its Variation** <Japan 59/4/34>	**Continues** →
Target Setting		◆ **Utilize Marginal Abatement Cost Curves** <Norway> ◆ **Efficiency Improvement** <Japan>	**Continues** →
UNFCCC		**Report** → **COP15**	

Stance of our country in reducing CO_2 emission in terms of international maritime transportation

International maritime transportation market features

- Single world market
- Because of global economic growth, trend in shipping amount keeps on increasing
- Maritime transportation is the most efficient transportation mode. Through the modal shift, it can focus on CO_2 emission reduction.

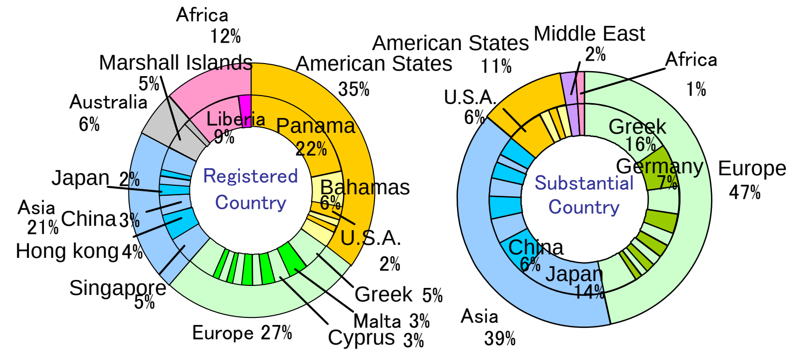
Basic line of action

- It is important for international shipping markets to reduce CO_2 emission
- Needs leadership of IMO
- Should be mindful of the feature of maritime transportation, which is its having low environmental burden
- Requires a framework which is acceptable to all country
- Should pursue energy efficiency

Action

To IMO, propose an index for evaluating individual vessel's CO_2 emission

Detail of main countries (gross ton base)

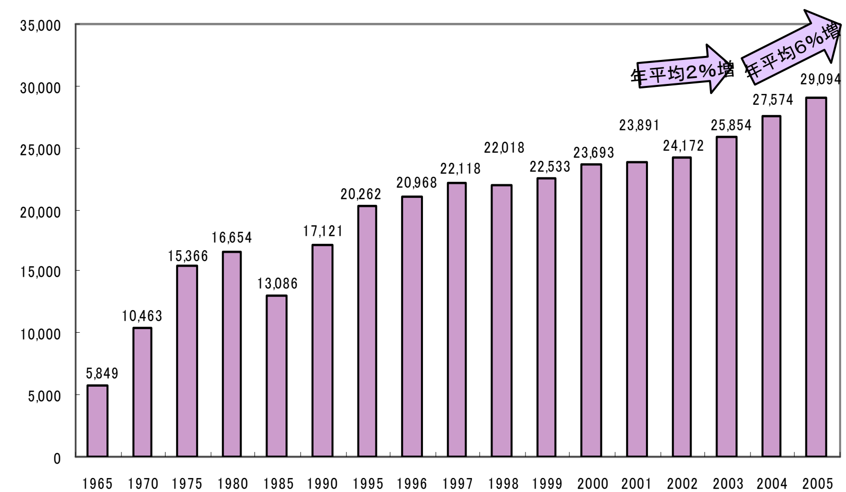


- Share of countries responsibility for emission reduction
  - Ship's registry base: 18%
  - Rule ship base: 55%

Source: 2005 Lloyd's Maritime Information Service

Global shipping amount

（10億トンマイル）



- About 6% of the CO_2 emission in the world
  （About 800M ton : This amount is similar to emission amount of Germany）
- Recently, shipping amount is rapidly increasing
  （about 6% per year）。

Source :ファンレイズ社「REVIEW」より作成

Approach to reduce CO_2 emission in international maritime transportation

Suggestion to IMO

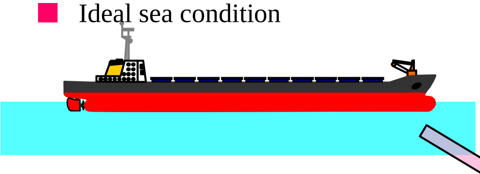
In actual sea conditions,

CO_2 emission of ship performance is defined as

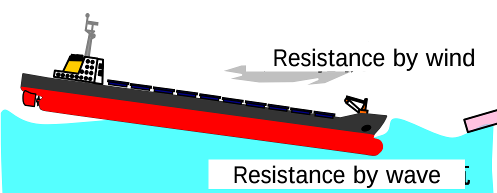
$$CO_2 \text{ emission (g/ton·mile)} = \frac{\text{Actual fuel consumption rate (g/h)} \times CO_2 \text{ emission rate}}{\text{Deadweight (ton)} \times \text{Actual speed (mile/h)}}$$

The necessity of Index of actual fuel consumption

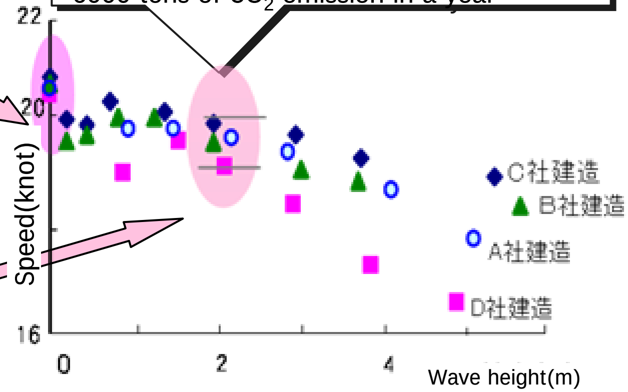
■ Ideal sea condition



■ Actual sea condition



Due to mean wave height in the North Pacific Ocean, there is an increase of about 6000 tons of CO_2 emission in a year



The efficacy of Index of actual fuel consumption

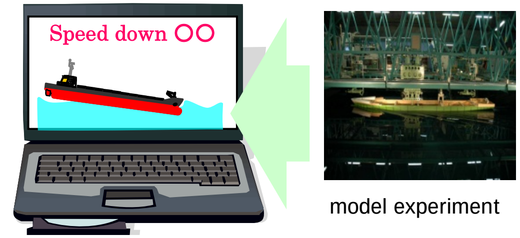
○ the incentive for introduction of energy-saving ship
→ To shipping company, etc.

○ the incentive for building and designing of energy-saving ship
→ To ship building company, etc.

Future plan

10mode of the sea

● Development of calculation methodology about index of actual fuel consumption



model experiment

Set wind , wave, ship → Evaluate by means of simulation

● With the help of the shipping industry, actual experiments using about 20 ships (from 2008) were conducted.

Improving ship energy efficiency → CO_2 emission reduction

Source国土交通省

Courtesy of Mr. S. Ohtsubo, MLIT

Measures for CO_2 Emission Reduction

CO_2 Emissions (g) = Activities (ton-mile) × Efficiency (g / ton-mile)

Components of Emission Reduction

Emission Reduction =

A Reduction of Activities

B Improvement of Efficiency

B-1 Technical Measures: Hardware improvement

(Improved Hull, Waste Heat Recovery, Renewable Energy)

B-2 Operational Measures:

(Speed Reduction, Higher Loading factor)

2nd Generation

<New & Existing Sips>

Market-based Measures

- Emission Trading Scheme
- Fuel Levy
- Modified Form of Fuel Levy

Promote All Measure

1st Generation

Promote Technical Measure

<New Ships>

EEDI (Energy Efficiency Design Index)

- **Certificate (e.g. EEDI = 5.0 g / ton-mile)**
- **EEDI Requirement**
  (EEDI < Baseline, e.g. EEDI < 5.5)
- **Baseline will be lowered in phased way**

Promote Operational Measure

<New & Existing Ships>

SEMP (Ship Efficiency Management Plan)

- **Develop SEMP for ship and company**
- **Monitoring of EEOI (Energy Efficiency Operational Indicator)**

Concept of EEOI and EEDI – Part 1

EEOI (Energy Efficiency Operational Indicator)

EEOI indicates the efficiency that was achieved in actual operation, calculated by "*Fuel Consumption*", "*Cargo Mass*", and "*Sailed Distance*".

$$\underset{\text{(g/ton mile)}}{\textbf{EEOI}} = \frac{\text{Actual Fuel Consumption} \times C_F}{\text{Cargo Mass} \times \text{Sailed Distance}}$$

Actually achieved Efficiency

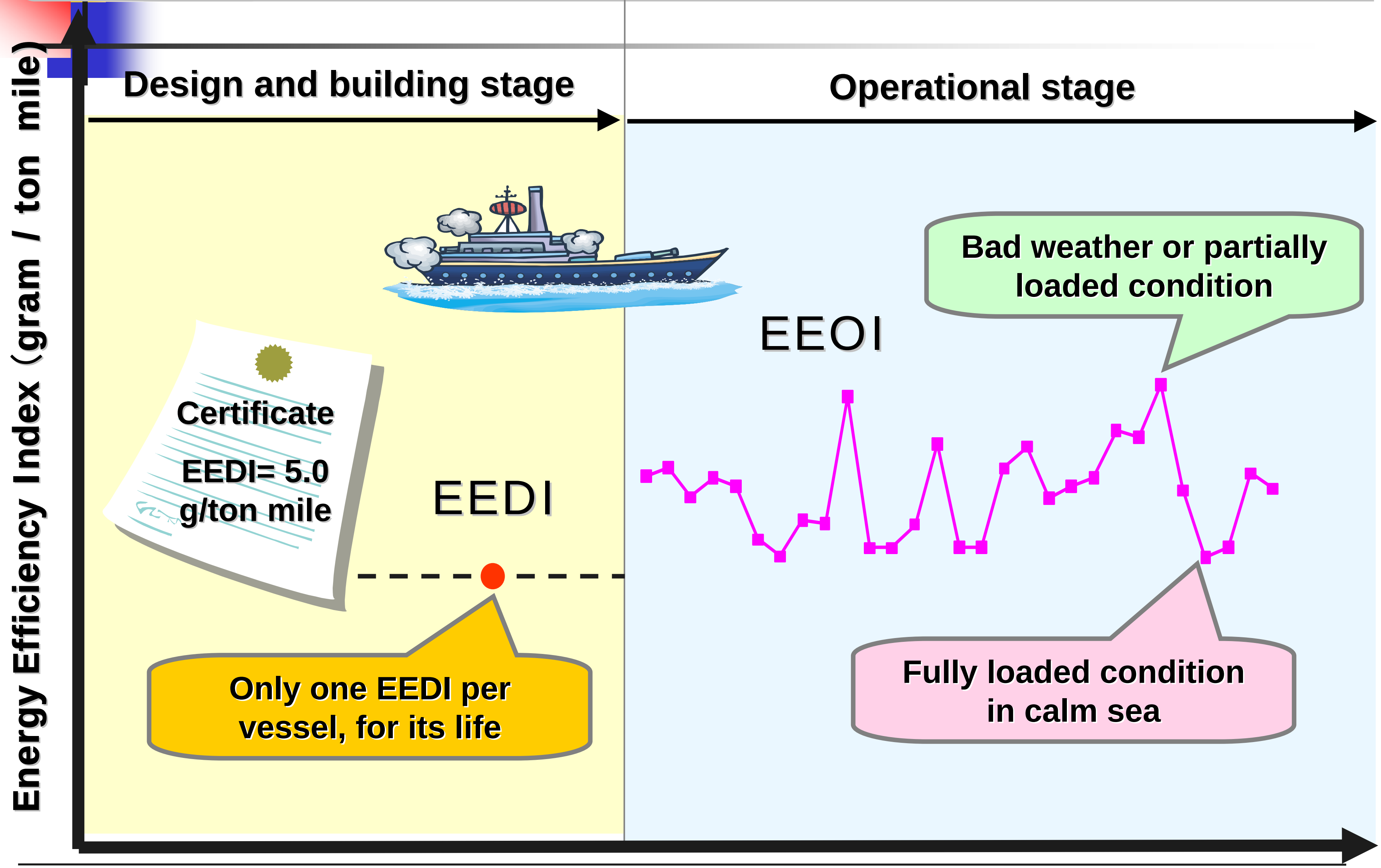
EEDI (Energy Efficiency Design Index)

EEDI indicates the efficiency that is expected for a ship to achieve, based on the ship specifications, calculated by "SFC X Engine Output", "DWT", and "Speed".

$$\underset{\text{(g/ton mile)}}{\textbf{EEDI}} = \frac{\text{Engine Power} \times \text{SFC} \times C_F}{\text{Capacity(dwt)} \times \text{Speed}}$$

Efficiency "potential"

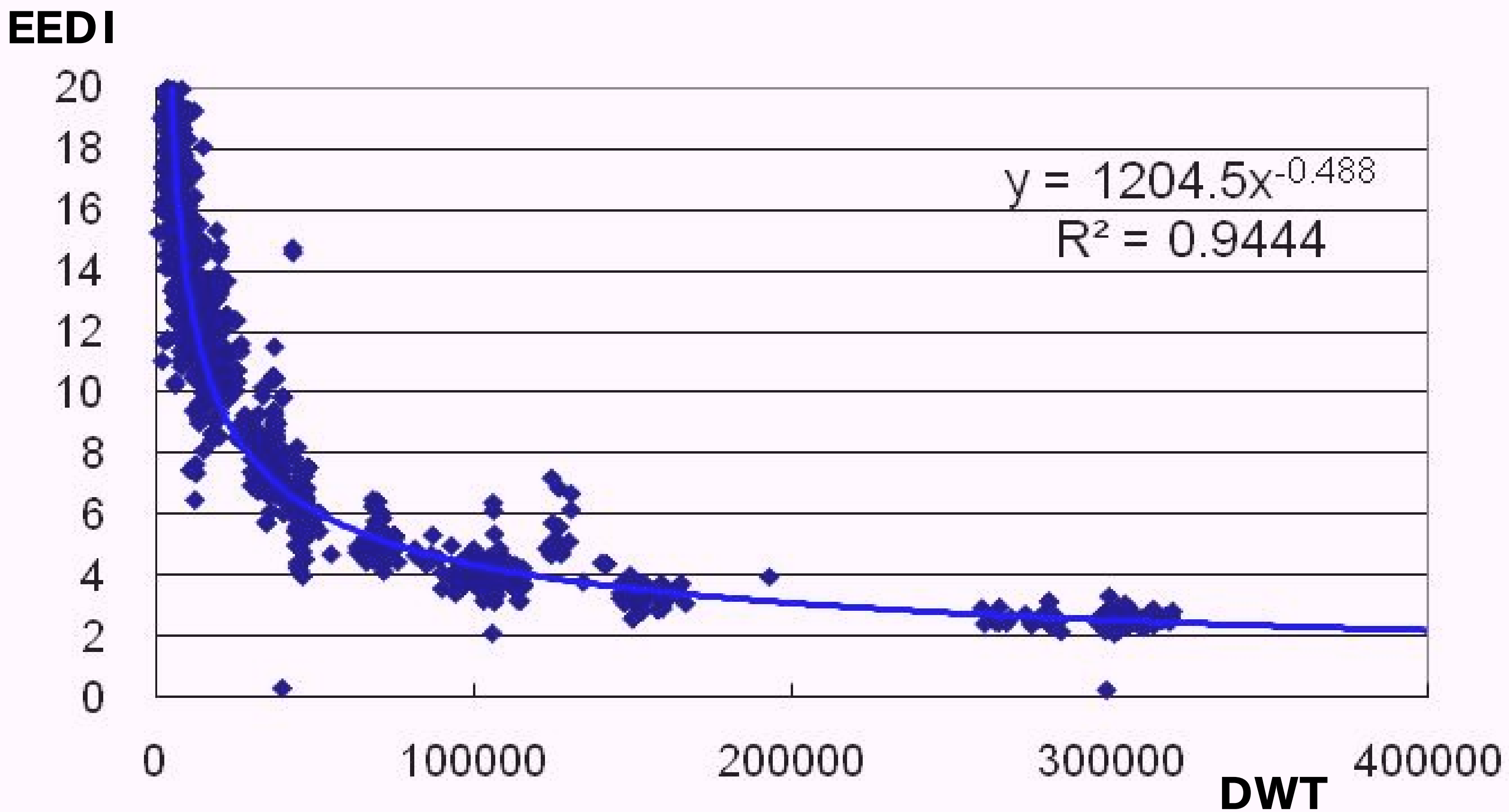
Concept of EEOI and EEDI – Part 2



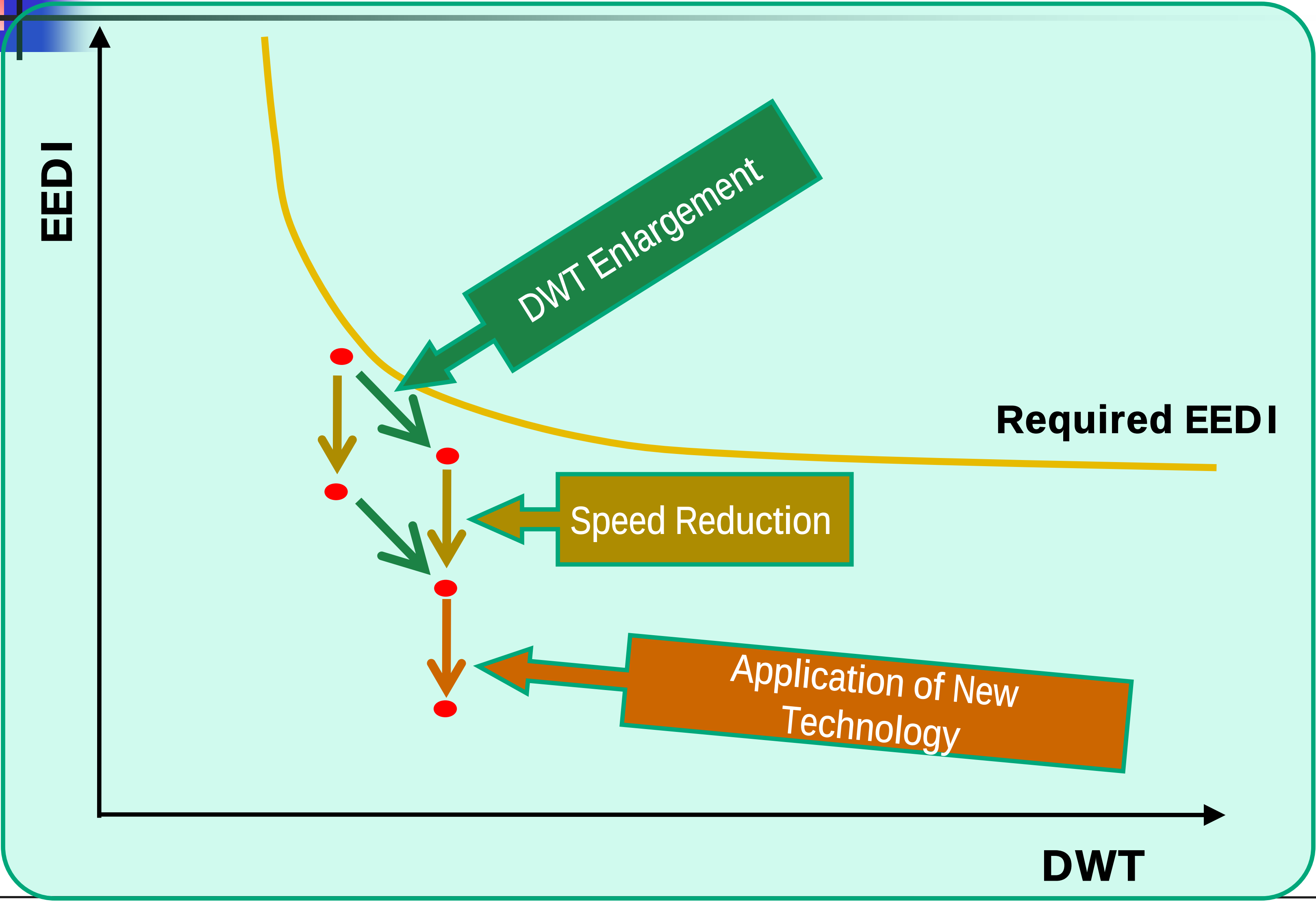
Future Regulation based on EEDI

Attained EEDI < Required EEDI

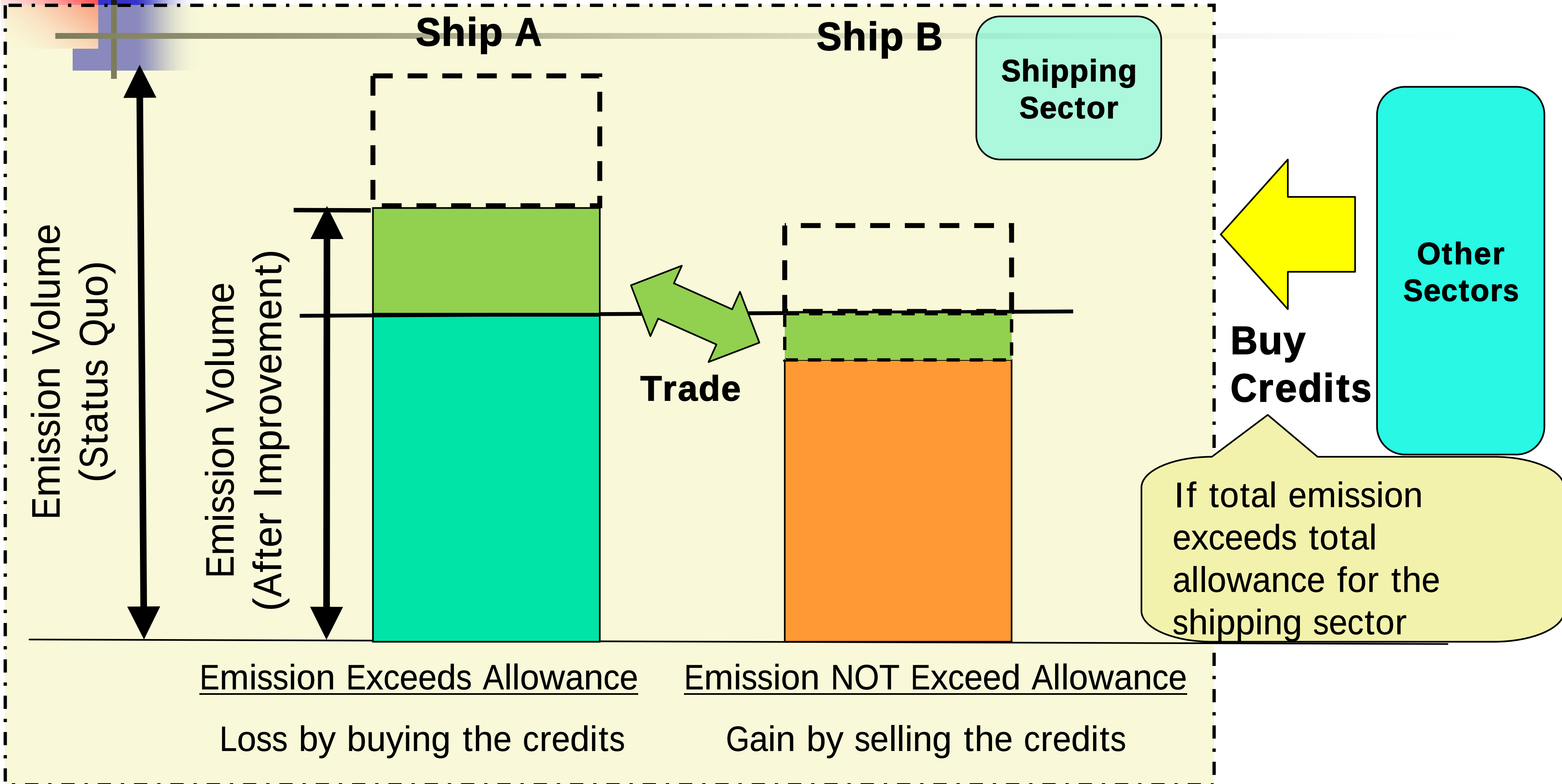
= Baseline [a × b $^{-c}$] × Reduction Rate [1 − X/100]



How Reduction Measures Affect EEDI



Emission Trading Scheme



Trade between PLAYER A (higher Marginal Costs – larger emission) and PLAYER B (lower MC – smaller emission): this is *"efficient"* as microeconomics teaches us... <u>BUT the whole depends on how you set the total allowance (capping).</u>

Efficiency Improvement Scenario

(MEPC 59/INF.27)

New ship

Speed reducion/Enlargement

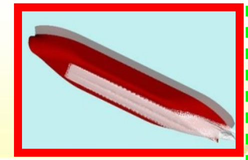
Modification of specs

Speed reduction/ DWT Enlargement

Application of New technology

Setting the time of year for application of New technology, taking into account the cost of new technology and progress in development.

{Example of New technology}



Implementation of case study to estimate the effect of speed reduction, DWT enlargement and new technology

Efficiency Improvement Scenario of New ships

Contract	2012-2016	2017-2021	2022-2026	2027-2031	2032-2036
Delivery	2015-2019	2020-2024	2025-2029	2030-2034	2035-2039
Bulk/General Cargo	25%	40%	45%	50%	50%
Tanker	35%	40%	55%	55%	55%
VLCC	40%	50%	60%	60%	60%
Container	35%	45%	55%	65%	70%

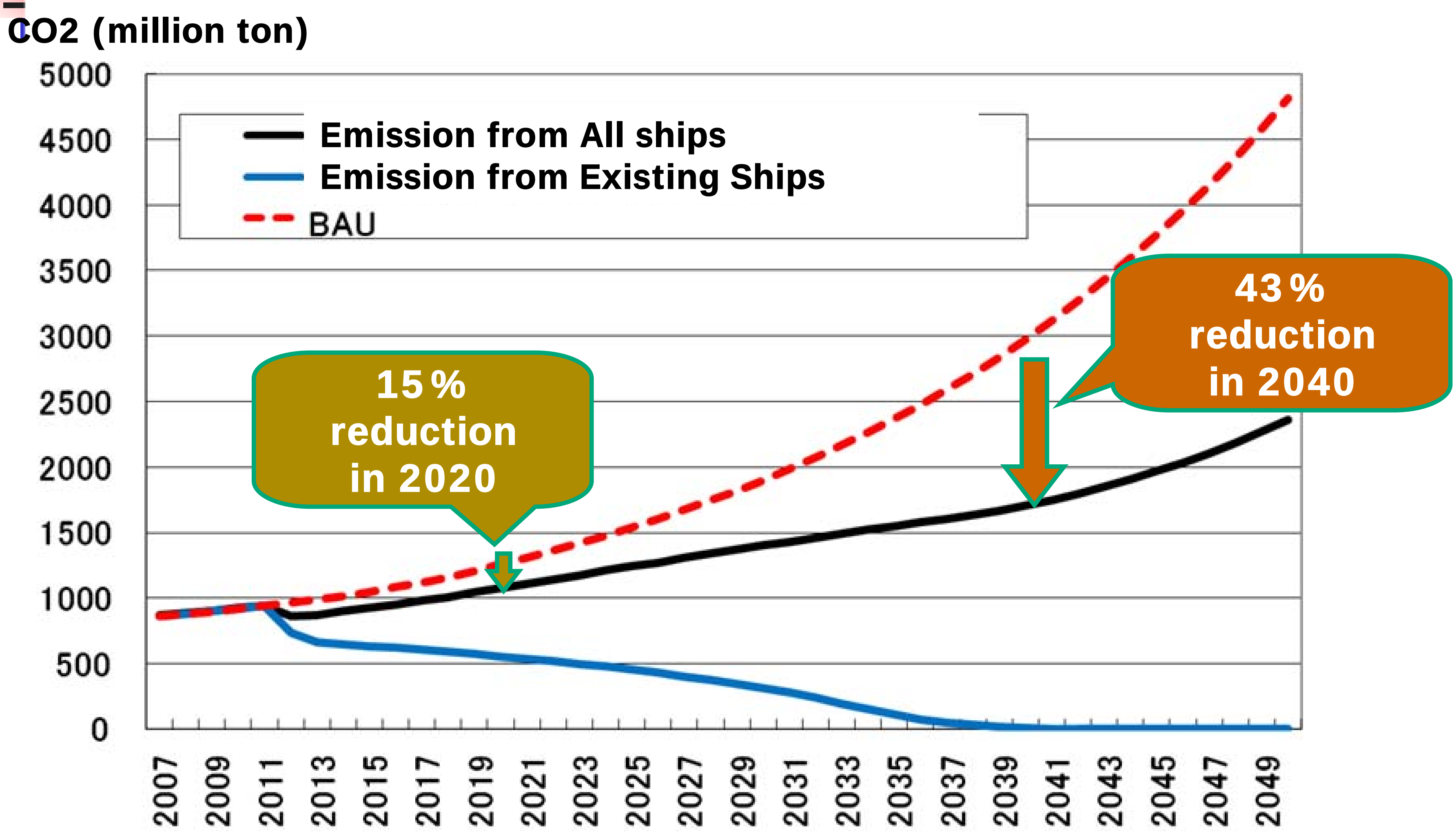
Existing ship

10% speed reduction (as to container ships, 15% speed reduction)

Estimated Efficiency Improvement, Panamax Bulker

		Present	2012-2017 2015-2020	2022-2027 2025-2030	Note
Speed Reduction / Enlargement	Speed	14.00	12.6 (-10.0%)	12.5 (-10.7%)	Lowest :12.5
	DWT	82,951	91,246 (+15.0%)	99,541 (+20.0%)	
	EEDI	3.72	2.94 (- 21.0%)	2.81 (-24.5%)	
New Technology	Ax Bow	–	○	○	0.1 m $: 2015
	CRP	–	○	○	3 m $: 2013
	Costa Bulb	–	–	○	0.1 m $: 2014
	Duct	–	–	○	0.5 m $: 2013
	Spray	–	–	○	0.1 m $: 2019
	Micro-Bubble	–	–	○	2 m $: 2025
	Twin - Propulsion	–	–	○	3 m $: 1011
	FOC Improvement	–	9.95%	31.44%	
Improvement of EEDI	EEDI	3.72	2.65 (- 28.8%)	1.93 (-48.2%)	

Projection of CO_2 Emission, A1B Case

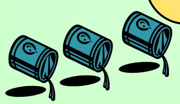


Leveraged Incentive Scheme for GHG Fund

Labeling
(Evaluation of efficiency improvement)

Refund
(based on evaluation)

Contributions
(per unit fuel)



International GHG Fund

[60%] → Refund

[40%] →

- Mitigation/Adaptation project
- R&D for highly efficient ships
- IMO-TC
- Assistance to infrastructure development
- Human Resource development
- Recycling capacity building

Leveraged Incentive for Efficiency Improvement
(improvement effort will be rewarded in the form of refund.

Contributing to the adaptation of developing countries and to investment to reduce CO2 emission
(Compatibility of CBDR principle and uniform application of rules)

Outline of Toyako Summit, UNFCCC AWG

Outline of G8 Toyako Summit (2008/7/7～9 at Toyako, Hokkaido)

○ Long-term Goal

With respect to the goal of achieving at least 50% reduction of global emissions by 2050, the G8 leaders agreed to seek in sharing and adopting the United Nations Framework Convention on Climate Change with all Parties.

○ Mid-term Goal

In order to achieve absolute emission reductions in all developed nations, G8 leaders agreed to implement ambitious economy-wide mid-term goals.

○ Sectoral Approach

It was recognized that sectoral approaches are useful tools for achieving national emission objectives and for reducing GHG emissions.

○ International maritime transportation concerned

・ They agreed in reducing GHG emissions by expeditious discussions with IMO

<G8 Hokkaido Toyako Summit Leaders Declaration (abstract)>
~ International maritime transportation~

Climate change

The importance of expeditious discussions in the International Civil Aviation Organization (ICAO) and the International Maritime Organization (IMO) for limiting or reducing GHG emissions in the international aviation and maritime sectors was emphasized, bearing in mind the distinct processes under UNFCCC toward an agreed outcome for the post-2012 period.

Outline of UNFCCC AWG (2008/8/21～27 at Accra, Ghana)

□ **AWG-LCA（Summary）**

○ ***Sectoral Approach***

・ The Sectoral Approach which can complement goals of each country was discussed.
A common view was achieved. But, some developing countries regard this approach as unfair.

□ **AWG-KP（Summary）**

○ ***Aviation・Maritime field***

・ At this time, a full-fledged discussion was not engaged in. Next time, emissions will be discussed. Stance of each country at this AWG-KP is as follows

- Point of focus on ICAO and IMO (US, Canada, Singapore, Australia, Japan)
- In addition to AWG-KP, discuss at AWG-LCA (Norway, New Zealand, EU, Australia)
- Discuss at UNFCCC (Some developing countries like Chile, India)
- Discuss about reducing amount of maritime transportation at COP15 and consider binding implementation system of IMO
- Include aviation into ETS （EU, Norway, New Zealand）

Source国土交通省

Approaches and Future Prospects of MEPC58

Design Index of CO_2 emission in MEPC-GHG

Definition: CO_2 emission of cargo transportation at normal speed

Japan

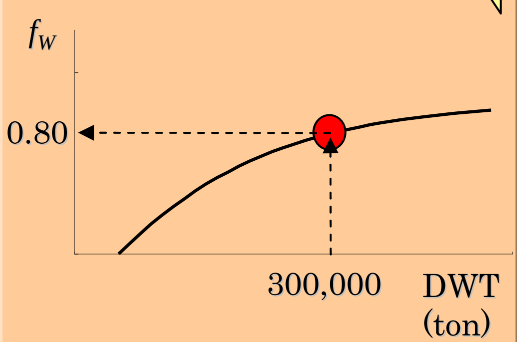
$$\text{Design Index (g/ton·mile)} = \frac{CO_2 \text{ emission by main E/G} + CO_2 \text{ emission by aux. machi}}{\text{DWT} \times \text{Velocity} \times f_w \text{ (coefficient in lowering velocity*)}}$$

Fuel consumption rate × Power × CF of CO_2 × Coefficient of specific ship form

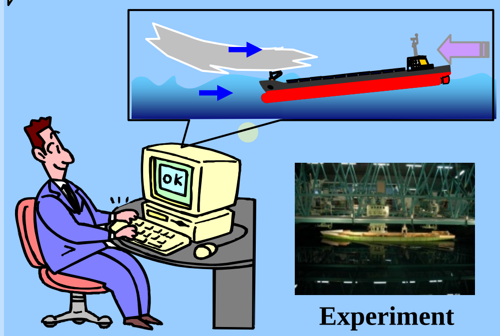
* f_W: Coefficient in lowering velocity under typical sea conditions (BF6)

How to calculate f_w (coefficient in lowering velocity)

Standard f_w curve



Simulation



① Standard f_W curve of each ship based on navigation data provided by Japanese ship company

②Simulation guideline plan to evaluate ship performance

Evaluation of application of new technology/energy saving technology to prospective ships can be done by simulation by comparing f_W values.

Energy Saving Technology

Main and aux. macjhineries

- Axial motor (main ship)
- Turbo dynamo
- Exhaust gas economizer

About f_W (coefficient in lowering velocity)

- Ship form (propeller etc)
- Superstructure

③Calculation methodology on CO_2 emission

Future prospects

◇ **~MEPC59 (July 2009) Validation**

- Normal f_W curve
- Simulation method
  ("10 mode" at sea experiment)
- etc..

◇ **MEPC59 Temporary Guidelines**

Guideline is validated by experimental period

◇ **MEPC?? Acceptance of Guidelines**

Source国土交通省

Enforcement policies on CO_2 emission

～ Maritime Environment Initiative（2008−2012）～

Actual Status

● 3% of total CO_2 emission
(Amount similar to Germany's emission)

●Amount of CO_2 emission increases in proportion with increasing amount of maritime transportation.
（Rate of increasing in maritime transportation：4％/year）
1995: 20B ton-mile
2005: 29B ton-mile

● The structure for decreasing CO_2 emission is not well-defined.
(Kyoto Protocol cannot be applied to International transportation)

Maritime Environment Initiative

Promotion of Development of New Energy Saving Technology for Ships

Goal : 30% reduction of CO_2 emission
→ Support private sector by subvention

Developing and Standardizing the Index of Actual Fuel Cost for Generalizing New Technology

・To show the amount of CO_2 emission more accurately on real sea area
・To promote diffusion of new technology

Promote cooperation between government, industry and academia

Impact

＜Sustainability＞

Huge reduction of CO_2 emission in international maritime transportation

＜Economic growth＞

◇Build up competitive edge in shipbuilding industry
◇Development of some regions by increased employment opportunities
◇Improvement in maritime transportation efficiency

Source国土交通省

Scheme for accelerating engineering development of CO_2 emission reduction in ocean-going vessels

【new scheme. 2009～】

- Implementation of development and practical realization of Energy saving technology
- Total business scale is about ¥20B
- Back up the development and practical realization of nautical energy-saving technology in the private sector.
- In addition to aid from national support, grant from private organization is sought.
- Intellectual property rights belong to private sector that implements the project.

Ministry of Land Infrastructure, Transport and Tourism

Private organizations

subvention

subvention（1／3）

subvention（1／3）

Private sector（responsible organization of engineering development）

Japan Ship Technology Research Association

【road map】

	H20	H21	H22	H23	H24	H25～
International movement	Kyoto Protocol appointed date					New scheme by post Kyoto Protocol
		COP15 New scheme accord				
Engineering development		Advertise for ideas	Energy saving engineering development aid			Diffusion of energy saving engineering
	Development of real fuel consumption indicator・Global standardization					

Source国土交通省

Trend of International Restriction about Exhaust Gas（NO_x、SO_x）（Agreement Appendix VI in MARPOL　New Plan）

Plan of NO_x Restriction

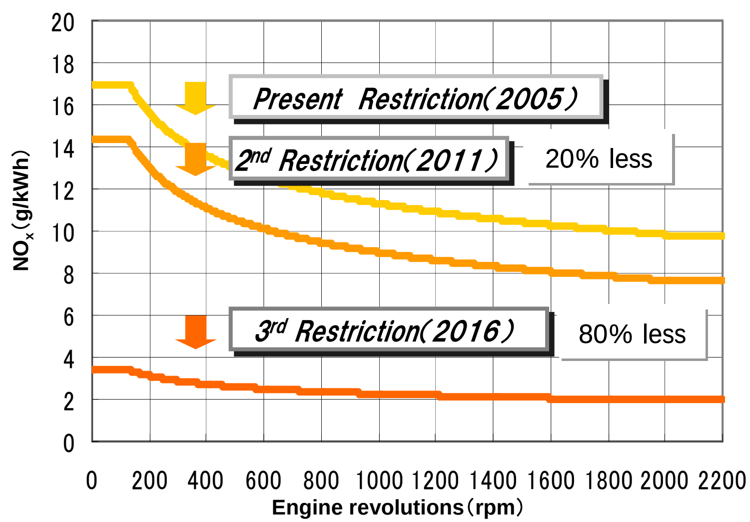
- **2nd Restriction Plan**
  - Start :2011～
  - 15%～22% reduction from present restriction
- **3rd Restriction Plan**
  - Start :2016～

    To review performance period between 2012 and 2013
  - 80% reduction from present restriction in specified sea area

    Except for

    ①Pleasure boat of 24m or less

    ②Ships designed with 750kW output or less



Plan of ship restriction on NO_x

	Only engines with accepted upgrade kits
Scope	Capacity of 90L or more of cylinder of existing ship constructed from 1990, and engine output of 5000kW or more
Restriction	Present values
Period	On the first periodical inspection one year after the control agency reports the certification of the upgrade kit to IMO

SO_x･PM　regulation proposal

The limit of sulfur density within fuel

Sea area	Outline
General	3.5%: 2012, 0.5%:2020/2025※
Specifications	1.0%: 2010, 0.1%:2015

※ Determine the restriction season in 2018

No limitation of distillate fuel, possible to use an alternative technology, for instance scrubber, etc.

MARPOL PACT:　International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto

Actions for CO_2 emission reduction

- Optimization of logistics
  - Ship routing and scheduling improvement, increased efficiency in loading, optimal design of total logistics system
- Reduction of ship hull resistance
  - Ship size enlargement, improved ship hull form, use of micro-bubble, steering refinement (installing current plate, etc.)
- Improvement of marine equipment
  - Propeller (shape, contra-rotating propellers), engines (fuel injection device, electronic control, etc.)
- Energy reuse
  - Exhaust heat recovery and utilization (fuel and cargo heat)
- Propulsive source
  - Change from bunker to light oil, LNG, CNG, methanol (including bio-methanol), DME and nuclear e

→Introduce some of the aforementioned topics

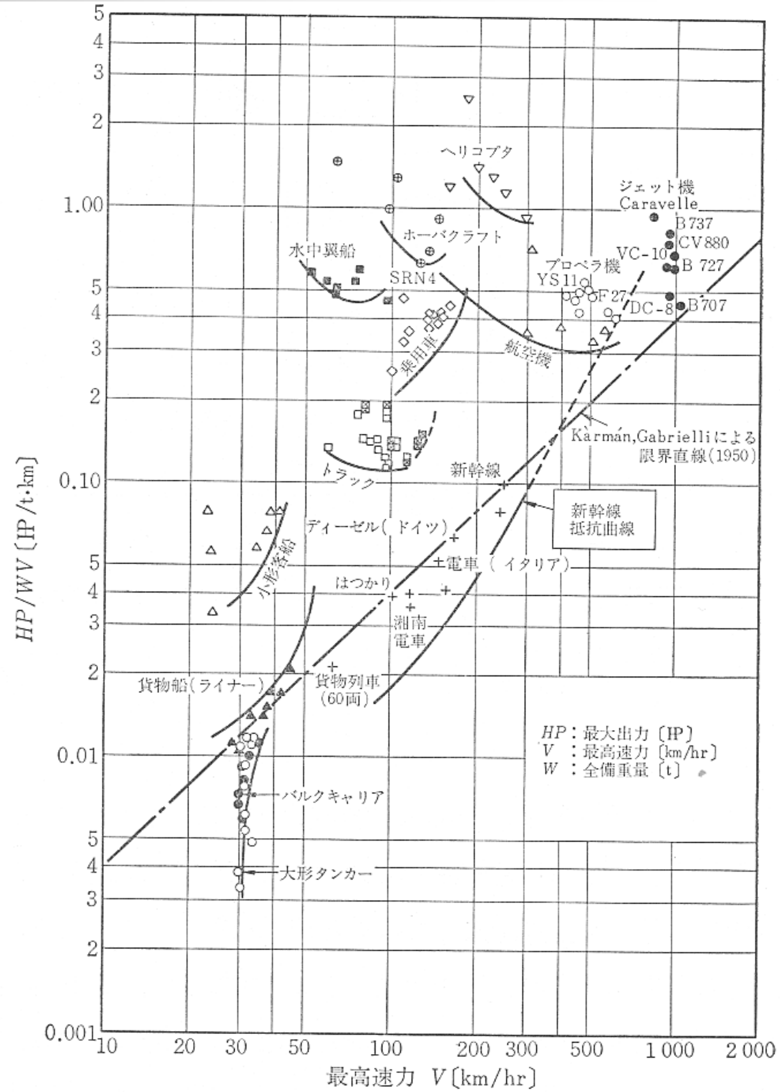
4. Technology development for CO_2 emission reduction

Ship enlargement

- By operating slow velocity large-sized ships, the energy efficiency will be improved.
- Karman-Gabrielli diagram
  - E=HP/VW ratio is plotted
  - The economic efficiency is significantly improved by enlargement of tankers and bulk carriers
- Example: mega container ships
  - Emma Maersk: 14,500TEU, length 397.7m, width 56.4m

http://www.maerskline.com/

Source: Shinsuke Akagi,交通機関論,1971



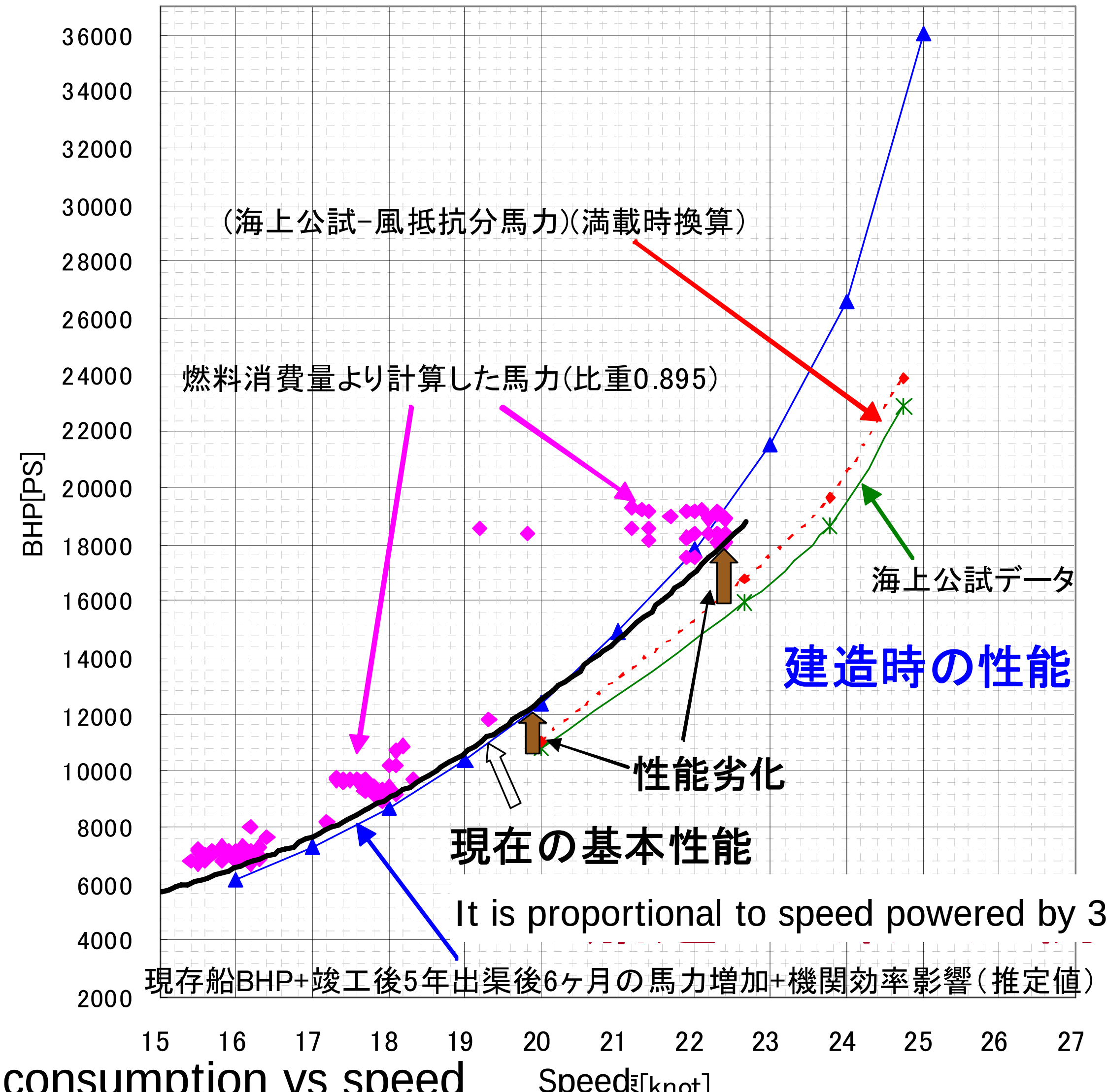
Karman-Gabrielli diagram

4. Technology development for CO_2 emission reduction

Energy consumption reduction by slow speed operations

- Friction drag in water is about 800 times larger than in air
- Energy consumption of the ship is proportional to speed powered by 3
  - Example：By slowing down from 25kn to 20kn, energy consumption will be reduced by half.

    $(20/25)^3 = 0.512$



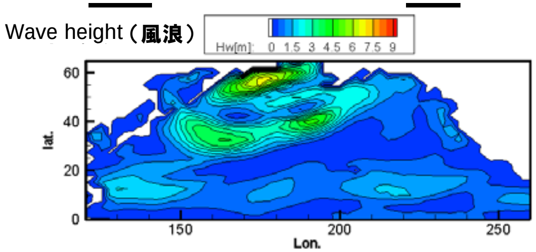
energy consumption vs speed

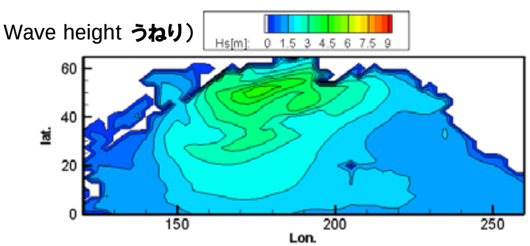
Source：Toshiyuki Kano, 海上物流効率化による低炭素社会の実現,ゼロエミッション船に向けて, 2008

4. Technology development for CO_2 emission reduction

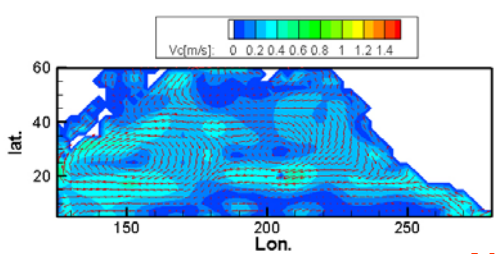
"WAN: Weather Adapted Navigation"

- Weather Adapted Navigation

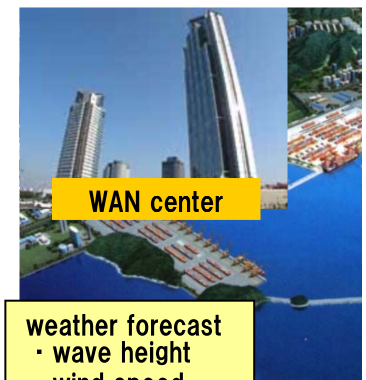




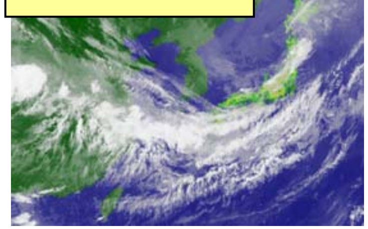
Hydrographic conditions forecast



Current data



weather forecast
- wave height
- wind speed
- direction of wave and wind
- etc.



Routing optimization

Routing optimization
- route
- Speed selection

Evaluation value
- energy consumption
- etc.

Constraint condition
- date of entry
- marine area
- etc.

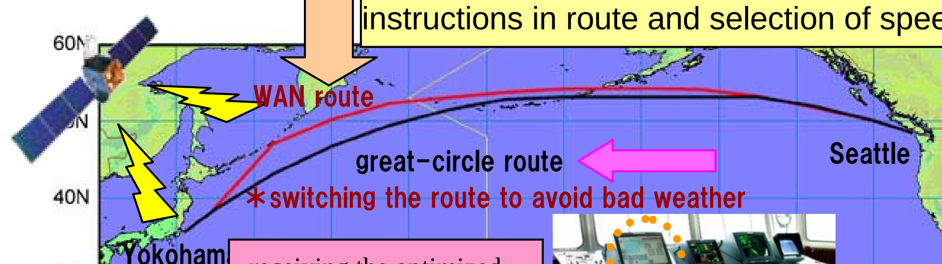
Validation methodology of long term performance

Validation methodology
- energy consumption
- cancellation rate
- maintenance cost
- etc.

Evaluation of each voyage

Accumulation of monitoring data

instructions in route and selection of speed



receiving the optimized shipping schedules

sending the logs

Able to reduce energy consumption by 15%

Source：Hiroyuki Yamato,海事分野のイノベーション,海洋技術フォーラム,2007

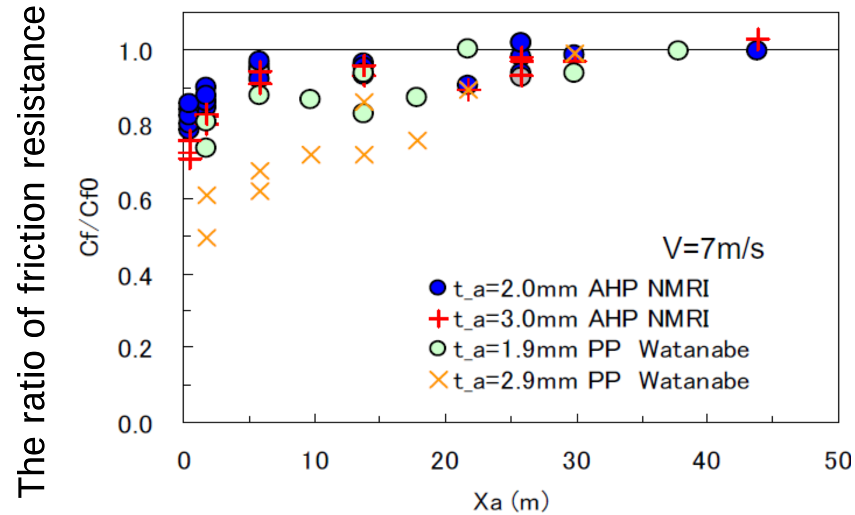
4. Technology development for CO_2 emission reduction

Reduction in fluid resistance

- Micro-bubble
  - 80% of resistance is due to frictional resistance of seawater for large cargo ships
  - To reduce resistance, microscopic bubbles are injected into the boundary layer between seawater and ship

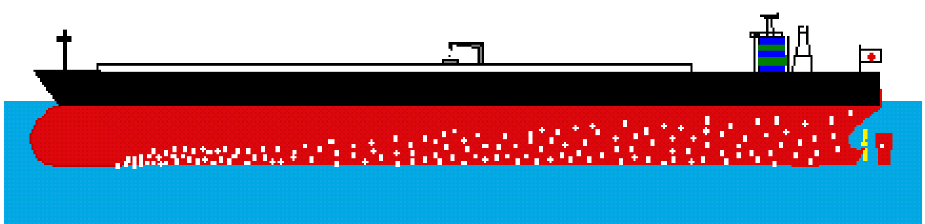
↓

  - For fully-loaded ships at low speed, energy-saving effect of about 10% from current level is possible
  - Japan is the top runner in this research



Distance from blow off point

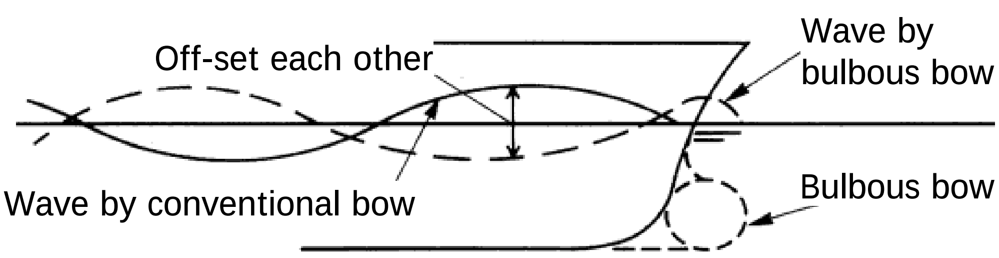
【Experimental result with model】

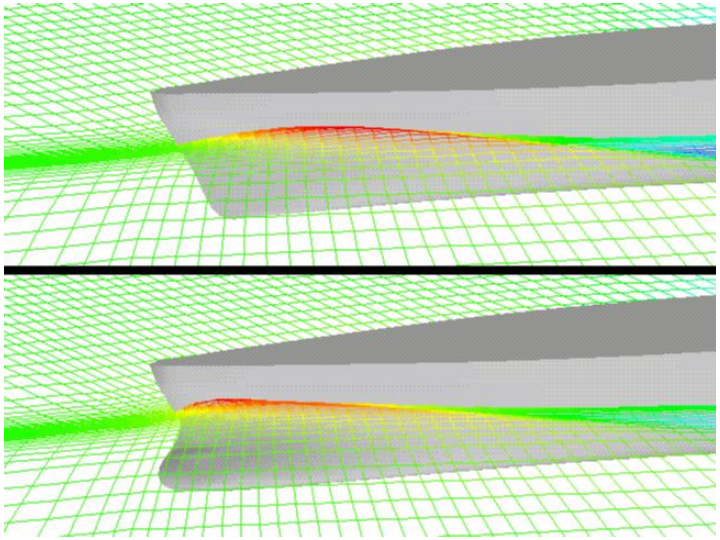


Source：海上技術安全研究所, http://www.nmri.go.jp

Reduction in fluid resistance

- Improvement of the bulbous bow shape
  - Also called “bulb bow”
  - Wave drag is reduced by waves created by bulbous bow when they balance out the other anti-phase waves.
  - First practical case in Japan is the battleship Yamato
  - Improvement in this research is continued by CFD technique





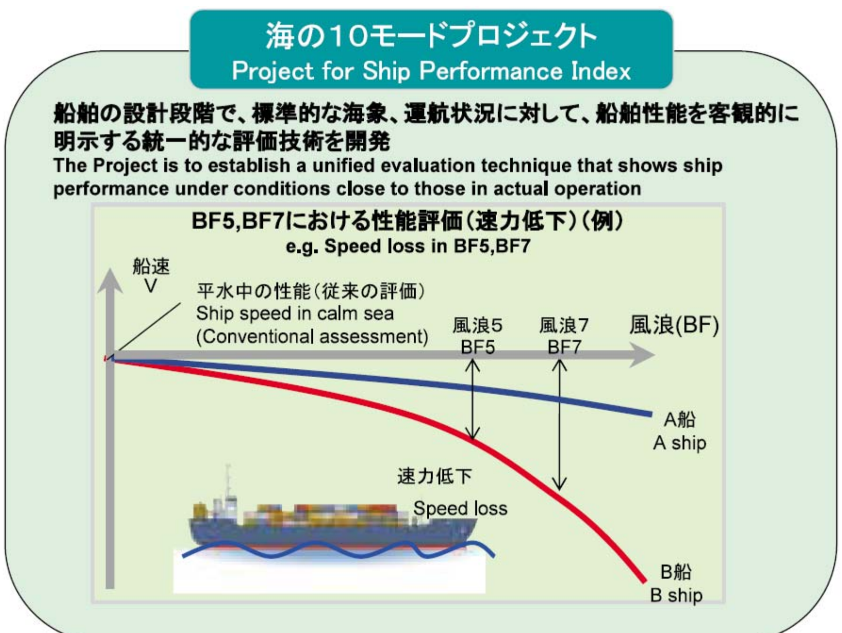
Source:日本海事科学振興財団 「船の科学館ものしりシート」

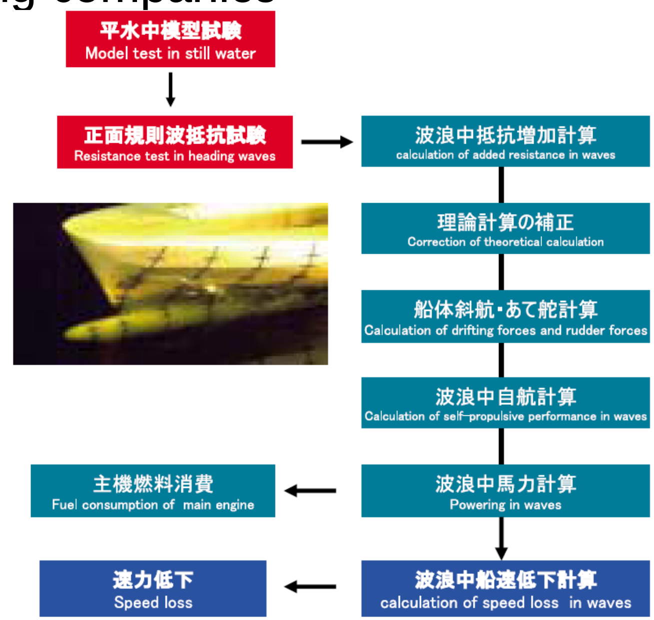
Source :海上技術安全研究所 http://www.nmri.go.jp/

4. Technology development for CO_2 emission reduction

Estimation System of Ship Performance in Actual Seas (ESSPAS)

- Promotion of energy-saving in ships by ESSPAS
  - Development and international standardization of ESSPAS
  - At design stage, estimate performance when in actual sea
  - Development of an energy-saving ship utilizing gas mileage index
  - Construction of a gas mileage certification system
  - Introduction of incentive scheme for shipping companies





Hybrid estimation system that combines theory with calculation

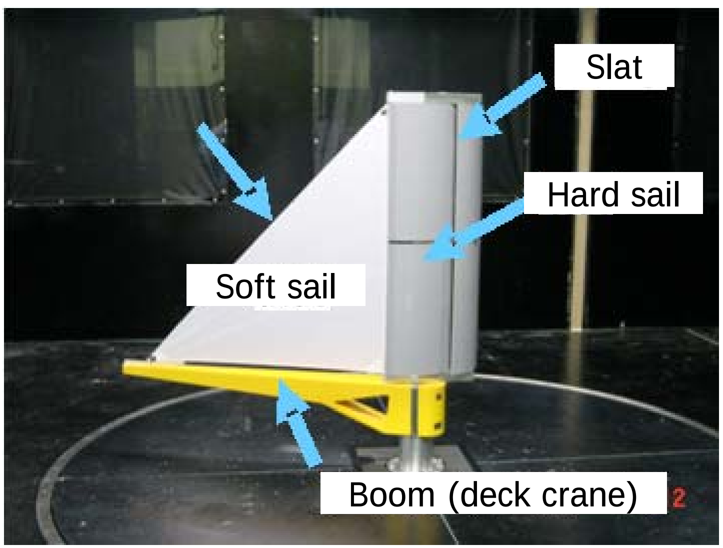
Source :海上技術安全研究所 2008年度パンフレット

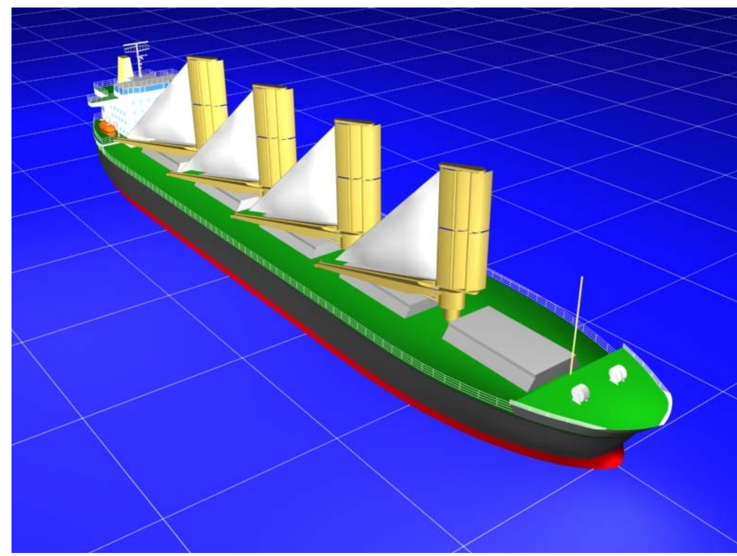
4. Technology development for CO_2 emission reduction

Next generation sailing vessel

- Development of next generation sailing vessels that could greatly reduce CO_2 emission

DHL, Beluga･SkySails





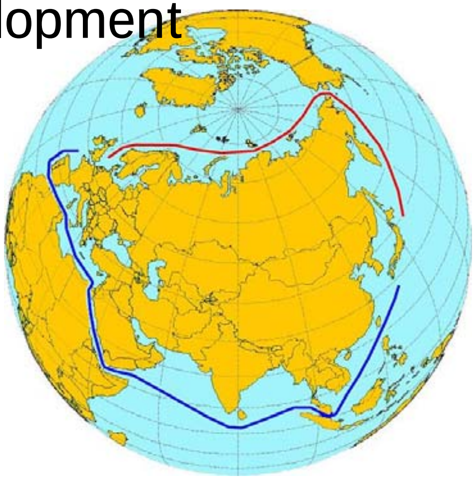
Next generation sailing ship equipped with high aerodynamic lift compound sail

Source :大和裕幸,海事分野のイノベーション,海洋技術フォーラム,2007，DHLジャパン, http://www.dhl.co.jp/

4. Technology development for CO_2 emission reduction
Arctic Ocean route

- Shorten shipping route between Asia and Europe
- Reduction of CO_2 emission on route.
  - ex) Nagoya-Rotterdam CO_2 emission would be cut to two-thirds
- By convoying together, not all ships need to be of high technology ice breakers
- Arctic Ocean used to be available only for 2 months in a year.
- But global warming and ice breaker technology development
  → lengthened available time


Antarctic Observation ship Shirase


Antarctic Ocean Route

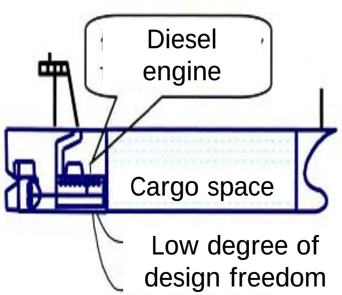
Source :Self-defense force http://www.mod.go.jp/msdf/formal/gallery/ships/agb/shirase/5002.html Wikipedia "Artic Ocean ruote"

4. Technology development for CO_2 emission reduction

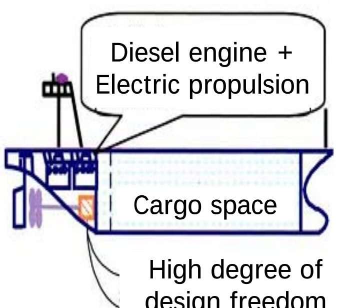
Next generation domestic vessel (SES: Super Eco Ship)

- Electric propulsion ship with gas turbine engine and contra-rotating propellers pod
  - 20% increase of cargo carrying capacity
  - Aims 25% decrease in CO_2, 90% in NO_x, and 60% in SO_x emissions on a ton/km basis compared to conventional ship
  - Improvement of inboard environment and saving of labor
  - Speeding up on pier docking and undocking
- Diffusion with two kinds of phases, I and II

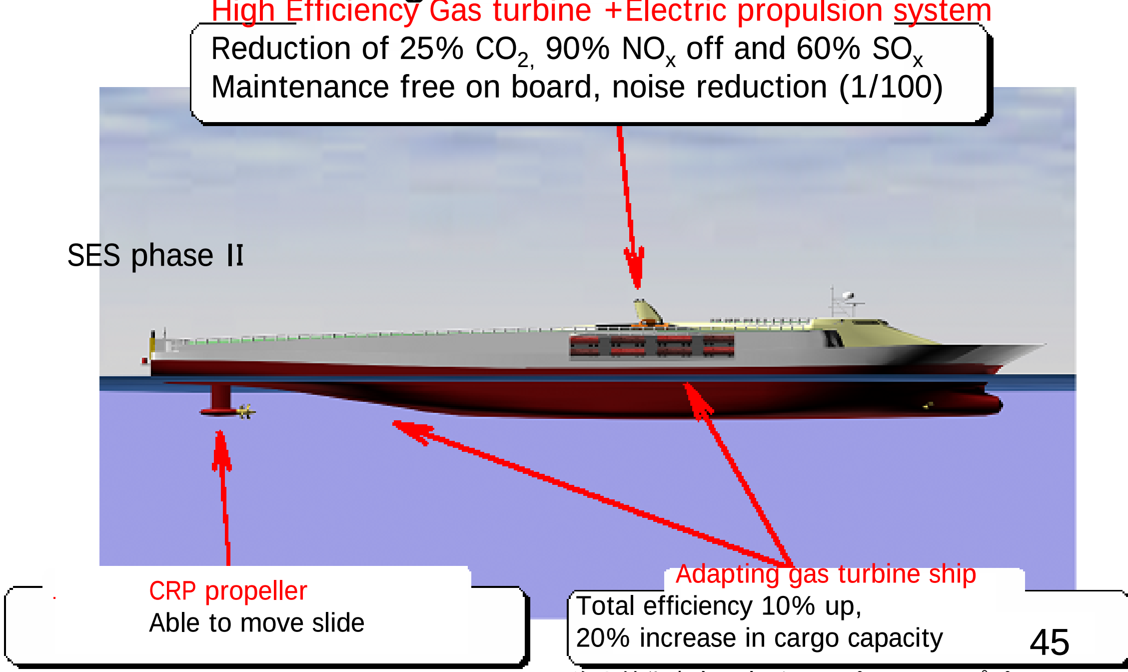
Conventional ship



SES phase I



SES phase II

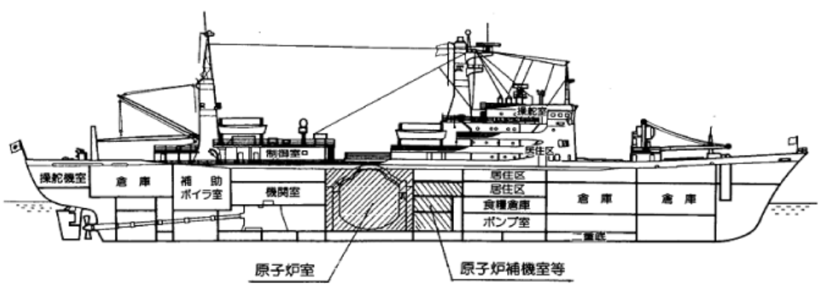


Source :海上技術安全研究所 スーパーエコシップパンフレット

4. Technology development for CO_2 emission reduction

Nuclear powered ship

Merits	Demerits
・No air pollution ・Relatively low fuel cost ・Stable fuel procurement ・Large ship can have large cargo capacity (relatively compact power unit)	・High initial cost of power unit ・Expensive and long-term dock and factory maintenance ・High ship and reactor unit disposal cost ・Not suitable for small ships due to large power unit size ・Fatal influence by serious accident ・Risk of hijacks ・Needs highly skilled crews and maintenance staff



用途	原子動力実験船	総トン数	約8240トン	原子炉型	加圧水型炉
全長	約130m	主機出力	10000馬力	熱出力	36MW
型幅	約19m	速度（最大）	32km/h	原子動力	145000
型深	約13.2m	速度（常用）	30km/h	航続距離	海里（計画）
吃水	約6.9m	補助動力	18km/h	乗船者定員	80名

Nuclear ship Mutsu

日本原子力研究所：原子力船「むつ」の成果、平成4年2月

Source :Wikipedia “原子力船”他

Conclusions

- Many environmental issues in the past.

  Today, CO_2 is the central problem.
- To halve CO_2 emission by 2050, 80% reduction is needed.
- Through IMO, steps for handling CO_2, NO_x and SO_x emissions are being discussed.
- Industrial, governmental and academic sectors have to execute strategic actions for “what it ought to be” based on long term prediction.