MARINE ENVIRONMENT PROTECTION COMMITTEE
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REDUCTION OF GHG EMISSIONS FROM SHIPS

Further details on the US proposal to reduce greenhouse gas emissions from international shipping

Submitted by the United States

SUMMARY

Executive summary:	The Technical Report attached to this document supplements the United States' submission, document MEPC 61/5/16, providing further details on the United States' proposal to establish efficiency index standards for existing ships and the trading of efficiency credits as an additional means for achieving compliance. Document MEPC 61/5/16 provides additional details on the proposal outlined in documents MEPC 59/4/48 and MEPC 60/4/12 (United States) which described a new approach to address international maritime GHG emissions.
Strategic direction:	7.3
High-level action:	7.3.2
Planned output:	7.3.2.1
Action to be taken:	Paragraph 4
Related documents:	MEPC 61/5/16, MEPC 60/4/12, MEPC 59/4/48, MEPC 59/24, MEPC 59/24/Add.1, MEPC 59/INF.10 and GHG-WG 2/2/7

Introduction

1 The Technical Report attached to this document supplements the United States' submission, MEPC 61/5/16 providing further details on the United States' proposal to establish efficiency index standards for existing ships and the trading of efficiency credits as an additional means for achieving compliance. Document MEPC 61/5/16 provides additional details on the proposal outlined in documents MEPC 59/4/48 and MEPC 60/4/12 (United States) which described a new approach to address international maritime GHG emissions.

2 Under this proposal, all ships, including those in the existing fleet, would be subject to mandatory energy efficiency standards. The stringency level of these efficiency standards would be based on energy efficiency technology and methods available to ships in the fleet. These standards would become more stringent over time, as new technology and methods are introduced. This proposal, which builds on the Energy Efficiency Design Index (EEDI) standards for new ships under development, focuses exclusively on improving the energy efficiency of the maritime sector.

3 This proposal would also create an efficiency credit trading program for ships. Ships operating more efficiently than required for the compliance period could earn efficiency credits based on current ship efficiency rate and activity, which could be sold for use in the maritime sector. Ships operating less efficiently than required would have the option of purchasing these efficiency credits, as one method of achieving compliance with the efficiency standards.

Action requested of the Committee

4 The Committee is invited to note the information contained in this document when considering document MEPC 61/5/16 and the concept of establishing effective market-based measures for reducing greenhouse gas emissions from ships.

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ANNEX

July 2010

Technical Report with Further Details on:

United States Proposal to Reduce Greenhouse Gas Emissions from International Shipping

SHIP EFFICIENCY CREDIT TRADING WITH EFFICIENCY STANDARDS

Related Documents:
MEPC 60/4/12, MEPC 59/4/48, MEPC 59 INF.10, MEPC 60/4/12, MEPC 60/4/36 and MEPC 60/J/9

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Executive Summary

Objective

The Marine Environment Protection Committee (the Committee), at its sixtieth session (MEPC 60), decided to undertake a feasibility study and impact assessment of all the market-based measure proposals submitted in accordance with the work plan for further consideration of market-based measures (MBM). The Expert Group on Feasibility Study and Impact Assessment of possible Market-based Measures (the Expert Group) established by the Secretary-General is set to review several MBM proposals recently submitted to the Committee. One of the proposals under consideration by the Expert Group was submitted by the United States in document MEPC 60/4/12. The U.S. paper presented the concept of potential energy efficiency index standards combined with in-sector efficiency credit trading for ships.

This document is submitted in accordance with the provisions of paragraph 4.7 of the Terms of Reference for the Expert Group (MEPC 60/J/9). It provides further details to the Expert Group, describing the extent to which the proposal described in MEPC 60/4/12 could assist in reducing GHG emissions from international shipping while still allowing for sustainable growth of the shipping sector that has minimal impacts on developing country economies.

Introduction

Under this proposal, all ships, including those in the existing fleet, would be subject to mandatory energy efficiency standards. The stringency level of these efficiency standards would be based on energy efficiency technology and methods available to ships in the fleet. These standards would become more stringent over time, as new technology and methods are introduced. This proposal, which builds on the Energy Efficiency Design Index (EEDI) standards under development for new ships, focuses exclusively on improving the energy efficiency of the maritime sector.

This proposal would also create an efficiency credit trading program for ships. Simply put, ships operating more efficiently than required for the compliance period could earn efficiency credits based on current ship efficiency rate and activity, which could be sold for use in the maritime sector. Ships operating less efficiently than required would have the option of purchasing these efficiency credits, as one method of achieving compliance with the efficiency standards. As a short-hand, we refer to this proposal as SECT to denote ship efficiency credit trading program (SECT) and the efficiency standards it builds on.

This Executive Summary is provided as an overview for readers unfamiliar with document MEPC 60/4/12. Chapter 1 provides an elaboration as to why an efficiency approach makes sense. Chapter 2 elaborates on the structure of the proposed MBM. Chapter 3 presents the technological and operational changes expected to be made in achieving the required efficiency standards. Chapter 4 presents a full description of the proposed trading mechanism for efficiency credits. Chapter 5 outlines the structure of the regulatory compliance program. Chapter 6 presents the United States' preliminary estimates of program costs and expected emissions reductions. Chapter 7 describes some likely market impacts of the proposed MBM. Lastly, Annex I defines the terminology used throughout this paper and MEPC 60/4/12.

The information provided in this paper is intended to aid the Expert Group in assessing SECT with regard to the nine criteria established in the Terms of Reference. Specifically, the United States respectfully submits that this MBM would be effective at reducing GHG emissions, cost effective and feasible. It would provide strong incentives for innovation and energy efficiency and would be compatible with other conventions and international law. It is plainly compatible with the existing IMO framework, and would not present a heavy administrative burden. Its implementation would present minimal burden for individual ships, and it could bring a positive impact on international trade supported by marine shipping.

Rationale for Efficiency Standards

SECT builds on the traditional strengths of the IMO by employing technical standards to create a simple, pragmatic and cost-effective solution to reduce GHG emissions from existing ships. The world fleet, both new and existing ships, can and should be made more efficient. This proposal focuses on how best to address emissions from existing ships and it complements the current effort within IMO to develop efficiency design standards for new ships through the Energy Efficiency Design Index (EEDI).

The U.S. supports the establishment of EEDI standards, which provide a common metric to measure new ship efficiency and will serve an important role for increasing the efficiency of new vessels during construction and entry into service. However, EEDI standards for new ships will not account for how ship efficiency changes over in-service time and will not address ships already in the fleet. Moreover, the rate of fleet turnover means that reliance only on the EEDI will yield fleet-wide efficiency improvements very slowly. As such, the EEDI only addresses part of the problem. The updated IMO study has also noted that while efficiency improvements for ships are affordable and exist, there are multiple hurdles for their implementation across the international fleet.

International shipping is a large and growing source of greenhouse gas emissions. In the coming years, it is expected that the transportation sector, including international shipping, will face increasing pressure to reduce GHG emissions originating from a variety of governmental as well as non-governmental entities. Without proven and measurable increased energy efficiency, ships would likely find these pressures placing heavy burdens on them in terms of cost and market share. In SECT, the U.S. proposes a common metric for measuring ship efficiency along with efficiency standards for all ships could be a critical instrument to help today’s fleet prepare to face these pressures, in part because it may possibly be implemented quickly through amendments to MARPOL Annex VI. Most importantly, a fleet with improved energy efficiency would be poised to smoothly navigate the uncertain waters of a carbon-constrained future.

By adopting this MBM proposal for existing ships along with the EEDI standard for new ships, the IMO would be implementing a comprehensive and workable framework that will improve the efficiency of international maritime shipping. This effective, efficient and timely pathway to fuel consumption improvements for ships will directly result in reductions of CO_2, NO_x, SO_x and PM emissions.

Key Elements

SECT provides equitable treatment of different ship types and different ship sizes (based on capacity), while including a method to periodically measure ship technical and operational modifications affecting overall efficiency. There are four key elements to the proposal:

1) Efficiency index standards for existing ships ("EIR")

Under SECT, IMO would agree on efficiency index baselines for existing ships, which could be the same as the ship-type and ship-size specific baselines for new ships that IMO is currently developing through the EEDI. IMO would use these baselines to derive efficiency index standards (EI_R) for existing ships, so that for any given compliance period, individual ships would have a specific efficiency index standard that reflects feasible technology and operational efficiency improvements for that ship.

2) Attained efficiency index ("EI_A")

The most straightforward and preferred method for determining the attained efficiency index of a ship (EI_A) is to calculate it using the same equation that is used for the new ship EEDI, along with a ship performance test. One difference is that the EI_A calculation would use actual parameters from the ship operational data representing actual usage of technologies, while the EEDI uses predicted usage of technologies. The main advantages of using the same equation for the EI_A as for the EEDI are that it creates a common metric for ships of a given type and size and that the EI_A is comparable back to a baseline EEDI to which the ship was built. The U.S. also considered alternative methods in MEPC 60/4/12, such as direct determination of the fuel consumed and cargo carried, similar to the Energy Efficiency Operational Indicator (EEOI), which accounts for operational performance as influenced by efficient technologies or operational measures. This paper provides further discussion of these approaches.

3) Efficiency credit (EC) trading for ships as one compliance option

Under SECT, the fundamental requirement is that a ship's EI_A be better (lower) than or equal to the applicable EI_R. Recognizing that not all ships would be able to meet this requirement as built or through the cost-effective application of technological or operational measures, this proposal would establish an efficiency credit (EC) trading mechanism, whereby those ships that are more efficient may sell their EC surplus to ships whose EI_A does not meet the applicable EI_R. The actual efficiency credit value for a ship is determined by multiplying the difference between the ship's required and attained efficiency and the ship activity level.

The concept of efficiency credit trading is distinct from other types of emissions trading in that it does not directly cap maritime activity or emissions, yet it has the potential to achieve significant emissions reductions quickly from the maritime sector. It should be made clear that these credits are based on a difference between the required and attained energy efficiency for any given ship, and are not intended to represent total CO_2 emissions from that ship. As such, this proposal is not necessarily mutually exclusive of other MBM proposals under consideration by the MBM Expert Group.

4) Certification and enforcement of each ship's compliance

The ship's flag State, or its authorized recognized organizations, would validate reporting and certify compliance with the efficiency requirement, either by verifying that a ship's EI_A is better (less) than or equal to EI_R or by verifying that a ship has obtained necessary efficiency credits. Flag States and port States would enforce the efficiency requirement and compliance option(s) employed by any given ship, consistent with current obligations under MARPOL Annex VI.

Practicality of Efficiency Credit Programme

The establishment of an in-sector credit trading program would improve the cost-effectiveness and the efficiency gains of the proposed efficiency index standards. It does this by making the most cost-effective efficiency gains available to all in the sector. For example, if a large tanker installs a new technology that is difficult to implement on a small container ship, then that small container ship could trade efficiency credits with the large tanker, taking advantage of lower cost efficiency improvement.

The proposed in-sector credit trading program would be relatively straightforward to administer. The ship's responsible party would calculate the efficiency credits according to its required and attained efficiencies and its activity level. The calculated efficiency credits of each ship could be enforced by flag Administrations and subject to port State control as with current obligations under MARPOL Annex VI. IMO would develop the necessary regulations and oversight for the credit program, but IMO would not operate or implement this program. Chapter 3 presents an approach to developing an effective credit trading mechanism.

Anticipated Impacts

SECT provides incentives, beyond the business as usual case, for ship owners, operators and charterers to maximize the efficiency of their ships. This program is intended to maximize in-sector efficiency improvements and does not attempt to cap net emissions through the use of offsetting credits from outside the maritime sector. Therefore, the costs associated with this program are directed at technologies and methodologies that would improve the efficiency of the international maritime sector. These efficiency improvements are expected to result in cost savings due to lower fuel consumption, with commensurate decreases in vulnerability to fuel price volatility. The cost, emission reduction, and market impacts anticipated for this proposal are discussed in more detail in Chapters 6 and 7.

Chapter 1 - Why Efficiency Is the Right Approach

This chapter outlines why an efficiency standard and efficiency credit trading system is the right approach to addressing emissions in the shipping sector, given international shipping's role in the global economy and that shipping emissions are projected to grow.

1.1 Shipping, the Global Economy, and Global Climate Change

It is clear that as the world moves to address climate change through long-term changes in emissions pathways, shipping too will need to play a part via actions taken in the IMO. However, those actions must recognize that international shipping is vital to the global economy. Countries across the globe depend on shipping to ensure their economies and global trade continues to grow. Indeed, because IMO guarantees that ships can move freely from port to port with equal treatment, shipping has facilitated globalization of the world economy and fuelled the growth of export economies over the last several decades. Further, shipping also provides a vital role for many small islands and other geographically isolated countries, allowing them greater access to goods.

Ships also provide the most greenhouse gas efficient way of transporting goods. In many ways an increasing reliance on shipping to carry world trade, as compared to other modes of transportation, will provide a net reduction to global greenhouse gas emissions. However, ship emissions cannot grow unchecked. Shipping today represents about 3% of global greenhouse gas emissions and the updated IMO study projects that emissions will increase 150% to 250% by 2050 in the absence of policies to reduce emissions. The Study also shows that many options exist to reduce shipping emissions, and considerable scope for doing so at low or no net cost to industry.

1.2 International Actions to Reduce Maritime Emissions

It is clear from these statistics that some policies must be put in place to reduce shipping's contribution to global climate change. A failure to act for this sector is not an option. So what policies will the international community put in place? Clearly an international solution, rather than an uneven patchwork of national or regional regulations, is preferable for the sector and those who depend on it. However, any policy to address shipping emissions must reconcile the importance that shipping plays in economies across the globe, particularly export economies, and the necessity to reduce emissions. It is not likely that countries will agree to policies that cap their growth or the movement of their goods across oceans. Nor is it likely that countries will let shipping emissions grow unchecked. The United States fully supports IMO's efforts to develop a comprehensive market-based measure to reduce shipping's contribution to global climate change, but we believe that approach must take into account each of these perspectives.

1.3 Why Efficiency?

Efficiency provides a way forward for IMO that allows for the sector (and by extension the global economy) to grow, but in a way that manages the carbon footprint of the sector. An approach based on efficiency is the right starting point, given that substantial opportunities exist to improve ship efficiency at low or no net cost to industry. This is especially true at a time of high fuel costs. However, there are often barriers to adoption of efficiency technologies beyond a lack of carbon pricing, and any successful market-based measure will have to address these barriers.

Efficiency standards are commonplace across various sectors and countries. As part of the Copenhagen Accord, many countries inscribed efficiency goals as their commitment to help reduce global emissions. These efficiency goals vary by country but all of them seek to save money and reduce emissions without capping economic growth. Countries have adopted this approach in the IMO context as well by using an efficiency framework to develop the EEOI, EEDI, and the SEEMP.

1.4 Why Efficiency - Ship Efficiency Credit Trading (SECT)?

The SECT approach provides a way to build on the political viability of efficiency approaches by implementing efficiency standards for the global fleet in a manner that minimizes the overall cost to industry. Instead of using the sector to generate revenue for outside uses, SECT rewards efficient vessel owners by allowing them to monetize efficiency credits. It keeps such revenue within the sector and stimulates low-carbon investment, many of which are zero or low net cost. Using data from the IMO study suggests that even a very stringent standard could still result in a net cost savings of $51/tonne of CO_2 reduced.

1.4.1 SECT is Environmentally Effective

Analyses conducted with data from the IMO updated GHG study suggests a 10 to 30% direct reduction of greenhouse emissions in 2020 is possible and it could be as high as 40% (below business as usual) by implementing efficiency measures.

1.4.2 SECT is Cost Effective

SECT would create, for the first time, an incentive for ship-owners to invest in efficiency measures with longer term payback periods. This is because a highly efficient ship will continue to generate efficiency credits for several years, and the value of the future stream of credits can be factored into the price of a ship should the owner decide to sell it. In addition, a focus on efficiency is inherently cost-effective for ship owners because they are lowering operating costs. The impacts on trade are expected to be minimal as there is no cap on growth of the sector and in many cases the overall transport cost would decline due to decreased fuel costs. As such, the impact on LDCS and SIDS is also expected to be minimal.

1.4.3 SECT Provides Incentives For Technological Change

By setting efficiency standards and then allowing trading, there is a regulatory and financial incentive to increase ship efficiency. SECT does not prescribe what technologies to use or how to use them; instead it lets ship owners/operators decide what technologies work best for their ships. Given that SECT would be exclusive to the maritime sector; it provides the highest of a incentives to employ a variety of efficient technologies.

1.4.4 SECT is Practical

SECT would be relatively simple to implement as it builds on the significant work already undertaken by IMO on the EEDI, EEOI, and SEEMP. The administrative systems and procedures for efficiency credit trading would have to be created, but these would be a simplified version of what is needed to implement a full cap and trade system.

1.4.5 SECT Does not Require Significant Technology Transfer

As the updated IMO GHG study indicates, substantial negative cost efficiency measures are available for the global shipping sector using existing commercialized technologies. By and large, technology transfer required by a developing country ship builder or ship operator can therefore be acquired through commercial means.

In as much as SECT will require developing country administrations or ship owners to familiarize themselves with credit trading, the U.S. believes that support for capacity-building programs would be appropriate and straightforward to arrange.

As for mobilizing climate change finance, we note that the original nine criteria for greenhouse gas measures to be adopted by the IMO (agreed at MEPC 57) did not include raising revenue for external benefit. Accordingly, SECT is designed to reduce emissions within the sector at minimal cost and to the benefit of the sector only. The SECT system is self-contained in that all costs to industry are spent on investments in their own vessel efficiency.

1.4.6 SECT is Consistent with International Law

SECT is fully compatible and consistent with international law.

1.4.7 SECT has Minimal Administrative Burden

SECT creates some additional work for owners/operators, flag states, and port states. However, we believe there is an additional burden for any market-based measure. The additional burden in the U.S. would be comparatively minor and would complement what is currently being undertaken under current Annex VI requirements.

1.4.8 SECT has Minimal Additional Work

SECT would require efficiency gains from ships. Although there would be additional workload to implement the efficiency measures, the efficiency gains would result in cost savings from reduced fuel consumption which would lead to positive market impacts for shipping. The credit trading program results in decreased costs and provides ship owners and operators with flexibility on their compliance approach to the proposed requirements

Implementation of the SECT would present minimal burden for individual ships, and it could bring a positive impact on international trade supported by marine shipping.

1.4.9 SECT is Compatible with Existing Enforcement Provisions

SECT is compatible with the existing enforcement and control provisions under the IMO legal framework as it builds on work undertaken in Annex VI.

Chapter 2 - Description of SECT

The U.S. recognizes the importance of international shipping to the global economy and acknowledges that greenhouse gas emissions from this sector are growing and need to be addressed in a comprehensive manner. The proposal focuses exclusively on improving the energy efficiency of the maritime sector. Significant potential exists to improve the efficiency of existing ships through technologies such as waste heat recovery and propeller optimization as well as operational improvements such as maintenance or voluntary speed reductions. Increased efficiency would reduce fuel consumption and greenhouse gas emissions, provide financial rewards to efficient ship owners and operators, and illustrate the maritime sector's commitment to tackling climate change even while carrying the majority of the world's trade. As a short-hand, we refer to this proposal as SECT to denote the combination between a ship efficiency credit trading program (SECT) and efficiency standards it builds on.

2.1 Key elements of the proposal

SECT builds on the traditional strengths of IMO by employing technical standards to create a simple, pragmatic and cost-effective solution to reduce greenhouse gas emissions from existing ships. The world fleet, both new and existing ships, can and should be made more efficient. The proposal focuses on how best to address emissions from existing ships and it complements the current effort within IMO to develop efficiency index standards for new ships through the Energy Efficiency Design Index (EEDI).

The U.S. supports the establishment of EEDI standards which provide a common metric to measure new ship efficiency and will serve an important role for increasing the efficiency of new vessels during construction and entry into the fleet service. However, EEDI standards for new ships will not account for how ship efficiency changes over time, and will not address ships already in the fleet. As such, the EEDI only addresses part of the problem. This proposal is intended to complement the EEDI by accounting for efficiency gains or losses for ships in the fleet, including: 1) maintenance of the engine, hull, and propeller, 2) addition or deletion of installed equipment, 3) operation of the equipment and ship and 4) long lifetime with slow fleet turnover.

SECT provides equitable treatment of different ship types and different ship sizes (based on capacity), while including a method to periodically measure ship technical and operational modifications affecting overall efficiency. There are four key elements to the proposal: 1) develop required efficiency index standards for existing ships (“EI_R”); 2) each ship calculates its attained efficiency index (“EI_A”); 3) establish efficiency credit (EC) trading for ships as one compliance option and 4) regulatory authorities would certify and enforce each ship's compliance. Each of these key elements is briefly explained below with further details in section 2.2 and in subsequent chapters.

2.1.1 Develop required efficiency index standards for existing ships ("EI_R")

The first step would be to develop efficiency index baselines for existing ships. The simplest approach to developing these baselines would be to use the same ship-type and ship-size specific baselines for new ships that IMO is currently developing through the EEDI process.

IMO would use the baselines to derive efficiency index standards for existing ships,[a] so that for any given compliance period, individual ships would have a specific efficiency index standard that reflects feasible technology and operational efficiency improvements for that ship. This approach ensures equitable treatment of different ships because the baselines themselves are specific for each ship type and each baseline is a continuous function of ship size (i.e. capacity). These standards for existing ships could be developed using the same or a similar process as is currently underway at IMO for developing EEDI standards for new ships.

The standards, which are proposed to be called the required efficiency index (EI_R), would be calculated as a percent above or below the applicable baseline curve, and would be made more stringent over time by amounts and intervals to be determined by IMO. The units of EI_R and the EEDI for new ships are identical and while a new ship is subject to the EEDI standard when it is first built, it would only be subject to EI_R once it begins operating. The EI_R would be the only efficiency index standard for ships in operation.

2.1.2 Each ship calculates its attained efficiency index ("EI_A")

The attained efficiency index of a ship (EI_A) can be calculated using the same equation that is used for the new ship energy efficiency design index (EEDI). The one difference is that actual ship operation data would be used along with the ship performance test. MEPC 60/4/12 also discusses an alternative equation based on direct determination of fuel consumed and cargo carried similar to the Energy Efficiency Operational Indicator (EEOI). The merits and limitations of these equations are discussed in further detail within this paper.

2.1.3 Efficiency credit (EC) trading for ships as one compliance option

Under this proposal, the fundamental requirement is that a ship's EI_A be better (lower) than or equal to the applicable EI_R. However, recognizing that not all ships would be able to meet this requirement, this proposal would establish an efficiency credit (EC) trading mechanism, whereby those ships that are more efficient may sell their EC surplus to ships whose EI_A does not meet EI_R. The actual efficiency credit value is determined by the difference between the required and attained efficiency multiplied by ship activity. [$EC = (EI_R + EI_A)*(Activity)$]. If a ship is not meeting its required efficiency index (EI_A greater than EI_R), it would generate negative efficiency credits (debits) and would have to obtain positive efficiency credits to offset its negative efficiency credits at a reconciliation point. The efficiency credits are based on a difference between the required and attained energy efficiency for any given ship, and are not intended to represent total CO_2 emissions from that ship.

[a] As a point of clarification, "existing ships," in this document, refers to all ships in the fleet today and in the future. This term is used to distinguish these ships from "new ships" which are subject to the EEDI standards. Once a new ship passes its sea trial and enters the fleet, it becomes an existing ship. Annex I provides a clarification of terms used in the U.S. proposal.

2.1.4 Regulatory authorities would certify and enforce each ship's compliance

The ship's flag State, or its authorized recognized organizations, would validate reporting and certify compliance with the efficiency requirement, either by verifying that a ship's EI_A is better (less) than or equal to EI_R or by verifying that a ship has obtained necessary efficiency credits to offset negative values. Flag States and port States could enforce the efficiency requirement and compliance option(s) employed by any given ship, consistent with current obligations under MARPOL Annex VI. Chapter 5 presents more detail on regulatory compliance methodology, timing, and applicability.

2.2 Details on the structure of the efficiency index standards

This section provides further detail on how efficiency index standards for existing ships (EI_R) are established, the relationship between the EEDI (new ship) and EI_R (existing ship) efficiency index standards, how a ship would calculate its attained efficiency index (EI_A), and how a ship calculates efficiency credits.

2.2.1 How efficiency index standards for existing ships (EI_R) are established

As noted above, under SECT, the required efficiency index standard for existing ships (EI_R) would be established by first determining the baselines for existing ships and then determining (the level of) the standards for specific ship types relative to the baselines, for existing ships over time. It is recommended that the stringency of the required efficiency index standard (EI_R) increase over time reflecting feasible, cost effective technologies and operational methods expected to be used on existing ships.

This follows the same approach as the development of the EEDI standard for new ships. For instance, it recognizes that a tanker is not the same as a container ship, and every ship type and size (as measured by capacity) should have a unique baseline value on which standards would be based. In addition, the stringency would be increased over time reflecting feasible and cost effective technologies expected to be used on new ships.

The U.S. recommends using the EEDI baselines as the baselines for existing ships, which means the baseline for each different ship type would be a continuous curve that is a function of ship size. Draft EEDI baselines are currently based upon data from a 1998-2007 subset of the Lloyd's Fair play database. These baselines are still under development, but are expected to be completed this year. Using identical baselines for both the EEDI and the EI_R would add simplicity and build upon the work IMO will have already completed with respect to new ships.

All existing ships would be subject to the same percent improvement in efficiency relative to their respective baselines at any point in time. As the baselines are scaled by type and size, the required improvement is also scaled by type and size. This creates an equitable and straightforward approach that is consistent across the entire international maritime fleet. While all ships are subject to the same percent (relative) efficiency improvement over time, the required level of the efficiency index (EI_R) of a specific ship would be based upon its unique baseline. For example, the EI_R for a 100,000 DWT dry cargo carrier would be different from a 150,000 DWT dry cargo carrier or a 100,000 DWT tanker. All three ships would need to meet the same percentage improvement from their efficiency index baseline over the same time period, which would result in different absolute EI_R improvements for each ship.

The efficiency index requirements for both new and existing ships (EEDI and EI_R respectively) would gradually become more stringent over time. Setting the required efficiency index standards well in advance of their effective dates would provide certainty to the international fleet and to the firms and shipyards responsible for developing, installing, and measuring the performance of more efficient technologies and operational measures.

The EI_R for existing ships need not be as stringent as the EEDI requirements for new ships. This is because new ships are more likely to incorporate more efficient technologies or operational methods and thus have somewhat greater energy efficiency than existing ships of the same type and size.

2.2.2 Relationship between the EEDI (new ship) and EI_R (existing ship) efficiency index standards

For new ships, the U.S. recommends mandatory adoption of the currently proposed mechanism for the EEDI as soon as possible. A new ship's calculated EEDI value would be compared to the required EEDI applicable to the size and type of ship at time of build or contract; those new builds that meet the applicable EEDI would be allowed to enter service in the global fleet. The EEDI would also establish a common metric for comparison across applicable ship types and sizes. The proposal for existing ships complements the new ship EEDI requirement, but it does not replace it. The new ship EEDI would continue to serve an important role for measuring and increasing the efficiency of new ships prior to entry into the fleet. Under SECT, once a ship has entered into service, it would immediately be subject to the existing ship standard (EI_R), and its compliance would be periodically verified and certified.

Once a new EEDI-compliant ship enters into service and becomes an existing ship, it is likely that it would generate positive efficiency credits compared to older ships of equivalent type and size. Furthermore, it would continue to generate positive efficiency credits until, over time, the applicable EI_R becomes more stringent than the EEDI to which the ship was constructed. This provides an incentive for the construction of new efficient ships, or to employ new innovative technologies or operational measures on new or existing ships, as these positive efficiency credits are available to be sold or traded to offset the negative credits that older existing ships would generate.

2.2.3 How a ship calculates its Attained Efficiency Index (EI_A)

As noted above, the term EI_A is used to distinguish an existing ship efficiency index value from a new ship's initial EEDI value. There are a number of ways to consider how EI_A is determined, all of which need to accommodate the variety of technical and operational measures that may be employed to improve a ship's efficiency in order to meet the EI_R standard.

The most straightforward method is to use the EEDI equation, shown below for reference. An importance difference is that some variables used in the equation would be based partially on formal sea-trial data and partially on current and historic operational data. For example, as used in the EEDI equation the term f_{eff} is a predicted usage factor for innovative energy efficient measures such as kites or sails which reduce a ship's overall power requirement. As used in the EI_A calculation, this predicted value would be replaced with an actual value based on historical operating usage to reflect accurate usage and subsequent power reductions from this energy efficient device or system. In addition, a periodic formal or in-use sea trial would be required to accurately capture the ship's current efficiency by measuring the ship's speed (V_{ref}) at a specific power and capacity.

$$EEDI = EI_A = \frac{\prod_{j=1}^{M} f_j \left(\sum_{i=1}^{nME} P_{ME(i)} C_{FME(i)} SFC_{ME(i)} \right) + \left(P_{AE} C_{FAE} SFC_{AE} \right) + \left(\left(\prod_{j=1}^{M} f_j \sum_{i=1}^{nPTI} P_{PTI(i)} - \sum_{i=1}^{nWHR} f_{eff(i)} P_{AEeff(i)} \right) C_{FAE} SFC_{AE} \right) - \left(\sum_{i=1}^{neff} f_{eff(i)} P_{eff(i)} C_{FME} SFC_{ME} \right)}{f_i \times Capacity \times V_{ref} \times f_W}$$

There would be a need to establish the period of time for required updates to the ship's calculated efficiency index value (EI_A). The updated value would account for positive or negative changes to the current ship's energy efficiency to reflect a ship's technology or operational improvements or EI_A degradation from items such as lack of maintenance or equipment inefficiencies. We propose that the MEPC consider a maximum update periodicity of five years and an option for earlier updates to take advantage of a ship's technology or operational improvements. Such updates would be verified by the ship's flag Administration.

The strength in using the EEDI equation above with regular updates is that it accounts for periodic operational measures such as regular maintenance and cleaning performed to maintain or increase efficiency. Consideration of a different optional calculation based on fuel usage to include these operational measures was presented in MEPC 60/4/12. However, including only operational measures in the equation makes it more difficult to establish a common metric to use as a basis for setting a standard. This is discussed below in section 1.3.1.

2.2.4 How a ship calculates efficiency credits (EC)

As illustrated in the equation below, the difference between a ship's EI_R and EI_A is multiplied by a ship's activity level over a reporting period to determine the efficiency credits (EC) for that ship. The U.S. originally proposed three options for measuring activity including: reporting of actual cargo tonne-miles, reporting miles only with a default capacity, or using an overall activity tonne-mile default value based on type and size of ship. Generated ECs could be positive or negative in a given period. For example, a ship operating more efficiently than the efficiency index requirement (EI_A is less than EI_R) would generate positive efficiency credits (the quantity of which would increase with increased activity), which could be sold to ships needing credits to comply with their applicable EI_R. If a ship is not meeting its required efficiency index (EI_A greater than EI_R) it would generate negative efficiency credits (debits) depending on activity. In such a case, the ship operator would have to obtain positive efficiency credits to offset the ship's negative efficiency credits or not use the ship. In order to continue operation, a deficient ship's EC would have to be periodically reconciled to zero. Individual ships would be able to meet this EC requirement through:

.1 Technologies that improve EI_A;
.2 Operational measures that improve EI_A;
.3 Fleet activity optimization to manage efficiency credits; and

.4 Efficiency credit trading within the maritime sector, as explained below, where:

$\pm EC = (EI_R - EI_A) * Activity$

The efficiency credits generated by a ship over a given period of time are calculated by multiplying the difference between the EI_A and the EI_R by a measure of the ship's activity in cargo tonne-nautical miles. MEPC 60/4/12 discussed three approaches to determining the activity term for ships. The merits and limitations of different approaches for determining activity are discussed in section 1.3.2. Chapter 5 presents a more detailed description of the efficiency credit program.

Figure -1 presents an illustration of hypothetical baseline, EEDI, and EI_R curves. Note that the same baseline curve could be used for the EI_R as for the EEDI. Although the EEDI and EI_R standards could be based on the same baseline, the stringency would not necessarily be the same. As illustrated below, EI_A would be a single point, and efficiency credits would be calculated based on the distance of this point from the EI_R curve.

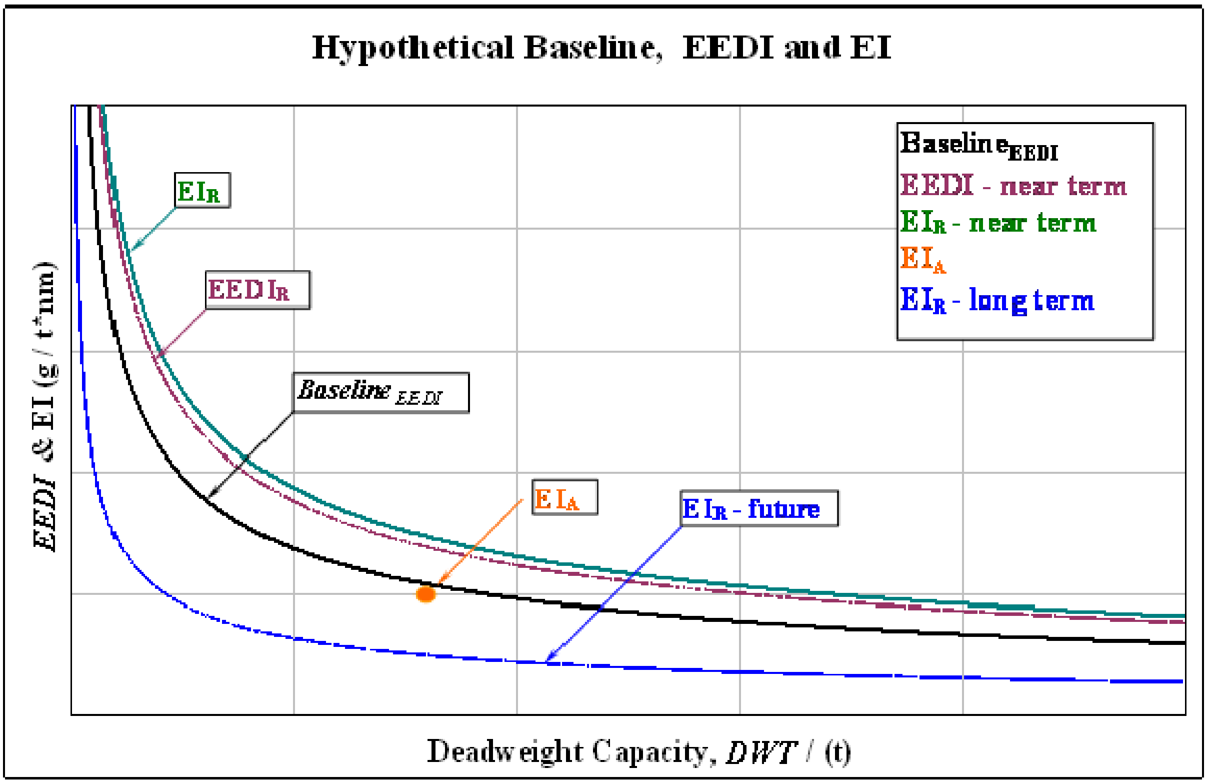

Figure 2-1: Illustration of Baseline, EEDI, and EI

2.3 Alternative program details under consideration

The efficiency index program described here is intended to build upon and enhance the EEDI standards currently under development. While this program would offer significant additional incentives to improve energy efficiency of ships, certain details of the proposal represent a balance between simplicity and fidelity. The U.S. believes that the concepts above provide this balance, but is open to further discussion of certain components of the proposal. To facilitate this discussion, MEPC 60/4/12 raises alternative approaches for both the EI_A equation and for the activity term used in the EC calculations. These alternative approaches are discussed in more detail below.

2.3.1 EI_A Equation

The most straightforward method for determining the attained efficiency index of a ship (EI_A) is to calculate it using the same equation that is used for the new ship EEDI. An importance difference is that some variables used in the equation would be based partially on formal sea-trial data and partially on current and historic operational data. For example, in the EEDI equation the term f_{eff} is a predicted usage factor for innovative energy efficient measures such as kites or sails which reduce a ship's overall power requirement. In the EI_A calculation this predicted value would be replaced with an actual value based on historical operating usage to reflect accurate usage and subsequent power reductions from this energy efficient device or system.

In addition, a periodic formal or in-use sea trial would be required to accurately capture the ship's current efficiency by measuring the ships speed (V_{ref}) at a specific power and capacity. In an attempt to explore this concept further, MEPC 60/4/12 presented both a formal and in-service sea-trial approaches. The in-service sea-trial would be similar to the simplified NO_x Technical Code methodology, and would capture a number of data points when operating near the capacity of the EEDI equation (i.e. 75% P_{ME}, 100% Capacity) with speed (V_{REF}) measured along with corrections for items such as wind or waves to obtain updated values for use in the EI_A calculation. The in-service at-sea test data would be collected using a standardized procedure to be further developed under the IMO's guidance and would be utilized along with historical data in the EEDI equation for calculation of EI_A for an individual ship. A formal sea trial could be coordinated with required surveys, twice in a 5 year period or optionally annually.

By using the same equation, the required and attained values of the EEDI and EI ($EEDI_R$, $EEDI_A$, EI_R and $EI_{A)}$ would be directly comparable. In addition, the metric for energy efficiency would be based on ship design and current ship efficiency, making it relatively simple to establish a corresponding efficiency index standard.

The shortcoming of using the EEDI equation above to measure *new* ships is that it does not account for periodic operational measures such as regular maintenance and cleaning that can increase efficiency. The strength in using the EEDI equation for *existing* ships with regular updates is that it accounts for periodic operational measures such as regular maintenance and cleaning performed to maintain or increase efficiency.

A limitation when using the EEDI equation for *existing* ships is that operational measures such as optimal voyage planning (including maximizing cargo in the ship) are not contained in the calculation. MEPC 60/4/12 recommended consideration of a different calculation option based on fuel usage so as to reflect these operational measures. However, including only operational measures in the equation makes it more difficult to establish a common metric to use as a basis for setting a standard. The U.S. believes that the most direct and accurate method of determining a specific ship's efficiency would be to use records of the actual fuel consumed divided by the work performed (cargo tonne-miles) for calculating the ship's EI_A. The alternative EI_A equation proposed is below:

$$EI_{\mathrm{A}} = \frac{\sum Tonnes\ Fuel\ Used * CO_2\ Conversion\ factor}{\sum Activity\ (tonne \cdot mile)}$$

The U.S. agrees with proposals that this calculation method would reflect actual technology and operational performance for existing ships. In addition, it would not require any initial or periodic sea trials. While this approach may provide insight into the efficient operation of a unique single ship, the primary limitation is that it would be difficult to establish a comparable efficiency index standard for a given class or size of ships. For instance, two identical sister ships may have the same EEDI and operate the same under similar situations. However, they may be used for very different routes and applications. Even if both ships are operated as efficiently as possible, one ship may consume much more fuel per tonne-mile of cargo moved due to a number of factors such as: prevalent winds, sea conditions on the route, demand for goods to be shipped on the back haul, and weight to volume ratio of the goods shipped. For these reasons, the EEDI equation appears to be the more favourable approach.

2.3.2 Activity used in EC determination

The measure of ship activity for the compliance period, e.g., one year, could be determined by several methods. In order to provide simplicity and flexibility, the original SECT proposal at MEPC 60 provided three options listed below for further review and comment. After additional review of the options for accuracy, simplicity and burden to ship owners and operators, the United States has determined that it prefers and recommends option number 2 to the MEPC. The actual miles travelled used with the EEDI value of capacity will provide adequate accuracy of the EI_A with minimized reporting burden. There might be some merit in allowing a ship's responsible party to choose either the recommended approach (option 2) or to use more specific information (actual tonne-miles) in the first option if it yields an improved EI_A value. Further comment is requested on the three options overall:

.1 Ships could report actual cargo tonne-miles of activity, based upon cargo and navigational logs.

Alternately, one of the following methods for approximating activity could be used:

.2 (The U.S. recommendation) Each ship would report actual activity miles only with the tonnes capacity per ship being the same as the capacity term in the EEDI equation.

.3 Use of an overall default activity indicator as a function of ship type and ship size. Using this method; a ship would be assigned a specific default cargo tonne-mile value based solely on the ship type and ship size in deadweight tonnes (DWT) as extrapolated from MEPC 59/INF.10.

For the option recommended by the U.S., miles travelled as measured by the ship owner/operator could be easily reported using daily log books with minimal additional burden. The capacity term would be the same term as used in the EEDI equation itself and the ship efficiency credit could easily be calculated. The use of the capacity term allows repeatable ship efficiency calculations while eliminating reporting of confidential business information.

Example Calculation of Efficiency Credits

In this hypothetical example of a 100,000 tonne deadweight capacity dry cargo carrier, all of the calculated values needed to determine its annual efficiency credits for 2013 have been determined below.

.1 Attained efficiency index (EI_A) calculated in 2010 using the ship's most recent sea-trial verified data: 3.42 g/(t·nm).
.2 Required efficiency index (EI_R) in 2013: 3.55 g/(t·nm).
.3 Capacity value from EEDI equation – 100,000 tonne deadweight (100% full capacity)
.4 Nautical miles travelled in period – 14,000 nm

$\pm EC = (EI_R - EI_A) * \text{Activity}$
$\pm EC = (EI_R - EI_A) * (\text{Miles travelled} * \text{default capacity})$

$$EC_{2013} = (3.55 - 3.42) \cdot (14,000 * 100,000)$$
$$EC_{2013} = (0.12) \cdot (1,400,000,000)$$
$$EC_{2013} = +140,000,000$$
$$EC_{2013} = +140 \text{ efficiency credits (tonnes } CO_2)$$

Chapter 3 - Technological and Operational Compliance Options

Ship owners and operators have four options to achieve compliance with the energy efficiency standards under SECT:

.1 **Technologies to improve ship efficiency:** Although maritime transport is generally the most efficient mode of transport, significant technological improvements could be made to ships to improve their efficiencies (EI_A) even further. These improvements, which include propulsion efficiency technology and ship resistance technology, are discussed in section 3.1 below.

.2 **Operational methods to improve ship efficiency**: Operational improvements to improve a ship's efficiencies and EI_A are discussed in section 3.2 below. These methods include speed reduction, weather routing, and improved cargo management to maximize cargo carrying capacity.

.3 **Fleet activity optimization**: In the case of carriers with fleets of vessels there would be a disincentive to use ships that perform worse than the efficiency index requirement. All other things being equal, keeping the less efficient ships in service would require the expense of technology upgrades, training to employ different operational practices, and/or the purchase of efficiency credits. Increased use of an efficient ship, in contrast, would generate efficiency credits, which could be held or sold to other ships.

.4 **Efficiency credit trading**: In some cases it may not be possible or appropriate to improve a ship's energy efficiency index enough to meet the applicable EI_R. For example, it may not be possible to install and employ needed technology or operational measures in a cost-effective or timely manner. These ships could also employ efficiency credit trading to obtain efficiency credits sufficient to offset the difference between EI_R and EI_A. Chapter 4 provides a detailed description of a ship efficiency credit trading mechanism.

This chapter discusses technological and operational measures that may be used to improve ship efficiency, as listed in points one and two above. Prior to that discussion, this chapter provides an overview of the EEDI equation, which would also be used for determination of the energy efficiency index under this proposal. This overview is provided to put the technological and operational measures in context of SECT. The compliance options listed in points three and four above are based on ship efficiency credit trading, which is discussed further in Chapter 3.

3.1 EEDI Equation and Variables

As a review, the current form of the EEDI equation is referenced below:

$$EEDI = EI_{\mathrm{A}} = \frac{\prod_{j=1}^{M} f_j \left(\sum_{i=1}^{nME} P_{ME(i)} C_{FME(i)} \, SFC_{ME(i)} \right) + (P_{AE} C_{FAE} \, SFC_{AE}) + \left(\left(\prod_{j=1}^{M} f_j \sum_{i=1}^{nPTI} P_{PTI(i)} - \sum_{i=1}^{nWHR} f_{eff(i)} P_{AEeff(i)} \right) C_{FAE} SFC_{AE} \right) - \left(\sum_{i=1}^{neff} f_{eff(i)} P_{eff(i)} C_{FME} \, SFC_{ME} \right)}{f_i \times Capacity \times V_{ref} \times f_W}$$

Simplified version of the equation:

$$EEDI = EI_{\mathrm{A}} = \frac{Power \cdot SFC \cdot CO_{2\mathrm{factor}}}{Speed \cdot Capacity}$$

Both the EEDI and EI provide a measure of the ship's CO_2 emission efficiency:

- Units of g/tonne·nm
- N_2O, CH_4, and black carbon are not considered in the emissions profile

Variables in the EEDI and EI equation:

P is the power of the main and auxiliary engines, measured in kW. The summation on *i* is for all engines with the number of main engines (*NME*) and the number of auxiliary engines (*NAE*).

- P_{ME} is 75% of the rated installed power (MCR) for each main engine.

- P_{AE} is the required auxiliary engine power to supply normal maximum sea load including necessary power for machinery, systems, equipment and living on board in the condition where the ship is engaged in a voyage at the speed (*Vref*) under the design loading condition of *Capacity*. Auxiliaries used for cargo systems and operational conditions other than "at-sea" are ignored. Denmark presented a simplified empirical formula previously for MEPC consideration. When P_{AE} is "significantly different" from power used at normal sea-going conditions, P_{AE} should be estimated as the consumed electric power as found in the Electric Load Table.

$$P_{AE(MCRME>10000KW)} = \left(0.025 \times \sum_{i=1}^{nME} MCR_{MEi}\right) + 250$$

$$P_{AE(MCRME<10000KW)} = 0.05 \times \sum_{i=1}^{nME} MCR_{MEi}$$

- P_{PT} is 75% of the rated power consumption of shaft motors.

- P_{WHR} is the rated electrical power generation of waste heat recovery system at $P_{ME}(i)$.

- P_{eff} is the main engine power reduction due to innovative energy efficient technology.

- *MEi and AEi subscripts refer to the main and auxiliary engine respectively for each engine (i).*

$\boldsymbol{C_F}$ is a non-dimensional conversion factor between fuel consumption measured in g and CO_2 emission, measured in g of carbon content.

Type of fuel	Reference	Carbon content	C_F (t-CO_2/t-Fuel)
1. Diesel/Gas Oil	ISO 8217 Grades DMX through DMC	0.875	3.206000
2. Light Fuel Oil (LFO)	ISO 8217 Grades RMA through RMD	0.86	3.151040
3. Heavy Fuel Oil (HFO)	ISO 8217 Grades RME through RMK	0.85	3.114400
4. Liquified Petroleum Gas (LPG)	Propane Butane	0.819 0.827	3.000000 3.030000
5. Liquified Natural Gas (LNG)		0.75	2.750000

SFC is the designed specific fuel consumption, measured in g/kWh, of the engines at the power output of P.

V_{ref} is the ship speed, measured in nautical miles per hour (know), on deep water in the maximum design load conditions assuming the weather is calm with no wind and no waves.

Capacity *is defined as follows:*

- The maximum design load condition shall be defined by the deepest draught with its associated trim, at which the ship is allowed to operate. This condition is obtained from the stability booklet approved by the Administration.

- Deadweight for dry cargo carriers, tankers, gas tankers, container ships, ro-ro cargo and passenger ships and general cargo ships, should be used as Capacity. Under current thinking, container ships are considered to have the EEDI calculated at 65% DWT to represent normal operating conditions. No other ship types use a reduced capacity value.

- Gross tonnage for passenger ships, in accordance with the International Convention on Tonnage Measurement of Ships 1969, Annex 1, regulation 3.

Vref, Capacity**,** and ***P*** should be consistent with each other, and should represent the designed sea-going condition of the ship.

Correction Factors

- ***fj*** is the correction factor to account for ship specific design elements [such as, e.g., ice strengthening, cargo gear or reefer containers].

- ***fi*** is the capacity factor for any technical/regulatory limitation on capacity, and can be assumed one (1.0) if no necessity of the factor is granted.

- ***feff*** is the availability factor of any innovative energy efficient technology.

- ***fw*** is a non-dimensional coefficient indicating the decrease of speed in representative sea conditions of wave height, wave frequency and wind speed (e.g., Beaufort Scale 6).

3.2 Methods to improve ship efficiency

The *Second IMO GHG Study 2009* presents cost-effectiveness estimates for several energy efficiency measures that could be applied to vessels currently in the fleet. The study also considers whether the efficiency measures can be applied to all ships in the fleet or only to new ship designs. Generally, there are greater opportunities to make use of new energy efficiency measures when designing a new ship compared to retrofitting existing vessels. These estimates include a low bound, a high bound, and a central estimate. Table 5-1 presents the cost-effectiveness estimates from this study. Note that these estimates were made considering a $500/tonne fuel cost and 4 percent interest rate on capital.

Although maritime transport is generally the most energy efficient mode of transport, significant improvements could be made to ships to improve their efficiencies (EI_A) even further. Each unique ship type and size has both common and unique methods for improving ship efficiency through technical or operational methods.

To increase an existing ship's efficiency (lowering the EI_A) by using the EEDI equation, it is obvious that the numerator of the equation should decrease, the denominator of the EEDI equation should increase, or both the numerator and denominator should be reduced proportionally. Reference the simplified equation shown below.

$$EEDI = EI_{\mathrm{A}} = \frac{Power \cdot SFC \cdot CO_{2\mathrm{factor}}}{Speed \cdot Capacity}$$

3.2.1 Technology to improve ship efficiency

There are numerous available technologies for existing ships to decrease the numerator resulting in a lower EI_A value and more efficient ship. Available technology is defined as one which can be considered as technically achievable and be applicable to a particular ship type from an engineering viewpoint. The advantage of application of new technology is that it can improve a ship's efficiency without changing DWT or ship speed. The resultant improvement of the efficiency would not cause any changes to, or constraints on, the operation patterns of the ship. A few examples are presented below but they are not considered inclusive of all available or proposed technologies.

<u>Reduction of the power term (P_{ME}, P_{AE}):</u>
Propulsion efficiency technology that reduces the power required to achieve or maintain a ships speed includes but is not limited to advanced engine designs or main and auxiliary systems, waste heat recovery, and ship resistance technology.

.1 Ship resistance technology includes but is not limited to optimization of hull shape, optimization of hull structure, application of low friction hull coatings, air lubrication of the hull, and use of stern fins or ducts.

.2 Advanced engine designs with higher efficiencies.

.3 Innovative energy efficient technology installed and used frequently (as shown by historic data) will reduce power requirements accordingly.

.4 Installation and increased usage of waste heat recovery systems.

Reduction of fuel conversion factor (CF):
Using alternative fuels with lower carbon content while maintaining specific fuel consumption and power will result in a lower EI_A value and more efficient ship operation.

Increase Capacity (Capacity):
Although larger DWT requires larger engine power, increased capacity can improve the efficiency and reduce the value of EI_A. This is because, generally speaking, the necessary engine power increases in proportion to the DWT increase powered by two-thirds and therefore the increase of the denominator outweighs that of the numerator. It should be noted that, while DWT enlargement improves the efficiency and lowers the EI_A of a ship, the ship would be subject to lower (more stringent) requirement for both EI_A and EEDI due to the increase in the capacity.

3.2.2 Operational methods to improve ship efficiency

There are various operational methods for existing ships to decrease the numerator resulting in a more efficient ship and lower EI_A value. A few examples are listed below, but these are not considered inclusive of all available or emerging options. Some operational methods are not captured in the EI_A equation but are expected to be utilized by ship owners and operators in parallel with reductions affecting the measured efficiency of an existing ship.

Speed Reduction (V_{REF}):
Lowering ship speed would reduce the necessary engine power considerably as the engine power is in proportion to the speed powered by three. Thus, speed reduction is very effective in improving the efficiency. Two methods below are proposed for use in the EI_A equation:

.1 Permanent engine derate:
Deciding to *permanently* operate slower than the design speed of the ship by permanent engine derating would provide the opportunity to improve the ship's efficiency index by reducing the power and speed terms in the EI_A equation. The reduced power of the PME would be used at 75% MCR in the EI_A calculation along with the corresponding speed reduction.

.2 Voluntary engine derate:
Operational methods that are not accounted for in the power term (P_{ME}) or speed (V_{REF}) of the EI_A equation could address concerns of additional safety margin propulsion power and long term voluntary slow speed operation. Using an optional calculation for the P_{ME} and V_{REF} terms in the attained Efficiency index (EI_A) by using historical data of continuous slower speed operation would result in an improved (lower) EI_A for the ship. For example, the current EI_A and EEDI equations use 75% MCR P_{ME} to obtain ships speed V_{REF}. Using this optional method, for a compliance period the ship owner or operator can demonstrate compliance to a continuous voluntary power or speed reduction that will be used in the EI_A calculation for the compliance period. It is critical that Flag state and Port state Administrations would be authorized to review documents and transactional records to verify compliance with voluntary speed reduction.

Auxiliary power (P_{AE}):
Optimized auxiliary engine usage as shown by load calculations can be used instead of default values for EI_A calculation.

Chapter 4 - Ship Efficiency Credit Trading

The market-based component of the U.S. submission to MEPC consists of efficiency credit trading among ships. Its design is based on the recognition that the global fleet is large enough and diverse enough to allow the use of market mechanisms to facilitate efficiency improvements beyond those that would derive from technology and operational measures meant to comply with a mandatory ship energy efficiency standard. This chapter discusses issues related with this market mechanism in general and with efficiency credit trading in more detail.

4.1 General Fundamentals of Emissions Trading

One of the oldest, strongest findings of economics holds that there is almost always a potential cost savings, or gain from trade, whenever the relative costs of performing an activity differ among nations, companies, facilities or individuals. This is why all nations, including all IMO Members, engage in international trade of the commodities, goods and services that certain countries excel at providing and others desire. In turn, this simple rule is the very driver for most of the demand for maritime transportation.

In recent decades, the United States and many other countries have successfully applied this fundamental principle underlying international trade to domestic, regional and even global efforts to achieve environmental goals more cost-effectively than is possible through traditional command-and-control mandates. It involves allowing entities subject to an emissions control obligation to find and apply the lowest-cost methods for reducing pollution rather than requiring the use of a specific emission control technology or practice. An entity with relatively lower-cost control options can reduce its emissions more than would otherwise be required. If it can trade those additional emissions reduction units to other entities with relatively higher-cost control options, which then can reduce their own emissions less, the entities can comply with the overall emissions goal at a lower overall cost. In addition, the flexibility in choosing how to meet the goal creates a strong incentive to develop new, lower cost operational and technological measures to reduce emissions.

A successful trading program requires the following essential elements: (1) a set limit on emissions (in absolute or relative terms) that is lower than the business as usual (BAU) emissions expected from those sources covered by the program; (2) a large number of sources with different control options and costs (and thus large potential gains from trade among the sources); and (3) monitoring, reporting, verification and enforcement to ensure trust in the emissions reductions themselves and the emissions trading market. Such a trading program makes the most sense when the costs of controlling emissions vary widely across covered sources or over time. What matters is the difference in relative cost; trading (and thus cost savings) can take place even among entities with only high-cost compliance options *so long* as there is a difference in cost. [2]

2 Since the location of greenhouse gas emissions is irrelevant to the objective of limiting atmospheric concentrations at the global level, and since the global shipping fleet is very large and extremely diverse in terms of ship type, size, age, trade and other characteristics, the control of GHG emissions from international shipping is an ideal candidate for a global emissions trading program.

Note that this fundamental concept holds true whether the emission standard is fixed (as in an absolute cap on CO_2 emissions) or an intensity- or rate-based emission limit (as in the case of an energy-efficiency standard for a ship). SECT employs the latter form because it so cleanly integrates with ongoing IMO work to establish the EEDI, EEOI and SEEMP.

4.2 Efficiency Credit Trading

The fundamental idea behind efficiency credit trading is that any particular energy efficiency target can be achieved at lower total cost to society if those responsible for achieving the energy efficiency target can exploit "gains from trade." Here, gains from trade refer to the possibility of those ships with higher cost options for improving energy efficiency paying those ships with lower cost efficiency-improvement options to undertake even more energy efficiency improvements. Those with higher costs benefit by reducing their net cost of compliance – they pay others to undertake energy efficiency improvements, but they avoid even higher costs of controlling themselves. Those with lower costs benefit because they voluntarily enter into transactions that yield revenues at least as large as the extra control costs they assume. Society benefits by having a more cost-effective control program; in this case, fewer real resources devoted to the achievement of the energy efficiency goal for international shipping.

Efficiency credit trading provides an incentive for some to improve energy efficiency *beyond* the requirement with which they must comply. Such highly energy efficient ships could generate more efficiency credits and trade or sell them to those with less energy efficient ships for monetary rewards. Therefore, this system would inherently incentivize highly energy efficient ships and operations, especially because it would reinforce existing market drivers such as increasing fuel prices and the growing demand from shipping customers for cleaner, greener transportation. Ultimately, efficiency credit trading would provide a means for the maritime sector to collectively invest in the most cost-effective efficiency improvements, which would in turn enhance efficiency within the entire industry much faster than would occur in the absence of this market mechanism.

Under the proposed efficiency credit trading mechanism, there also would be an incentive to use ships that have an EI_A that is better (lower) than the applicable EI_R because the generated tradable efficiency credits can then be sold or traded to ships that cannot affordably meet the required efficiency index standard even through technological or operational modifications. The strength of this incentive could be changed by adjusting the level of the required efficiency index standard or through fleet turnover and/or the utilization of more or less efficient ships. At no point does this market-based mechanism cap activity levels or the ability of international shipping to supply needed transportation services. As such, the incentive to be more energy efficient would remain consistent even if the international fleet increases or decreases in number, capacity, or activity. Changes in fleet activity and the market mechanisms in place for the cost containment of credits could impact the volume and/or price of efficiency credits traded, but not the level of the requirement.

4.3 Components of a Ship Efficiency Credit Trading Mechanism

In SECT, ship owners, operators and charterers could most efficiently buy or sell efficiency credits. Since these entities (the ship's 'responsible party') typically make key decisions regarding new-build design features, retrofits of existing ships, and the operational practices of existing ships, they would constitute the set of potential efficiency credit generators and purchasers. The IMO would develop the necessary regulations and oversight mechanisms for the Ship Efficiency Credit Trading (SECT) Mechanism, but the IMO would not operate or implement the mechanism. While further discussion is required regarding the most appropriate administrative entities to regulate and oversee the SECT, the following three components would help ensure a transparent and efficient scheme that provides ships' responsible parties (i.e. Registry Account Holders in the SECT) with real-time data to support trading and to assist in managing reduction targets and compliance status:

Registry: The SECT Registry would be an electronic database that serves as the official record holder and transfer mechanism for efficiency credit accounts. The ships' responsible parties would have an SECT Efficiency Credit account, and would use their registry accounts to manage SECT credits holdings, search for trades and credit transfers, and review SECT registry accounts statements. The Registry would include a settlement function to record transfers among Registry account holders. The SECT Registry Account Holders would access both daily and monthly clearing statements by logging onto the SECT Registry.

Trading Platform: The SECT Trading Platform could be established as a marketplace for executing trades among Registry Account Holders, and for completing and posting trades established through private, bilateral negotiations. This Trading Platform would be internet-accessible for each Registry Account Holder. The trading platform would be an anonymous, fully electronic system for posting and accepting bids and asking to buy and sell efficiency credits. Electronic trading in SECT would provide price transparency and anonymity. All trades would be guaranteed through the SECT's clearing and settlement systems. Delivery of SECT credits between SECT Registry Account Holders would occur on the same day the trade takes place. Alternatively, this function could be left for the private market to establish, as is the case in the European Emissions Trading System (EU ETS), which lacks a government-run trading platform.

Under the SECT, the ship's responsible party would calculate the efficiency credits according to its required and attained efficiencies and its activity level. The calculated efficiency credits of each ship could be enforced by flag Administrations and subject to port State control as with current obligations under MARPOL Annex VI.

The ship's owner/operator would use its SECT account to continuously monitor the amount of credits that it must buy or sell to meet its requirements in a given compliance period.

Options to trade credits include:

- privately trading credits between ships within a company headed by the responsible party;
- trading over the counter, using a broker to privately match buyers and sellers; or
- trading credits on an exchange, including the potential dedicated SECT Trading Platform.

4.4 Design Features to be Determined

In order to design the most effective efficiency credit trading mechanism from an economic, administrative and environmental perspective, several issues and concepts will need further clarity and explanation. The most notable issues and concepts are as follows.

Credit Life and Banking: The SECT mechanism could allow for efficiency credits to be banked (or held) for use in future compliance periods. Trading works because of the relative difference in marginal costs, in this case, of enhancing the energy efficiency of ships. The marginal cost differences for viable technological and operational efficiency-enhancing measures increase with the growing number of and diversity in the sources, i.e., ships. Moreover, allowing banking of credits increases the potential for trading because future advances in technologies and operational practices typically will have lower marginal costs than is true of those measures available today.

However, there is a concern that allowing credits to be banked indefinitely, that it may create a disincentive to trade. Ship operators may wish to hold on to credits as insurance against future actions. Establishing a limited credit life provides an incentive for these credits to be traded to those who desire to use the credits in the near term. This would also avoid the risk of delayed and potentially less enforceable compliance with the required efficiency standards as stringency levels change in the future. For these reasons, efficiency credits ($EC_{[year]}$) generated in any given year or period could have a limited lifetime (e.g. five years).

The credit lifetime, however, would not be affected by the compliance period or the stringency period. The remaining lifetime left for vintage credits would be indicated in each registry account while they are banked, and also, would be marked clearly while they are listed for sale in the trading platform.

Length of Formal Compliance Period: Selecting the length of a compliance period also establishes the periodicity of required compliance reporting. The choice involves striking a balance among various design factors. A short compliance period with more frequent reporting increases the administrative burden to some degree on all stakeholders, including the regulated entities (the ships), national Administrations, the credit trading exchange, and so on. A short compliance period also allows for faster response to and correction of identified cases of non-compliance. It also provides more timely and relevant price discovery information to regulated entities seeking to meet ship energy efficiency requirements in the most cost-effective fashion. By contrast, a longer compliance period and less frequent compliance reporting will see somewhat lower administrative burdens on all stakeholders, somewhat greater risk of undetected or long-running non-compliance, and less transparent, timely price discovery regarding the market price for efficiency credits and marginal abatement costs for specific efficiency-enhancing measures. To date, most emissions trading systems around the world have employed annual compliance periods and reporting requirements.

The SECT Mechanism Administration: Regulations established to administer the SECT mechanism would be verified by IMO parties or the appropriate administrative arrangements authorized by IMO. Any changes or updates in the regulations would be verified by the appropriate administrative arrangements, including the trading rules, transaction costs and administration fees, etc. The administration and establishment of the SECT Registry would be supervised by an IMO body, but its operation could be outsourced to a private entity if appropriate.

Incentives under SECT: Notwithstanding external influence from other regulatory measures, incentives towards efficient ships could be changed in two primary ways:

- **Manipulating the stringency of the required efficiency standard:** The percent by which each ship's efficiency requirement would be changed from its applicable baseline for a given compliance period (EI_R). Such an increase would decrease the number of ships generating Efficiency Credits and simultaneously increase the number of ships that would be required to purchase credits.

- **Fleet turnover and/or through the utilization of either more or less efficient ships:** If the international fleet were to become more efficient via fleet turnover or by the preferential utilization of the fleet's most efficient ships, there would be an increase in the supply of Efficiency Credits and a simultaneous decrease in the demand for Efficiency Credits. This shift would decrease the strength of the incentives and disincentives by decreasing the price of Efficiency Credits. It is important to highlight that at no point does this market–based measure cap activity levels.

Availability of Credits: As with any system involving trading, care would be need to taken to ensure that the system provides appropriate levels of affordable efficiency credits to meet potential demand. It is not our view that there will be a lack of credits, as credit trading is one of several means to achieve compliance with the standard. Nonetheless, there are a number of mechanisms that could be used to ensure credit availability. One approach is to employ a safety-valve whereby if the price of efficiency credits temporarily rises above a certain level, the regulating authority is empowered to issue additional credits into the system. Another approach would be to allow for the efficiency standard to be relaxed if prices were to exceed a specified threshold. Further work would need to be undertaken to further design these elements.

Compliance Assurance Provisions: Beyond the monitoring, reporting and verification elements required in any successful emissions trading program, there must be some sort of penalty for non-compliance. Otherwise, the environmental integrity and cost-effectiveness of the program is adversely affected. At a minimum, the U.S. envisions the establishment of a two-tier penalty that involves an obligation to acquire efficiency credits equal to the shortfall, as well as an automatic fine. This follows the successful precedent of the penalty system employed in many emissions trading systems. The imposition of an automatic fine on top of the loss of efficiency credits ensures that the non-compliance penalty exceeds the cost of compliance regardless of the market price for efficiency credits. If the efficiency credit takes place through the proposed exchange, then non-compliance on the part of one party also would result in the loss of its performance bond or collateral required as a condition of membership in the exchange.

4.5 Experience from Similar Schemes

Over the past two decades, the United States has used in-sector averaging, banking, and trading (ABT) schemes for a wide range of environmental regulations for transportation sources. These programs include exhaust emission standards for HC, NO_x, and particulate matter for engines used in on-highway vehicles (cars and trucks) and non-road equipment (boats, trains, tractors, forklifts, lawnmowers, etc.). In addition, this is the model behind Corporate Average Fuel Economy Standards (CAFÉ) for vehicles in the U.S. In many ways, SECT is also modelled after these programs.

Under the exhaust emission standards, a performance requirement is established that engine manufacturers must meet before they can introduce their products in to commerce. These engines are subject to the performance standard throughout their useful lives. The performance standards may be met either through the application of low emission technology to the engines or through the use of emission credits.

Engine manufacturers may earn credits for exceeding (building engines with lower emissions than) the emission standards. These credits may be used by the engine manufacturer in that year (averaging) to offset emissions from engines that do not comply with the performance requirement. Alternatively, the engine manufacturer may save these credits for use in future years (banking) or sell these credits to another engine manufacturer (trading). These credits can only be used among specific engine types. For instance, credits earned by boat engines may not be used to offset emission deficits from tractor engines.

Since the first in-sector emission credit trading program was established more than 20 years ago, engine manufacturers have widely participated in the averaging and banking of emission credits. These credit trading schemes have provided manufacturers with product planning flexibility which has resulted in reduced compliance costs. In addition, because this flexibility allows for early introduction of new emission control technology to be phased-in over time, more stringent standards, with earlier implementation, were possible than if the ABT provisions had not been established.

Rather than attempting to give an overview of the wide range of credit trading programs established in the U.S., we provide a specific example for outboard marine engines. Similar to the approach for efficiency standards under consideration by IMO, a baseline emission rate was first established for uncontrolled outboard marine engines. An emission performance standard was then established based on a percent reduction from baseline.

The outboard marine engine industry was unique, when these standards were developed, in that almost all of the engines were carburetted, crankcase scavenged, two-stroke engines. These inefficient engines have high exhaust emissions because roughly one-quarter of the fuel into the engine passes through the combustion chamber unburned. The technical solution was to upgrade the engines to either four-stroke designs or to direct-injected two-stroke designs (fuel injected into the cylinder after the exhaust port has closed).

The emission standards were phased-in over nine years, from 1998 through 2006, with the percent reduction from the baseline becoming more stringent each year. Engine manufacturers were able to meet the increasingly stringent standard by upgrading portions of their product line each year and averaging their emissions through the use of credits. Where upgrades were made faster than required, emission credits were banked, and used in later years.

Figure 4-1 provides a snapshot of the certification exhaust emission data for the outboard marine engine products sold in the U.S. in 2006. Note that, even in that year, limited high-emitting two-stroke engines could be produced due to the availability of emission credits. At this time, these high-emitting engines are no longer sold in the U.S.

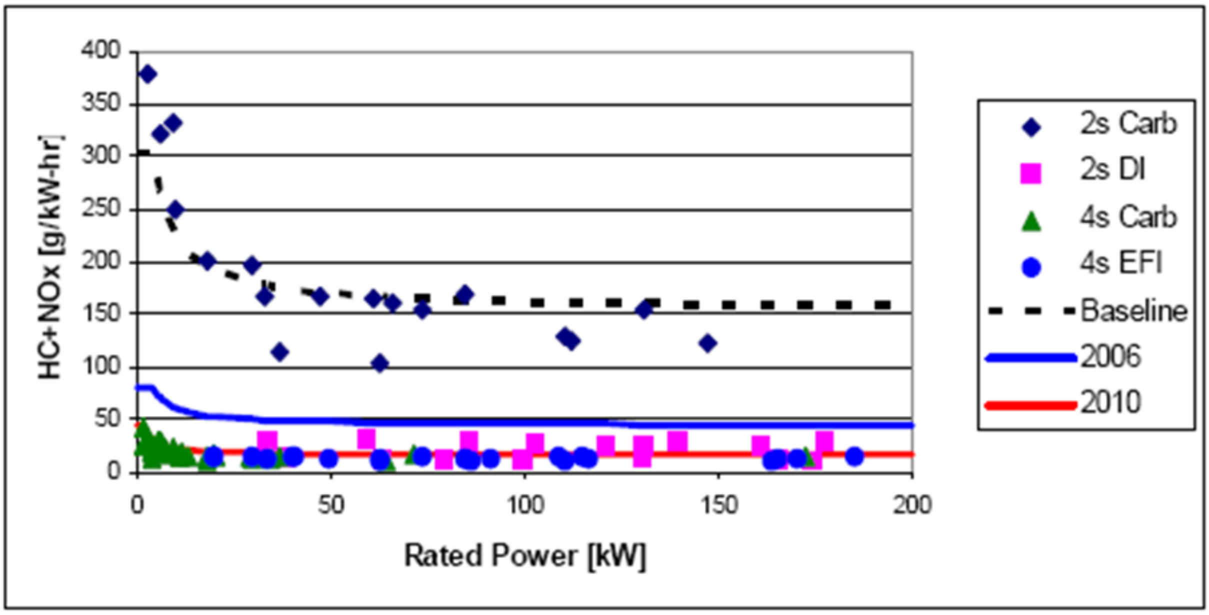

Figure 4-1: 2006 Model Year Outboard Marine Engines HC+NOx Certification Levels

Our experience has been that, if the credits can be banked indefinitely, there is little incentive for the credit holders to sell these credits. In the past the engine manufacturers typically held on to their emission credits as insurance against the uncertainty of future events. We believe that limiting the credit lives creates an incentive for credit earners to sell credits. If the credits are sold, the credit holder may earn the value of the credits. If the credits are retained to the end of their life, the credits simply expire with no gain to the credit earner.

Chapter 5 - Regulatory Compliance Structure

We hold the view that efficiency index standards for both new and existing ships should come into force as soon as possible. Prior to the final implementation of these standards, SECT would include a brief phase-in period starting as soon as possible, where new and existing ships would have to begin reporting their attained efficiency (EI_A) index values. This allows time to finalize the initial efficiency index standards, determine feasible ship efficiency improvements for future efficiency requirements, and settle other details as necessary.

Many of the details of the regulatory compliance structure are discussed in previous chapters. This chapter presents additional information.

5.1 Applicability

Under this proposal, all ships, including those in the existing fleet, would be subject to mandatory energy efficiency standards. As discussed above, this proposal builds upon the EEDI concept by expanding the efficiency index the entire life of all ships. This includes ships that will eventually be subject to the EEDI standards for new ships and ships (of the same type) currently in the fleet. As such, only ship types with approved EEDI baselines would be required to comply. This implies a phasing in of other ship and propulsion types as those values are determined and adopted by IMO.

Generally, only ships 400 gross tonnes and greater engaged on international voyages would be included in this program. For some ship categories, the lower threshold of the EEDI applicability may be greater than 400 tones. In those cases, the same lower threshold would apply for EI applicability.

One factor for consideration is the applicability of the EI standards to very old ships. For vessels with short remaining lives, it may not be cost-effective to retrofit the vessels for more efficient technology. This is because there may be few years take advantage of the fuel savings and to recover the costs. In this case, the only options for the ship operator may be to purchase credits or to stop using the vessel. Because of this, one concept under consideration would be to exclude vessels with very short remaining lives in the early years of the program. Any ship making use of this provision would be required to be removed from service within a short period of time, such as three years.

5.2 Certification and Compliance

Annex VI to MARPOL might be used as the mechanism to implement efficiency index standards for new and existing ships. It is anticipated that each new ship will be required to have an Energy Efficiency Design Index (EEDI) certificate. The EEDI certificate would identify the index rating for the ship and would serve as demonstration that the ship owner/operator has met applicable requirements related to ship design and documentation of compliance.

The EEDI certificate could be modelled after the MARPOL Annex VI IAPP certificate, and it would be expected that during surveys and inspections the Administration would verify the ship's compliance. To allow such verification, including verification of a ship's activity and its attained and required efficiency indices, ships would be required to record relevant shipboard data, maintain record books for inspection, and report efficiency credit transactions. As described above, the ship's flag State, or its authorized recognized organizations, would validate the reporting and certify compliance with the EEDI standards.

The compliance program associated with the in-use EI standards is more involved. Ship operators would establish an attained efficiency index, EI_A as described in Chapter 2. This process could be tied in with the schedule for surveys described in Regulation 4 of the NOx Technical Code or by a formal sea trial. For new ships that are produced after these standards are in place, the initial value of EI_A would be established with the ship's initial survey for getting an IAPP. For ships produced earlier, the initial value of EI_A would be established at the first annual survey after the in-use standards are in place. Once an initial value of EI_A is established, all ships would be on a schedule to update the value of EI_A at a minimum with each subsequent annual survey. The EI_A result would apply for demonstrating compliance over the preceding year in combination with the associated level of activity as described in Chapter 2.

Ship operators would be responsible for demonstrating compliance with the in-use efficiency standards at the date of the annual survey for each vessel. Ship operators would be allowed to spread their compliance demonstration over a two-year period to allow sufficient time to make technological and operational changes that would yield the proper balance of efficiency credits. In practice, this would mean that ship operators may have a negative credit balance for a given survey, but they may never have a negative credit balance for a vessel for two consecutive annual surveys. If positive credits are not available to offset a negative balance of credits, ship operators would need to make further efficiency improvements.

At the end of a compliance period, a ship must demonstrate either that its EI_A is better than or less than EI_R or that the efficiency credit for the ship for that period of time is either equal to or greater than zero, and report such data to its flag Administration. Ships with a negative efficiency credit value in any given year, where EI_A does not meet EI_R, must bring its emission credit value to zero by the end of the following year. This could be achieved through improved technology, operational methods, fleet management or purchasing efficiency credits.

If the EI_A changes during the compliance period, the ship owner could perform a prorated efficiency credit calculation using both its old and new efficiency index values. This could occur if the ship owner or operator decides to implement new technological and/or operational improvements to a ship at some time during the compliance period.

For positive credits that a ship operator generates at the time of a survey, those credits would be available to that ship operator for that same vessel, and for any other vessels it operates, for the following two years. These credits may also be sold to other ship operators. After the initial two-year period, for an additional three years, the ship operator would not be able to use these efficiency credits, but would be able to sell those efficiency credits to another company. On December 31 of the fifth year, those efficiency credits would no longer have any value.

The ship operator would have the following responsibilities:

- Demonstrate compliance with the in-use efficiency standard for the given vessel at the annual survey. If there is a negative credit balance at any point, the ship operator would need to acquire credits to show a positive or zero credit balance by the date of the subsequent annual survey.

- Estimate the positive or negative credits for the upcoming year using the value of EI_A established in the current survey.

- Manage the balance of credits for each ship it controls. This may include buying and selling these credits.

- Keeping records to document efficiency credits (positive and negative) and to document activity. Activity-related records may include bunker notes or other means of tracking fuel purchases and logged information to document tonne-miles, speed, and other operating parameters. Some of these records may need to be shared with another company if another company is responsible for certain aspects of ship operations.

Flag State and Port State Administrations could be authorized to review documents and transactional records to verify compliance with efficiency standards. This would be similar to the manner as is currently the case for verifying EIAPP and IAPP certification with respect to the NOx standard. Port state inspectors currently have responsibility for inspecting ships with respect to a wide range of technical, safety, and environmental requirements. The documentation involved would be related to the efficiency ratings for a ship's engines, the ship's rated capacity, and distance associated with the routes travelled.

Chapter 6 - Costs and Reductions

SECT builds on the Energy Efficiency Design Index (EEDI) standards currently under development at IMO for new ships. For ships constructed in the future that are built to be compliant with the EEDI standards, the proposal would simply extend the application of efficiency standards to the full lives of the ships. For ships currently in service, the proposal would establish efficiency standards that these ships must meet. As discussed in Chapter 3, the stringency level of these efficiency standards would be based on new technology and methods available to ships in the fleet. As such, these standards would likely differ from the EEDI and would become more stringent over time.

This chapter discusses the potential costs and emission reductions associated with the proposed efficiency index (EI) standards. The discussion distinguishes between ships that are already in the fleet and ships that will be built, in the future, compliant to EEDI standards. These costs and benefits are directly related to the stringency of the energy index standards which, similar to the EEDI standards, would be developed through IMO. Depending on the stringency level and future fuel costs, the efficiency index may result in significant cost savings to the ship operators, due to reduced fuel consumption. As stringent standards are pursued through IMO, the cost-effectiveness of the EI_R standards would be expected to be similar to the EEDI standards.

This analysis also considers the impacts of the efficiency credit trading mechanism described in Chapter 4. The establishment of an in-sector credit trading program would improve the cost-effectiveness and the efficiency gains of the proposed efficiency index standards. It does this by giving ship owners and operators additional flexibility in how they comply with the requirements.

6.1 Cost-Effectiveness of Individual Measures

For the purpose of this analysis, the cost estimates and potential efficiency gains are drawn from the *Second IMO GHG Study 2009*.[c] This study evaluated the reduction potential of a number of energy efficiency measures for ships, and the associated costs. These cost estimates included both the cost of applying and maintaining the various measures and the fuel savings associated with the efficiency gains. For many of the efficiency measures, the fuel cost savings are larger than the cost outlays. In other words, these efficiency measures result in a net cost savings to the ship operator.

The *Second IMO GHG Study 2009* also considers whether the efficiency measures can be applied to all ships in the fleet or only to new ship designs. Generally, there are greater opportunities to make use of new energy efficiency measures when designing a new ship compared to retrofitting existing vessels. In this section, we first consider the cost-effectiveness of applying efficiency measures on vessels currently in the fleet. We then discuss the cost-effectiveness of additional measures that could be used in new vessel designs.

[c] "Second IMO GHG Study 2009, Update of the 2000 IMO GHG Study; Final report covering Phase 1 and Phase 2," note by the Secretariat, Marine Environmental Protection Committee, 59th Session, Agenda Item 4, MEPC59/INF.10, April 9, 2009.

6.1.1 Vessels Currently in the Fleet

Under the EEDI concept, the efficiency standards would not apply to vessels already in the fleet. However, there are a number of technologies that could be used to improve the energy efficiency of these vessels. As discussed in Chapter 7, there are a number of potential barriers to the use of these technologies on existing vessels, even when they could lead to a net cost savings to the operator. The efficiency index standards described in SECT would provide an incentive for ship operators to maximize the use of energy efficiency measures on existing vessels.

The *Second IMO GHG Study 2009* presents cost-effectiveness estimates for several energy efficiency measures that could be applied to vessels currently in the fleet. These estimates include a low bound, a high bound, and a central estimate. Table 6-1 presents the cost-effectiveness estimates from this study. Note that these estimates were made considering a $500/tonne fuel cost and 4 percent interest rate on capital.

The measures in Table 6-1 include both technological upgrades and operational improvements. As discussed in Chapter 3, the establishment of an energy efficiency index for existing vessels would provide an incentive for ship owners and operators to retrofit their vessels with energy efficient technology. It would also provide an incentive to perform hull and propeller maintenance to improve the attained energy efficiency index. The energy efficiency index also reflects some operational measures such as maximizing the use of energy saving devices such as towing kites and could even be used to reflect planned speed reduction measures (through voluntary derating). When the periodic surveys are performed, the real data on the use of these measures would be used in the efficiency index equation. As shown in Table 6-1, all of these measures could be used to reduce operating costs through reduced fuel consumption.

It should be noted that the cost efficiency estimates in Table 6-1 include both annual costs and non-recurring costs. The recovery period for the non-recurring costs is based on the actual expected lifetime of the measure which is less than 10 years for some measures and up to 30 years for others. Therefore, the remaining life of the vessel is a factor in determining if the fuel cost savings will outweigh the investment costs. For an older ship with few years remaining in its useful life, some of these measures may not result in positive financial returns. In such cases, the purchase of emission credits may be a favourable option. As discussed in Chapter 5, it may be appropriate to exclude a vessel from this program if she will be retired soon after the implementation date of the energy efficiency standards.

Table 6.1: Cost-Effectiveness of Energy Efficiency Measures for Existing Ships

	Applicability	Cost Efficiency ($US\$/tonne$ if CO_2) central	low	high	Low reduction potential	High reduction potential
Retrofit hull improvements		-155	-160	-140		
Transverse thruster opening (flow optimization, grids)	All ships		-160	-140	0.90%	4.20%
Voyage and operations options		-150	-160	-140		
Shaft power meter (performance monitoring)	All ships		-105	115	0.40%	1.70%
Fuel consumption meter (performance monitoring)	All ships		-60	330	0.40%	1.70%
Weather routing	All ships		-165	-100	0.10%	3.70%
Autopilot upgrade/adjustment	All ships		-160	-140	1.75%	1.75%
Propeller/propulsion system upgrades		-115	-70	-155		
Propeller/rudder upgrade	All ships **		-80	120	1.60%	4.70%
Propeller upgrade (winglet, nozzle)	Tankers *		-90	600	0.10%	0.90%
Propeller boss cap fins	All ships		-155	-150	3.40%	4.20%
Other retrofit options		-110	-135	-75		
Towing kite	Bulk carriers, tankers *		-135	-75	3.00%	8.00%
Hull coating and maintenance		-105	-65	-140		
Hull performance monitoring	All ships		-150	-45	0.50%	4.90%
Hull coating (#1)	All ships		-150	-105	0.50%	2.10%
Hull coating (#2)	All ships		-140	-15	1.10%	5.20%
Hull brushing	All ships		-155	-65	1.00%	10.00%
Hull hydroblasting (underwater)	All ships		-155	-35	1.00%	10.00%
Dry-dock full blast (as opposed to spot blast)	All ships (old ships)		-160	-150	0.60%	1.30%
Propeller maintenance		-75	-120	-65		
Propeller performance monitoring	All ships		-160	-130	0.40%	3.40%
Propeller brushing (increased frequency)	All ships		-160	-130	0.50%	2.90%
Propeller brushing	All ships		-125	-65	2.00%	5.00%
Auxiliary systems		80	-90	250		
Low-energy/low-heat lighting	Ferries & cruise ships		-95	440	0.00%	0.00%
Speed control pumps and fans	All ships		-90	250	0.20%	0.80%
Speed reduction		110	80	135		
10% speed reduction of the entire fleet	All ships		80	135	7.90%	7.90%
Main engine retrofit		175	-120	470	0.40%	2.50%
Main engine tuning	All ships **		-90	470	0.10%	0.60%
Common rail upgrade	All ships		-125	45	0.10%	0.40%

* Tankers (crude oil, product, chemical, LPG, LNG, and other) only
** Other than ferries and cruise ships.

Table 6-1 above shows a positive cost-effectiveness for speed reduction. This means that the costs of the measure outweigh the fuel savings. The cost associated with speed reduction is based on the assumption that the market is in equilibrium with no extra shipping capacity. Therefore, new ships must be built to offset the reduced capacity associated with operating at lower speeds. However, when overcapacity exists (such as in the market today), this measure would be expected to result in a cost savings.

The EI equation in SECT is similar to the EEDI equation and includes a speed component at 75% of maximum continuous rating (MCR) for the engine. Small reductions in vessel speed can result to large reductions on power demand. This results in a lower attained EEDI and EI. As such, the ship owner could use speed reduction as an energy efficiency measure in two ways. The first is to derate the engine. This would change the 75% MCR value and result in a slower speed for the EI calculation. However, ship operators may wish to have the extra power available in case of emergencies. The second approach is a “voluntary” derating of the engine, whereby no change is made to the engine, but the ship operator agrees to operate at the lower speed. In this approach, the extra power would still be available in case of emergencies.

In conclusion, there are a number of measures that may be used to improve the energy efficiency of vessels that are already in the fleet. The majority of these energy efficiency measures have a marginal cost-effectiveness below zero. In other words, many of these measures could result in a net cost savings. The energy index would provide an incentive to overcome non cost related barriers to the implementation of these measures on existing vessels.

6.1.2 Future Vessels Compliant with EEDI

Currently, efforts are underway at IMO to develop energy efficiency design index standards for new ships. When these standards go into effect, new ship designs will incorporate new efficiency measures to comply with the EEDI requirements. These same energy efficiency measures would be reflected in the EI as well. The stringency of the EEDI and EI standards would be determined by maritime experts working under the auspices of IMO.

Because the EI standards would apply to all ships, new and old, it is likely that the EI standards would be less stringent than the EEDI standards. For this reason, ships compliant with the EEDI would likely be compliant with the EI requirements, especially early in their lives. As time goes by, the EI standards could eventually become more stringent than the EEDI requirements that the ship was originally designed to meet. In that case, the ship owner would need to take actions to bring the ship into compliance with the EI requirement.

The EEDI will provide an incentive for new ship designs to incorporate many of the measures described in Table 6-1. In addition, Table 6-2 presents efficiency measures that are practically only available to new ship designs. These measures include air lubrication and power management systems, which have the potential to reduce operating costs.

Table 6.2: Cost-Effectiveness of Additional Energy Efficiency Measures for New Ships

	Applicability	Cost Efficiency ($US\$/tonne$ if CO_2) central	low	high	Low reduction potential	High reduction potential
Air lubrication		-130	-150	-90		
Air lubrication (new ships only)	New ships *		-150	-90	0.90%	1.90%
Auxiliary systems		80	-90	250		
Low-energy/low-heat lighting	*Ferries & cruise ships ** *		*-95*	*440*	*0.00%*	*0.00%*
Speed control pumps and fans	*All ships ** *		*-90*	*250*	*0.20%*	*0.80%*
Power management	All new ships		-130	130	0.00%	0.10%

* * Crude oil tankers and bulk carriers > 60,000 dwt, LPG tankers > 50,000 m^3, all LNG tankers, full container vessels > 2000 TEU
** Could be applied to existing vessels as well

There are measures that would not be reflected in the EEDI equation but would result in significant in-use efficiency gains. These measures, which include hull and propeller maintenance, would be essential to complying with the EI standards. The EEDI is determined for a new ship, when the hull and propeller would be clean and in good condition. However, the attained EI would be periodically determined on the vessel in-use, and compared to the EI standard. As time goes by, hull and propeller fouling could adversely affect the results. It should be noted that, based on the estimates in Table 6-1, these maintenance measures result in net cost savings to the ship operator.

6.2 Projected Emission Reductions

By implementing this proposal for existing ships along with the EEDI standard for new ships, IMO would be implementing a comprehensive and workable standard that will improve the efficiency of international maritime shipping. This effective, efficient and timely pathway to fuel consumption improvements for ships will directly result in reductions of CO_2, SOx, PM, and NOx emissions.

The EEDI will drive technologies that can lead to efficiency improvements from new ships. SECT would enhance the EEDI standards by 1) driving efficiency improvements for ships already in the fleet and 2) ensuring that the efficiency improvements achieved by a new ship design are realized in use.

While this approach will result in reduced CO_2 emissions from ships, it is not designed to cap absolute CO_2 emissions from the shipping sector. The U.S. approach is designed to promote in-sector improvements in energy efficiency by promoting investment in technology and other efficiency measures. In other words, the goal is to maximize the improvements in the shipping sector, and not necessarily to offset a fixed amount of CO_2 emissions. These in-sector efficiency improvements will complement and facilitate other efforts to increase energy efficiency along entire transportation supply chain.

6.2.1 Baseline Emissions

The *Second IMO GHG Study 2009* projects greenhouse gas (CO_2, CH_4, N_2O) and other relevant emissions (NOx, SOx, PM, CO, NMVOC) from international shipping for several different growth scenarios. For the purpose of this discussion, we focus on the projected CO_2 emissions, which track projected fuel consumption.

All of the growth scenarios presented in the *Second IMO GHG Study 2009* suggest that fuel consumption due to shipping activity will increase over time, leading to increases in CO_2 and other emissions. In fact, without further control measures, CO_2 emissions are projected to double, from today's levels, in the 2035-2045 timeframe. These projected CO_2 emissions from international shipping are presented in Figure 6-1.

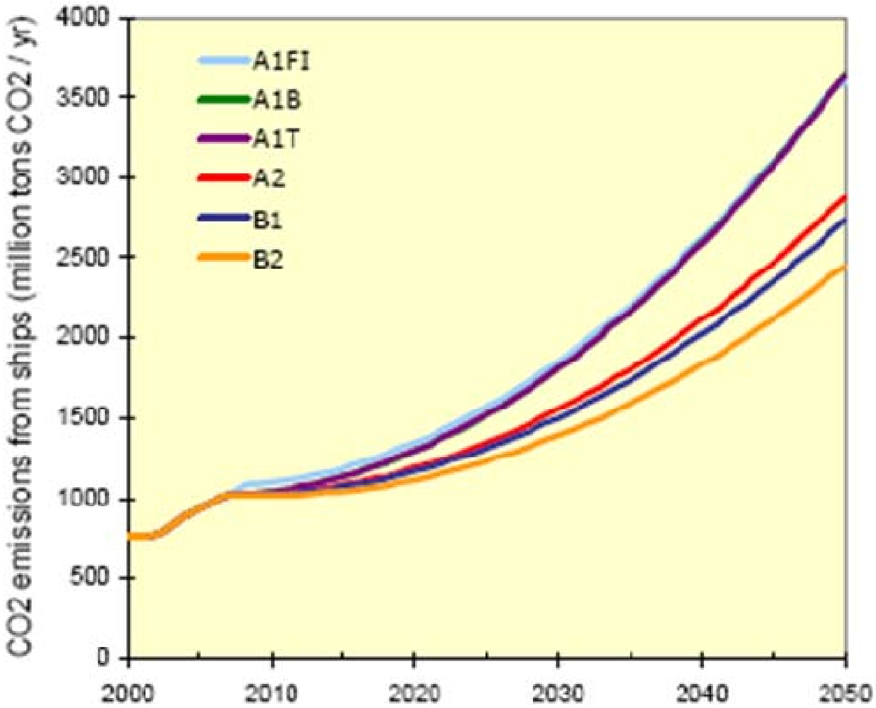

Figure 6-1: Projected Baseline CO_2 Emission from International Shipping

6.2.2 Controlled Emissions

The potential efficiency gains, and therefore emission reductions, are directly related to the stringency of the standards developed at IMO for both the EEDI and the EI. For this reason, it is difficult to project, at this time, the impact of SECT on emissions inventories in the future. It should be noted that EI standards for vessels in the fleet could result in near term reductions through ship retrofits and other measures. EEDI standards only apply to new ships, so the emission reductions therefore would not be fully realized until sometime in the future, when the fleet is made up of ships that were built subject to the EEDI requirements. Even in the case of these vessels, the EI would help ensure that the efficiency gains are achieved throughout the life of the vessels, and even drive improvements for older vessels.

As an illustration of potential emission reductions associated with energy index standards, we consider the potential reduction scenarios presented in the *Second IMO GHG Study 2009.* This study considered base and high scenarios for aggregate improvements in transport efficiency from 2007 through 2050. The base scenario considers efficiency improvements that would be market driven, and considers the impacts of existing regulatory programs (such as anti-fouling, air emission standards, ballast water requirements, etc.) on energy efficiency. Relative to 2007, the base cumulative fleet average efficiency improvement is 12% in 2020 and 39% in 2050.

The high fleet average efficiency improvements are those which are technologically feasible but may not be adopted due to lack of incentives. The 2020 high projection is 22% for ocean-going and coastwise shipping and 39% for container shipping. The 2050 high projection is 58% for ocean-going shipping, 65% for coastwise shipping, and 75% for container shipping. The establishment of efficiency index standards would provide the necessary incentive to promote such innovation in efficiency technology for ships.

Figure 6-2 presents the potential efficiency improvements for ships. For this example, which is presented here for illustrative purposes, the high projections for the different ship types were simply averaged without any weighting. Note that these projections do not consider efficiency for vessels already in the fleet. Therefore, the reductions in the early years are a composite of new ships that make efficiency improvements and existing ships that do not. Under SECT, ships already in the fleet would also be subject to the EI, resulting in additional near term efficiency improvements.

The efficiency improvements described here would be expected to achieve reduced greenhouse gas emissions as well as other regulated emissions such as NOx, SOx, and particulate matter.

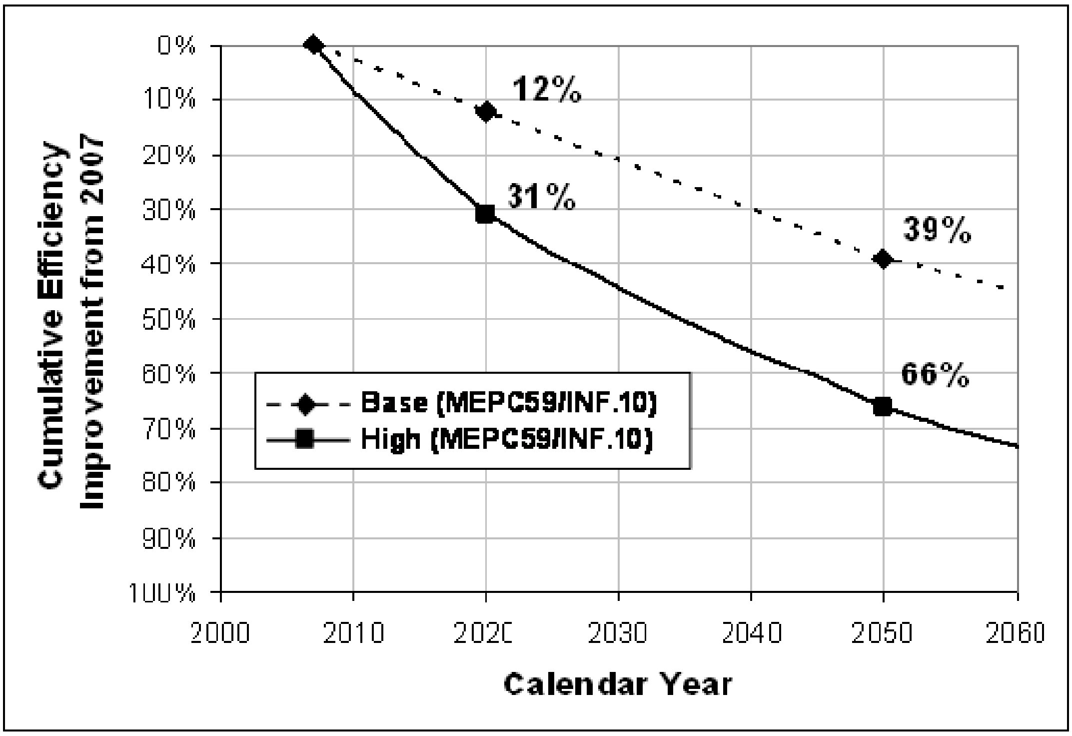

Figure 6-2: Aggregate Efficiency Improvements for Base and High Case

SECT focuses on maximizing efficiency rates rather than attempting to cap total emissions from the sector. As such this approach would not limit growth in shipping activity. However, depending on future shipping growth and the stringency of the EEDI and EI standards the potential exists for shipping emissions to continue to grow in the future, even though the efficiency of the fleet improves. We believe that promoting efficiency improvements in the international maritime sector ensures that the sector will maximize efficiency improvements, thereby enhancing sustainability in support of the global economy. In addition, such an approach provides incentives for innovation in efficiency measures. As history has repeatedly shown, such innovation can result in improvements in the future that are well beyond what is considered possible today. In any case, SECT is not necessarily mutually-exclusive of, and may even compliment, other approaches intended to cap total greenhouse gas emissions from ships.

6.3 Marginal Abatement Cost Curves

The *Second IMO GHG Study 2009* includes a number of marginal abatement cost curves (MACC) for energy efficiency measures for ships. These cost curves consider the range of cost-effectiveness estimates presented above in Tables 6-1 and 6-2. In addition, the study considers a range of assumptions for fuel costs and interest rates. Figure 6-3 below presents the MACC curves for the low, central, and high estimates considering a fuel cost of $500/tonne and an interest rate of 4 percent.

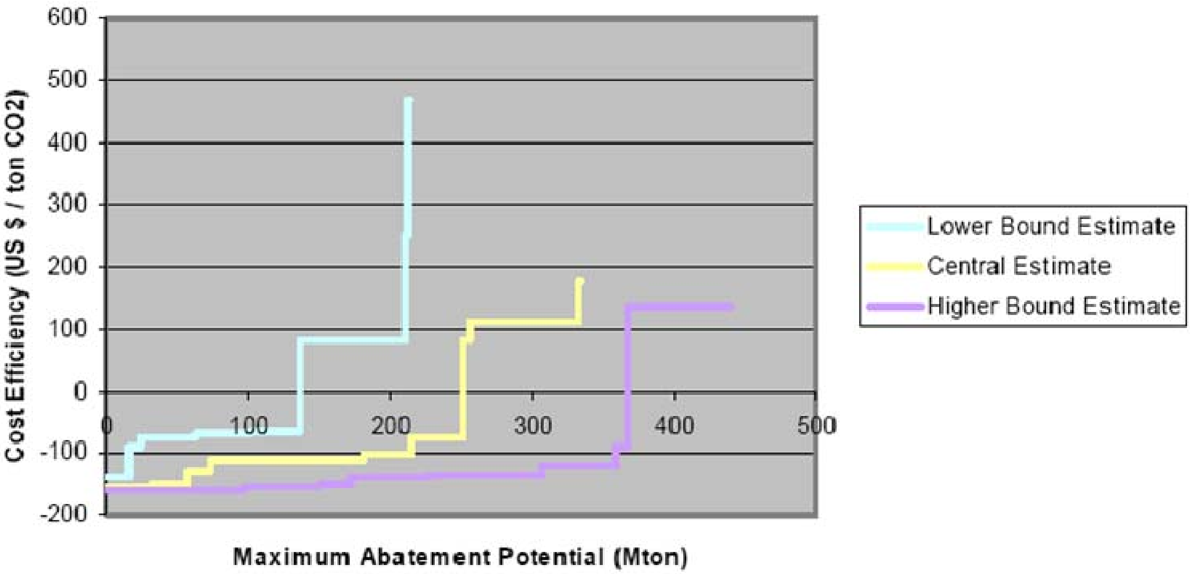

Figure 6-3: Marginal CO_2 Abatement Cost Curve, 2020, Fuel Price 500$/ton

Considering only those marginal costs below $0/tonne CO_2 (net cost savings), the efficiency measures presented here represent an emission reduction of roughly 10 to 30 per cent in 2020. Considering the full range of technology, the reductions are increased by another 5 to10 per cent. Much of this additional efficiency gain comes from speed reduction, which during times of overcapacity, can result in net fuel savings as well.

With respect to SECT, we recognize that if the EI standards are based on a similar equation as the EEDI, some efficiency measures may not be accounted for by the standard. For instance the EEDI equation, in its current construction, would not account for weather routing or reductions in auxiliary power on non-passenger ships. However, based on the MACCs shown above, it appears that the EI, as proposed, would capture more than 90 per cent of the efficiency gains from measures described here.

6.4 Cost Implications of Ship Efficiency Credit Trading Mechanism

The establishment of an in-sector credit trading program would improve the cost-effectiveness and the efficiency gains of the proposed efficiency index standards. It does this by making the most cost-effective efficiency gains available to all in the sector. In addition, because low-efficiency outlier ships can use credits as a lower cost alternative for complying with the standards, the stringency of the standards does not need to be limited to what the least efficient ships in the fleet can accomplish.

As an example, consider the case where a large tanker installs a new technology that is difficult to implement on a small container ship. It may be that this technology is very efficient, leading not only to significant fuel savings, but also the opportunity for the owner of the tanker to generate ship efficiency credits. This ship owner could profit by selling these credits as long as the sale price of the credits outweighed the minor administrative burden associated with making the transaction. The owner of the containership may find itself in a position where the efficiency index cannot be achieved cost-effectively. This could be due to factors such as a given technology being difficult to implement on the ship, an unusually inefficient design to begin with, or a short remaining ship life to recover costs through fuel savings. For the owner of the container ship, purchasing the emission credits may be a much lower cost option. In this case, the small container ship could trade efficiency credits with the large tanker, taking advantage of lower cost efficiency improvement. In this situation, both ship owners would attain cost savings that would not have been available without SECT.

The cost of the emission credits would largely be a function of supply and demand. In general, the net effect of the credit program would be to provide some ship owners an incentive to achieve further efficiency gains beyond what is required by the efficiency index. For the owners of ships that are low energy efficiency outliers, the credit trading program would bring their compliance costs closer to the average cost for the industry. Similar to existing credit markets, the administrative costs of the credit exchanges are expected to be minimal, relative to the value of the credits. Chapter 7 presents further discussion on credit costs, availability, and administrative costs.

Chapter 7 - Market Impacts

On a tonne-mile basis of goods moved, ships are generally the most efficient form of transport. Largely for this reason, approximately 90 percent of world trade by tonnage is moved by ships. Also, there are often no reasonable alternative shipping modes, making international shipping different from other transportation service markets. Although maritime transport is generally the most efficient mode of transport, there is significant potential to improve the efficiency of new and existing ships through technology improvements and operational measures, as discussed the *Second IMO GHG Study 2009* and Chapter 3 of this text.

SECT would provide an incentive for efficiency gains from ships. These efficiency gains would result in cost savings from reduced fuel consumption which would lead to positive market impacts for shipping. Net cost savings would result when fuel savings outweigh the costs of making the efficiency improvements. However, we recognize that this outcome is a function of the stringency of the energy index requirements developed at IMO, future fuel costs, and the cost of capital (interest rates). This chapter discusses the market impacts of these efficiency improvements.

This chapter also discusses the market impacts of the ship efficiency credit trading mechanism described in Chapter 3. Generally, this market-based measure results in decreased costs and provides ship owners and operators with flexibility on their compliance approach to the proposed requirements. Finally, this chapter discusses the importance of global participation in an efficiency program developed for ships.

7.1 Impacts of Energy Efficiency Index

SECT provides incentives, beyond the business as usual case, for ship owners and operators to maximize the efficiency of their ships. This program is intended to maximize in-sector efficiency improvements and does not attempt to cap net emissions through the use of offsetting credits from outside the maritime sector. Therefore, the costs associated with this program are directed at technologies and methodologies that would improve the efficiency of the international maritime sector. These efficiency improvements are expected to result in cost savings due to lower fuel consumption.

The purpose of this proposal is two-fold. First, this program would establish an in-use efficiency index (EI_R) for future vessels subject to the anticipated energy efficiency design index requirement (EEDI) for new ships. As such, the ships built under a mandatory EEDI regime would be subject to efficiency standards throughout their full life, which can be 30 years or longer. The EI_R will help assure that the efficiency gains are maintained, and even improved, beyond those measured at sea trials on new ships about to enter service. Second, the EI_R would apply to existing vessels that are already in the fleet prior to the implementation of EEDI standards. In this way, efficiency gains can be achieved much sooner than by waiting for the phase-in of newer, more efficient vessels through gradual fleet turnover. Similar to the EEDI, it may be possible to implement this proposal quickly through amendments to MARPOL Annex VI, which could be faster and less burdensome than developing a new annex or a new convention.

Also similar to the EEDI, the stringency of the EI_R standards would be developed by technical experts under the auspices of IMO. It is important that the standards be based on what is technologically feasible and be stringent enough to drive improvements beyond the business as usual case. To promote continual improvements, the standards could be revisited periodically to reflect new understanding of technologies and methods. At the same time, the EI_R standards should not be so stringent as to be unachievable in the sector.

While we expect that SECT would result in net cost savings due to improvements in fuel efficiency, this section considers two potential outcomes:

Scenario 1 considers the case where the fuel savings associated with the efficiency standards outweigh the costs associated with applying the efficiency technologies and methods. Based on the *Second IMO GHG Study 2009*, and as discussed in Chapter 6, many of the currently available efficiency measures lead to negative costs per tonne of CO_2 reduced. In other words, the fuel savings outweigh the investment costs. As such, this appears to be the likely scenario.

Scenario 2 considers the case where the net costs associated with the efficiency standards are positive. This could occur if the EI_R stringency is set to incentivize the use of efficiency technology that is effective, but costly. This could also occur if future fuel prices were to be lower than projected, therefore reducing cost savings associated with reduced fuel consumption.

7.1.1 Scenario 1: EI_R results in cost savings

It is anticipated that the efficiency standards will result in cost savings to the marine transport market due to reductions in fuel consumption per tonne-mile of goods moved. So this raises the following question: If the technologies and methods that could be used to comply with EI_R lead to cost savings, why has the market failed to drive these efficiency improvements under the business as usual scenario?

First, it should be acknowledged that, given enough time, many of the efficiency improvements described in this report would eventually enter the market, primarily on new ships. However, these improvements would probably not occur to the extent, and certainly not as fast, as would be achieved with a regulatory requirement in place. The *Second IMO GHG Study 2009*, which discusses a number of options for improvements in ship efficiency, states that "the potential for saving energy by these options is very significant. On the other hand, costs, lack of incentives and other barriers prevent many of them from being adopted." As a result, the IMO study only applies limited efficiency improvements in the business as usual scenario.

The *Second IMO GHG Study 2009* goes on further to state that "some options have negative cost and would be profitable to use. There may be non-financial barriers that prevent their use, or they may be cost effective from a social perspective, but not from the perspective of a ship operator." The discussion below presents a number of reasons that efficiency improvements may not be applied to ships in the absence of an EI_R, even though net cost savings may be available. It considers the perspective of the consumer, ship operator, ship owner, and ship builder.

Consumer – Generally, the seaborne transportation cost is only a small component of the final purchase price of goods moved by sea. In addition, the fuel cost is only a fraction of this transportation cost, which is much lower for marine shipping than other modes of transportation (per tonne-mile of goods moved). Furthermore, maritime transportation cost may only be one of several factors that the consumer of shipping services uses to choose a given shipping line. Other reasons may include capability to deliver on certain routes, logistics efficiencies and costs of the entire transportation supply chain and its component legs, long term contracts and other existing business relationships, services provided, national regulatory requirements, or even other environmental protection practices.[4]

For these reasons, the fuel cost borne by the consumer of marine transportation may not be enough of a factor in the marketplace to quickly drive investments in new technologies and methods that would improve fuel efficiency. A growing number of multinational companies that require international transportation services (e.g., Wal-Mart) are beginning to require cleaner, more fuel efficient transportation services as a contractual condition.[5] In many countries this has already prompted considerable efforts in the land-based transport modes to improve the energy efficiency and reduce the emissions of trucks and rail. However, to date this has not coalesced into a clear market driver for the maritime sector. Thus, for the foreseeable future, the establishment of mandatory ship efficiency standards would be a far stronger and timelier incentive for ship operators to provide more efficient transportation to consumers.

Ship Operator – Ship operators certainly have an incentive to minimize their operating costs, including fuel costs. However, there are a number of factors that may culminate in ships not reaching their full potential in terms of energy efficiency.

One factor in ship energy efficiency decisions is that the shipping lines may not bear the cost of the fuel used by the ships. These fuel costs can often be passed along to the consumer, and in many cases, the fuel costs are paid directly by the consumers of the transportation services. As such, there may not be a strong incentive for the shipping lines to spend time and resources to evaluate energy efficiency measures. As described above, it would likely take large reductions in relative fuel costs to become a deciding factor for many consumers when choosing a shipping line. In addition, the fuel cost savings anticipated by many of these technologies may be small relative to the very high volatility in bunker pricing over the past several years.

4 A number of high-profile reports, including the World Bank's 2010 *Logistics Performance Index* and the World Economic Forum's *Global Enabling Trade Report*, highlight the fact that consumers of transportation services must balance many factors when determining how to ship products. The key factors are efficiency of the clearance process, quality of trade and transport-related infrastructure, ease of arranging competitively priced shipments, competence and quality of logistics service, ability to track and trace consignments, and reliability of delivery. Fuel costs are only one element in this decision equation. Overall, the reliability of the supply chain is the most important aspect of logistics performance.

5 According to the World Economic Forum's 2009 Report *Supply Chain Decarbonization*, "Already, Wal-Mart has adopted a comprehensive approach to sustainability in its supply chain strategy to realize cost and carbon reduction opportunities across logistics, production and innovation. Through internal initiatives and engagement with its suppliers, the world's largest retailer will make its truck fleet '25 percent more efficient in three years, double in 10 years'. It 'plans to share [its] innovations throughout the supply chain, which [it] believes will create a ripple effect and magnify these solutions on a global scale.'"

It should be noted that when bunker prices peaked in 2008, many shipping lines began slow-steaming to minimize operational costs. This was a relatively straightforward measure for these companies to evaluate and to implement. This initiative was helped by the availability of excess shipping capacity that was caused by the economic conditions at that time. It is not clear if most ship operators, absent outside incentives in the form of clear market demand and/or regulatory requirements, will continue to slow-steam in the future as economic conditions improve and demand for ship capacity rises. [6]

Ship Owner – There is an inherent risk in making modifications to vessels and to purchasing more expensive vessels with improved efficiency designs. First, the ship owner faces the risk that energy efficiency gains from more efficient technologies may not be as large as anticipated. This is especially true for newer technologies where there is less in-use experience. Second, the ship owner faces risks associated with the cost of capital. To raise capital, ship owners must demonstrate that the investment will result in a net cost savings, over a reasonable payback period. However, there is uncertainty regarding the cost of capital and regarding the impact of future fuel prices on projected cost savings. If future fuel prices are underestimated by the shipping line, then the capital investment may not be made in a given technology that would have resulted in net cost savings.

For many of the larger shipping lines, the desired payback period for an efficiency improvement technology on a new vessel may only be a few years, even though the ship may be designed to be used for decades. The reason for this is that a larger company may only operate the ship for a few years, and then sell or charter it to another shipping operator. As such, the payback horizon may be limited to the time they plan to operate the vessel. In-use efficiency standards would help address this market failure by lengthening the time horizon for payback on efficiency improvements. Establishing an EI_R creates long term value for efficiency improvements which means the future revenue stream (fuel savings) can be incorporated into the sale price of the ship. Shipping operators purchasing or chartering used ships would place higher value on a ship with a lower EI_A.

Another factor to be considered is that, to be well informed on potential efficiency options, a shipping owner or operator must commit resources to investigate efficiency technologies and methodologies. This is especially true for retrofit options which must be evaluated on a ship-by-ship basis. Larger shipping lines may have the in-house engineering and naval architecture resources needed to perform these evaluations for their own fleet. However, smaller companies, especially individual operators, may be much more limited in these resources and, thus, much more dependent on the availability of robust, transparent, reliable and verifiable independent assessments of these technologies and methodologies. SECT would create incentives for shipping companies, or outside naval architecture firms, to evaluate technologies that may result in efficiency improvements. In addition, the ship efficiency credit system provides an option of purchasing credits, which, for some ship operators, may be a lower cost option to evaluating and implementing technical improvements.

6 In April 2010 IHS Global Insight forecast that the current economic recovery will generate 8.5% growth in global shipping volume this year and a further 7.8% increase in global shipping volume in 2011.

Ship Builder – Even a purchaser of new ships may be limited by what ship designs are offered by ship builders, as well as the time schedules offered to support design variations. Without a regulatory requirement, ship builders would have an incentive to minimize modifications to their standard designs, thereby minimizing workforce training implications and possible schedule delays. In doing so, the ship builder would be able to minimize engineering and naval architecture resources and to better standardize ship construction from year to year. However, the establishment of EEDI standards is expected to drive efficiency improvements in new ship designs. With the establishment of an EI_R, these ship designs would need to consider efficiency improvements over the full life of the ship. The growing demand by major maritime transportation customers for cleaner, greener transportation services will increase the need to design and retrofit ships to allow energy-efficient operation over the ship's operational life. This will introduce a desirable new element of competition among the world's shipyards.

7.1.2 Scenario 2: EI_R results in cost penalty

Here we consider a scenario where the cost of implementing the energy efficiency technology and methods outweighs the cost savings resulting from reduced fuel consumption. One way this could occur is if fuel prices were to drop in the future, resulting in a lower value of fuel savings. Another way this could occur is if the stringency of the EI_R were designed to maximize net social cost savings, including the value of CO_2 and other pollution reductions that would be driven by efficiency improvements. In this event, there could be a cost penalty to marine transportation, even though there was a net cost savings to society.

Even at a high marginal abatement cost, the proposed efficiency requirements are not expected to result in significant impact on trade overall. The economic theory for this is described below, followed by cost impact examples for specific ship types. Note that an extreme scenario had to be constructed to show a net cost increase associated with the efficiency measures.

7.1.3 Economic theory for cost impact on trade

The economic welfare implications of the market price and output changes with the regulation can be examined by considering consumer and producer net "surplus" changes associated with these adjustments. This is a measure of the negative impact of an environmental policy change and is commonly referred to as the "social cost" of a regulation. It is important to emphasize that this measure does not include the benefits that occur outside of the market, that is, the value of the reduced levels of air pollution with the regulation. Including this benefit will reduce the net cost of the regulation and even make it positive.

The difference between the maximum price consumers are willing to pay for a good and the price they actually pay is referred to as "consumer surplus." Consumer surplus is measured as the area under the demand curve and above the price of the product. Similarly, the difference between the minimum price producers are willing to accept for a good and the price they actually receive is referred to as "producer surplus." Producer surplus is measured as the area above the supply curve below the price of the product. These areas can be thought of as consumers' net benefits of consumption and producers' net benefits of production, respectively.

With a higher price for the product there is less consumer welfare, all else being unchanged. In addition to the changes in consumers' welfare, there are also changes in producers' welfare with the regulatory action. With the increase in market price, producers receive higher revenues on the quantity still purchased. However, this is offset by any loss in demand. The change in economic welfare attributable to the compliance costs of the regulations is the sum of consumer and producer surplus changes.

This discussion considers the price elasticity of demand in the international shipping market to be nearly perfectly inelastic (demand curve with near-infinite slope – a vertical demand curve). This means that the amount of these services purchased is not expected to change significantly as a result of compliance costs. In addition, any increases in costs are passed on to consumers of these services through an increase in freight rates. This is not to say that an increase in price has no impact on quantity demanded; rather, it means that the price increase would have to be very large before there is a noticeable change in quantity demanded.

The price elasticity of demand is expected to be near perfectly inelastic because there are no reasonable alternatives to shipping by vessel for the vast majority of products transported by sea. In many cases, it is impossible to ship goods between countries by rail or highway, because they are not connected by land. For example, goods moved between Asia and North America must be transported by air or by sea. In other cases, transportation of goods between countries by rail or highway would be inefficient due to the time and costs involved. As a result, over 90 per cent of the world's traded goods, by tonnage, are currently transported by sea.[7] While aviation may be an alternative for some very high value or perishable goods, it is impossible for goods shipped in bulk or goods shipped in large quantities. There are also capacity constraints associated with transcontinental aviation transportation, and the costs – not to mention the emissions – are much higher on a per tonne basis. As a result, the vast majority of the goods that most developing countries wish to export are unsuited for, or incapable of justifying the cost of, air freight. Maritime transport is their best, and often only, option for moving goods long distances to other markets.

A nearly perfectly inelastic price elasticity of demand result in a vertical demand curve. Figure 7-1 shows the relationships in a multi-level market with a nearly perfectly inelastic demand curve in the international shipping market. Specifically, if demand for transportation services is not expected to be affected by a change in price, then the demand for vessels will also remain constant, as will the demand for engines. The cost increase causes the market price to increase by the full amount of per unit control cost (i.e. from P_0 to P_1) while the quantity demanded for engines, vessels, and transportation services remains constant.

7 UN Conference on Trade and Development (UNCTAD), Trade and Development Report, 2008, Geneva

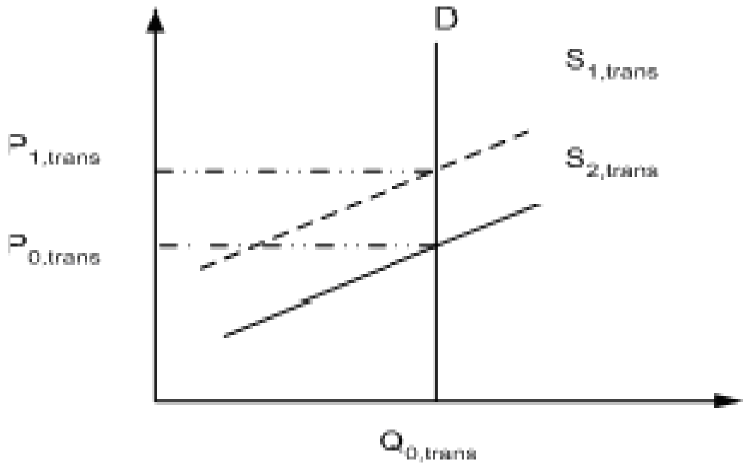

Figure 7-1: Market Impacts in Markets with Nearly Perfectly Inelastic Demand

Therefore, even if the cost of the efficiency measures exceeded the fuel savings, it is unlikely that this would result in significant adverse impact on trade overall.

7.1.4 Specific examples for ships

As discussed in Chapter 6, the *Second IMO GHG Study 2009* states that there is a range of efficiency measures where the fuel cost savings are greater than the costs of the measures. The majority of these measures may be retrofitted onto existing ships. The IMO study estimates that a 10 to 30 per cent efficiency gain may be achieved at a zero cost for CO_2 reductions. Under these conditions, there would be no impact on, or even a reduction in, the transport cost for traded goods.

Even if the costs for all of the efficiency measures listed in the IMO study are applied, including the least cost-effective measures, the average cost per tonne of CO_2 reduced still yields a net cost savings. Table 7-1 presents the central estimates from the *Second IMO GHG Study 2009* for ten technology measures for marginal cost efficiency and maximum abatement potential. In addition, this analysis presents the average cost efficiency. Note that the average cost efficiency of the measures remains below zero. This suggests that, on average, even a very stringent EI_R would still result in a net cost savings of $51/tonne of CO_2 reduced.

Table 7-1: Marginal and Average Cost-Effectiveness of Efficiency Measures (based on fuel cost of $500/tonne)

	Marginal cost/tonne of CO_2 reduced	Marginal abatement potential (Mt CO_2)	Total Cost ($Million)	Total abatement potential (Mt CO_2)	Average cost/tonne of CO_2 reduced
Retrofit hull measures	-155	30	-4650	30	-155
Voyage & operational options	-150	25	-8400	55	-153
Air lubrication	-130	20	-11000	75	-147
Propeller/propulsion upgrades	-115	50	-16750	125	-134
Other retrofit options	-110	70	-24450	195	-125
Hull coating and maintenance	-105	40	-28650	235	-122
Propeller maintenance	-75	45	-32025	280	-114
Auxiliary systems	80	5	-31625	285	-111
Speed reduction	110	100	-20625	385	-54
Main engine improvements	175	5	-19750	390	-51

Mt = million tonnes

However, in this section, we are interested in considering the potential impacts of efficiency standards on a ship where the fuel savings do not outweigh the costs. For this scenario, we consider a specific ship that, for whatever reason, is an outlier with respect to low effectiveness of efficiency measures and high costs of applying these measures. For instance, it may be an old, inefficient vessel that is scheduled to be retired soon. As such, the modifications could be more expensive than on average, and the payback period would be short. This ship would likely purchase efficiency credits during its remaining operational lifetime. For the example below, we consider a ship with an EI_A that is 30 percent above EI_R and efficiency credits offered at a cost of $110/tonne CO_2, which is the central marginal cost estimate of speed reduction in the *Second IMO GHG Study 2009*. This represents an extreme negative scenario for a single ship, and not an average impact on the international marine transportation market. Note that Chapter 4 discusses a concept where it may be appropriate to exclude ships that will retire soon after the EI_R is implemented from this proposal.

To perform this calculation, we must first know the price of goods transported by international shipping. For the basis of these calculations, we use estimates from a 2009 study[8] on maritime transport cost. The 2009 study includes information both on marine transport costs and on the percentage of the value of the traded good that is made up by transport costs. These costs are summarized in Table 7-2 for four commodity types. For the four commodity types considered here, the transportation costs have the largest impact on the price of raw materials and the smallest impact on manufactured goods. Note that the marine transport report uses a bunker fuel cost of $360.50/tonne. However, the *Second IMO GHG Study 2009* uses a central estimate of $500/tonne. For this reason, Table 7-2 also presents adjusted estimates based on a fuel cost of $500/tonne.

8 Korinek, J., Sourdin, P., (August 2009) Maritime Transport Costs and Their Impact on Trade, OECD paper http://www.etsg.org/ETSG2009/papers/korinek.pdf

Table 7-2: Maritime Transport Costs Compared to Value of Goods

Commodity	Ship type	Transport cost as percent of price of goods	Maritime transport cost ($/tonne)	Calculated value of goods ($/tonne)
Based on Fuel Cost of $360.50/tonne				
Agriculture	Bulker	11 %	$82	$740
Raw materials	Bulker	24 %	$33	$135
Crude oil	Tanker	4.0 %	$18	$449
Manufactures	Container	5.1 %	$174	$3,404
Adjusted for a Fuel Cost of $500/tonne				
Agriculture	Bulker	12%	$93	$753
Raw materials	Bulker	27%	$37	$140
Crude oil	Tanker	4.6%	$21	$451
Manufactures	Container	6.0%	$205	$3,435

In the above table, we used estimates from a 2010 study[9] for the fraction of the transport costs that are made up of fuel costs (the other cost components being general operational costs and capital costs). For the $360.50/tonne fuel cost scenario, the fuel costs were estimated to be 34-44 percent of transport costs for bulkers, 41-48 percent of transport costs for tankers, and 29-64 percent of transport costs for container ships. We used the average value of these ranges. The calculated fuel cost for the $500/tonne case is presented below in Table 7-3.

Even considering the extreme cost scenario, where a 30 percent efficiency improvement is required for a single ship and credits are purchased at a marginal cost of $110/tonne CO_2, the impact on the price of goods is relatively small. Table 7-3 presents these impacts which reflect a 0.4 to 2.6 percent increase in the price of goods shipped.

Table 7-3: Extreme Scenario for Impact of Increased Efficiency on Shipping Costs (based on fuel cost of $500/tonne)

Commodity	Ship type	Fuel Cost	CO_2 credits needed* (tonnes)	Increase in shipping costs	Increase in price of goods transported
Agriculture	Bulker	$44	0.08	10%	1.2%
Raw materials	Bulker	$18	0.03	10%	2.6%
Crude oil	Tanker	$9	0.02	9%	0.4%
Manufactures	Container	$109	0.21	11%	0.7%

* based on assumed 30% efficiency offset at $110/tonne of CO_2

Based on the above analysis, it seems that efficiency improvements associated with SECT would have little negative, and likely a positive, impact on trade supported by international marine shipping.

9 CE Delft, (January 2010), A Global Maritime Emissions Trading System; Design and Impacts on the Shipping Sector Countries and Regions.

7.2 Impacts of Ship Efficiency Credit Trading

Generally, market-based measures (MBMs) are attractive policy instruments to reduce emissions in a cost-effective manner. MBMs typically associate a cost with emissions, thereby creating incentives for emitters to reduce emissions and to continuously seek better, faster, and cheaper ways of doing so. By providing appropriate incentives, market mechanisms can drive investment in more efficient equipment, spur technological innovation, and encourage more energy efficient behaviour.

Ship efficiency credit trading (SECT) is one such market-based measure. SECT is intended to provide regulatory flexibility through an in-sector trading program. Under this program, a performance based efficiency standard is established for ships. If a ship can do better than the standard, it earns credits and, in turn, may sell these credits to other ships not meeting the standard.

The discussion below expands on the economic merits of the proposed SECT mechanism. In addition, this section addresses concerns that have been raised with regard to SECT by providing additional information on the program and by clarifying common misconceptions.

7.2.1 Economic merits of SECT

As discussed in Chapters 4 and 6, efficiency credit trading would reduce the cost and improve the technological feasibility of achieving the standards. As a result, SECT would enable the fleet-wide attainment of the proposed efficiency standards earlier than would otherwise be possible. Ship operators would gain flexibility in the management of their fleet and opportunity for a more cost-effective introduction of new technologies and methodologies. SECT also would create an incentive for the early introduction of new efficiency measures, which allows certain ships and shipping lines to act as trail blazers for new technology and methods. This would help provide valuable information to ship operators on efficiency measures before applying these measures across the entire fleet. In addition, the early efficiency improvements could provide significant cost savings through reduced fuel costs.

SECT would promote these efficiency improvements and keep the exchange of efficiency credits within the international maritime sector. This ensures that the sector will maximize efficiency improvements, thereby enhancing sustainability in support of the global economy. Because the revenues from SECT would remain in sector, this will further ensure that the maritime sector will reduce its emissions. In addition, credits traded are calculated based on the difference between the ships' required and attained energy efficiency indexes (respectively EI_R and EI_A). These credits would only be earned for efficiency improvements and would only be used to offset deficiencies in achieving the required efficiency improvements. This approach ensures efficiency improvements without capping activity or absolute emissions, and catalyzes action by industry leaders wishing to go beyond the required efficiency requirements and build and use more efficient ships.

The efficiency improvements are likely to achieve reduced greenhouse gas emissions as well as other regulated emissions such as NOx, SOx, and particulate matter. Additionally, they could drive investments into sustainable low-carbon fuels. An advantage of in-sector efficiency credit trading is that similar emission reductions are likely for efficiency improvements from different ships. Purchasing credits outside of the sector could result in equivalent CO_2 reductions, without the corresponding reductions in other pollutants. Another advantage of an in-sector trading program is that it does not rely on the establishment of external schemes to become effective.

7.2.2 Addressing comments on SECT

Since SECT was introduced, we received significant feedback on various aspects of the proposal. This feedback has been useful in helping us further refine the proposal and to identify what misconceptions there may be regarding the proposal. Three common comments were that the proposal 1) does not cap absolute CO_2 emissions from international shipping, 2) does not ensure availability of credits at reasonable cost, and 3) creates an unknown administrative burden. These comments are addressed below.

No cap on absolute CO_2 emissions from international shipping – Commenter's noted that SECT focuses on efficiency improvements directly from ships rather than setting a cap for absolute CO_2 emissions for the shipping sector. They have asked how the proposal could be used to cap absolute CO_2 emissions from the shipping sector.

While this approach will result in decreased CO_2 emissions from ships, it is not designed to cap absolute CO_2 emissions from the shipping sector. The U.S. approach is designed to promote in-sector improvements in energy efficiency by promoting investment in technology and other efficiency measures. It builds on the good work IMO has already performed towards developing EEDI standards for new ships. The standards would be revisited periodically to provide incentives for continuous improvement of efficiency technology and methods used on ships. As these technologies and methods improve over time, it may lead to substantial energy efficiency improvements and CO_2 reductions. However, the goal is to maximize the improvements in the shipping sector, and not necessarily to offset a fixed amount of CO_2 emissions. These in-sector efficiency improvements will complement and facilitate other efforts to increase energy efficiency along the entire transportation supply chain.

SECT has the potential to quickly achieve significant emissions reductions from the maritime sector. This proposal could potentially be accomplished with an amendment to MARPOL Annex VI, which could be faster and less burdensome than developing a new annex or a new convention. This proposal complements IMO's new ship EEDI by extending the regulatory incentive for efficiency improvements to the existing fleet.

SECT is distinct from some other market-based measures under consideration by IMO in that it does not directly cap maritime activity or emissions. In that way, it does not limit growth in the maritime sector, but rather strives to maximize the efficiency of shipping. Because it focuses on in-sector reductions only, the SECT mechanism should not be considered as mutually-exclusive of open-sector MBMs which target further CO_2 offsets for shipping through measures taken outside of the maritime sector.

Concerns regarding credit availability and cost – Because SECT is limited to credits generated in the international marine sector, concerns have been raised regarding how ship owners, operators or charterers (the responsible parties) would comply with the efficiency index standards when there is a limited supply of credits. In addition, concern has been raised that, because it is a closed trading system, there is no mechanism to align the cost of these credits with CO_2 credits in other transportation sectors.

This proposal focuses on how best to address emissions from existing ships and it complements the current effort within IMO to develop efficiency index standards from new ships with the EEDI. More efficient vessels would be able to earn credits that could be used by less efficient vessels. Because the credits are earned where efficiency gains are the most straight-forward, the cost-effectiveness of the efficiency index standards is maximized. It is also important to note that a properly-designed scheme would be expected to reduce fuel consumption, which presumably would translate into somewhat lower transport prices in a competitive transportation market. As with the EEDI, marginal abatement costs should be considered when setting the stringency of the efficiency index standards.

The availability and cost of efficiency credits will largely be a function of stringency of the standards, fuel costs, and the cost of the efficiency improvements. The market price of the credits should adjust to reflect these factors such that supply equals demand. If the credits become too expensive for certain ships, the most cost-effective way to meet the efficiency standards will be through technology improvements, operational improvements, or fleet activity optimization. At the same time, high market price for efficiency credits will provide an incentive for other ships to strive for additional efficiency improvements, so to earn credits.

In addition, as discussed in Chapters 4 and 5, the efficiency credits would expire if not traded or used within two years. If traded, the credit life would be longer at five years. This creates an incentive for credit earners to sell credits that they do not intend to use. This is expected to make more credits available to the market. Lastly, the ships most likely to be dependent on efficiency credits are those that will soon be retired. For these vessels, there is little time to take advantage of fuel savings and to recover costs. Chapter 4 raises a concept where it may be appropriate to exclude certain vessels provided they are retired within a short period after the EI_R standards go into effect.

Administrative burden – We received comment that MEPC 60/4/12 proposal did not provide sufficient detail on the regulatory and compliance details regarding administrative burden of the energy efficiency index standards or the SECT mechanism. Some concern was expressed that SECT could have significant administrative burden.

Chapter 5 presents additional details on the regulatory and compliance structure envisioned for the for SECT proposal. With respect to the efficiency standards, the administrative burden would be no greater than for NOx or fuel sulphur standards. The efficiency standards could become part of the IAPP for ships and similar verification and enforcement approaches could be used. Periodic verification of the efficiency index could be tied to the five year surveys combined with existing record keeping requirements. Verification procedures could be similar to those established for the EEDI.

The proposed in-sector credit trading program would be relatively straight-forward to administer. The ship's responsible party would calculate the efficiency credits according to its required and attained efficiencies and its activity level. The calculated efficiency credits of each ship would be enforced by flag Administrations and subject to port State control as with current obligations under MARPOL Annex VI. SECT would be based on much of the same information used for verification of the efficiency index, combined with activity information. IMO would develop the necessary regulations and oversight for the credit program, but IMO would not operate or implement this program. Because SECT focuses on in-sector credits, it should be less complex to administer than an open-sector trading program.

One thing to be noted is that SECT would be voluntary for the responsible parties. If the ship operator complies with the efficiency index without the need for credits, then the ship operator would not need to register with the SECT program. However, ship operators would have a financial incentive to participate in SECT if they are in a position to sell credits or if purchasing credits were their lowest cost option.

7.3 Value of Full Participation

For an international maritime agreement on ship energy efficiency to be effective, participants must be committed and bound to comply, as well as held accountable to objective and verifiable metrics. Regardless of the market-based measures applied to international shipping, the coverage will be an important factor in judging its effectiveness and the potential for perverse incentives, such as reflagging a ship to a non-participating country to avoid regulation. This is recognized in the IMO overarching principle of "no more favourable treatment."

The full participation of all international marine transport between all countries would offer obvious advantages in terms of delivering the largest environmental benefit and eliminating competitive distortion, as well as limiting leakage and the potential for perverse outcomes. This approach is consistent with other safety and environmental requirements established by IMO. For example, NOx and fuel sulphur standards apply to all ships engaged in international trade, regardless of where they are flagged.

Partial coverage of the maritime sector could lead to significant leakage concerns, whereby a perceived reduction in CO_2 emissions from covered sources would simply be offset by increased emissions outside of the controlled population. Leakage is always a potential problem when treating one segment of an industry rather than the whole, but the nature of the industry (particularly how easy it is to shift activity outside the regulated portion) determines how significant concerns should be.

Unique characteristics of the international maritime sector make it more vulnerable to leakage and perverse incentives from partial coverage for the proposed efficiency standards. For the fluid and global shipping industry, many of the major shipping operators are flagged in open registries and feasible evasion opportunities exist. Even if voyages were excluded based on destinations rather than flag, there would be the potential for perverse outcomes. For example, adding a stop in a developing country, land re-routing, or refuelling at sea could all offer means to avoid coverage. Thus, a ship exporting goods from a developing country could travel further in order to make a stop in another developing country and exempt that portion of the journey from coverage. As a result, overall emissions would increase due to longer shipping routes.

In addition, it is expected that ship energy efficiency standards will result in significant reductions in fuel consumption, which will, in-turn, result in cost savings. In the long run, providing an incentive for all countries to participate in the program would lead to benefits to all countries.

For these reasons, global participation should be ensured for an international maritime mechanism, regardless of where a ship owner is based, a shipping operator is flagged and regardless of the nation of departure or destination, as long as stops are made in a nation other than the country of departure. The greater the share of world fleet and flag States covered by the proposed efficiency standards, the more cost-effective this program will be with little or no adverse impact on trade and sustainable development.

7.4 Impacts on Developing Countries

The United States is doing an analysis of expected costs and impacts of the SECT program, including the impact on developing countries. Unfortunately, this analysis was not completed in time for the document submission deadline for MEPC 61. However, there is a wide variety of literature which outlines a wide range of validated energy efficiency measures that can be implemented that save money for the ship owner/operator, but are not implemented due to non-market barriers. A regulatory approach mandating efficiency will help overcome these barriers.

In fact, SECT would create, for the first time, an incentive for ship-owners to invest in efficiency measures with longer term payback periods. This is because a highly efficient ship will continue to generate efficiency credits for years, and the value of the future stream of fuel cost savings and efficiency credits can be factored into the price of a ship should the owner decide to sell or charter it. In addition, a focus on efficiency is inherently cost-effective for ship owners because they are lowering operating costs. SECT also creates a robust, standardized and verifiable grading scheme for ship energy efficiency that can be utilized by the growing body of major maritime transport users (e.g., Wal-Mart, Procter & Gamble, TESCO) that seek to make their production, logistics and transportation supply chain greener and less carbon-intensive.

While it is hard to ascertain the full impacts of SECT without knowing the stringency of the efficiency standards, we believe that much of the overall costs of the program will be recuperated in lower fuel costs for owners and operators. There is a concern that some developing countries would see an increase in the costs of their goods shipped to or from their countries as a result of this program. There is little data that shows the average age of a fleet servicing a given country, but there is significant data which shows the average age of a flag-state's fleet. For many developing country flag states, the average ship age is equivalent to, or in many cases less than, the average age of ships in many developed country fleets. The impacts on trade are expected to be minimal as there is no cap on growth of the sector, the decreased fuel costs and lower vulnerability to fuel price spikes should enhance the ability of ship owners and operators to maintain or improve service levels even on marginally profitable routes (such as to/from SIDS, or in competition with trucking or other transport modes), and in some cases the price of transportation may go down due to decreased fuel costs. As such, the impact on LDCS and SIDS is also expected to be minimal.

The United States will continue its analysis and would welcome any further information on potential impacts in any country, but particularly LDCS and SIDS. Should modelling or further analysis show that SECT will result in significantly higher costs for LDCS and SIDS, SECT could be altered in a way to minimize these negative impacts.

Chapter 8 - How the U.S. Proposal Meets the 9 MEPC Criteria

The MEPC, at its 60th session negotiated a series of criteria from which the various market based measure proposals would be evaluated by the IMO Market-Based Measures Expert Group. The information below provides the U.S. perspective on how SECT meets these criteria.

ToR	Criteria	How US Proposal (SECT) Addresses Criterion
5.1	**The environmental effectiveness and reduction of greenhouse gas (GHG) emissions from international shipping**	The U.S. proposal, Efficiency and Ship Efficiency Credit Trading (SECT) is environmentally effective as it would decrease fuel use per tonne-mile due. This would lead to reductions in a variety of air pollutants including greenhouse gas emissions. Analyses conducted with data from the IMO updated GHG study suggests a 10 to 30% direct reduction of greenhouse emissions in 2020 is highly possible and it could be as high as 40% (below business as usual). **For more detail see Chapters:2, 3, 6.2, 6.3, 7.1.2.1, 7.2, and 7.3.**
5.1 A	Mechanism of achieving emission reduction	Emissions would be reduced as compared to business as usual through increased efficiency standards on existing ships. The standards would tighten over time. **For more detail see Chapter: 2**
5.1 B	Reduction in CO_2 emissions from international shipping projected – absolute or relative (ie per tonne-mile)	The emission reduction is relative, not absolute, because our focus is on increasing the energy efficiency of international shipping. It is not an absolute cap on emissions. We are still conducting analysis on this question, but a preliminary analysis using the updated IMO GHG study suggests a high likelihood of a 10-30% reduction in 2020 compared to business as usual. However this could be as high as a 40% reduction if speed reductions are included. The actual reductions will depend on the stringency chosen for the standard. **For more detail see Chapters: 6.2, 6.3**
5.1 C	Direct reduction in emissions &/or indirect through reduction GHG emissions in other sectors (offsetting)	SECT focuses on reducing emissions within the sector, often with cost savings for ship owners, by facilitating ship energy efficiency improvements. At this stage, SECT does not provide for indirect reduction through offsetting. **For more detail see Chapters: 6.2, 6.3**
5.1 D	Certainty of outcome – how certain is it that the emission reduction potential will be achieved	The reductions projected above (from 10% reduction up to perhaps 40%) are considered quite likely. While SECT would not establish an absolute cap on emissions, it would create a mandatory efficiency standard that must be met. SECT envisions penalties sufficient to deter non-compliance. The efficiency cap will provide greater economic incentive for some technologies as it forces a look at a longer payback horizon and provides incentive for greater use of on-off technology (such as waste heat recovery kites). **For more detail see Chapters: 2.13, 2.1.4, and 5.**

ToR	Criteria	How US Proposal (SECT) Addresses Criterion
5.2	**.1 The cost-effectiveness of the proposed MBM** **.2 Potential impact(s) on trade** **.3 Sustainable development and impact on developing countries, in particular least developed countries (LDCs) and Small Island Developing States (SIDS)**	SECT calls for increased efficiency; the cost effectiveness is expected to be high. In fact, SECT would create, for the first time, an incentive for ship-owners to invest in efficiency measures with longer term payback periods. This is because a highly efficient ship will continue to generate efficiency credits for years, and the value of the future stream of fuel cost savings and efficiency credits can be factored into the price of a ship should the owner decide to sell or charter it. In addition, a focus on efficiency is inherently cost-effective for ship owners because they are lowering operating costs. In addition, SECT creates a robust, standardized and verifiable grading scheme for ship energy efficiency that can be utilized by the growing body of major maritime transport *users* (e.g., Wal-Mart) that seek to make their production, logistics and transportation supply chain greener and less carbon-intensive. The impacts on trade are expected to be minimal as there is no cap on growth of the sector, the decreased fuel costs and lower vulnerability to fuel price spikes should enhance the ability of ship owners and operators to maintain or improve service levels even on marginally profitable routes (such as to/from SIDS, or in competition with trucking or other transport modes), and in some cases the price of transportation may go down due to decreased fuel costs. As such, the impact on LDCS and SIDS is also expected to be minimal. **For more detail see Chapters: 6.1, 6.4, 7.1.2.1, 7.2, 7.3, and 7.4**
5.2.1.A	Cost of compliance to industry	The overall cost of compliance to the industry will depend on the stringency of the standard. Capital costs will be decreased through reliable streams of fuel cost savings Moreover, the trading mechanism of the SECT will ensure the lowest cost of compliance to the industry for any given efficiency standard. Many ships may be able to sell their excess credits and create additional revenue. Those ships that buy credits will find this a less expensive compliance route than the use of available technological or operational measures The Credit program helps minimize costs and achieves greater efficiency improvements in shipping efficiency and the improvements are made where they are most cost-effective. Credits available where improvements not very cost-effective. Using data from the IMO study suggests that even a very stringent EIR would still result in a net cost savings of $51/tonne of CO2 reduced. **For more detail see Chapters: 3, 6.1, 6.2.2, and 7.1.2.2.**

ToR	Criteria	How US Proposal (SECT) Addresses Criterion
5.2.1.B	Administrative costs	Some of the administrative aspects in SECT are not yet fully developed but it is expected the administrative costs will be modest and will compare favourably to those of the other MBM proposals. **For more detail see Chapters: 2.1.4, 3.3, 2.4, and 5**
5.2.1.C	Net revenues generated	We note that the original nine criteria for greenhouse gas measures to be adopted by the IMO (agreed at MEPC 57) did not include raising revenue for external benefit. Accordingly, SECT is designed to reduce emissions within the sector at minimal cost and to the benefit of the sector only. Our proposed system is self-contained in that all costs to industry are spent on investments in their own vessel efficiency. The fact that these investments would be made in better ship designs, technologies, construction and operation means that our proposal generates revenue not only for international shipping but the broader maritime sector as well. By helping ships become more efficient and generating new work in related maritime service fields, the U.S. proposal will help the maritime transport sector provide better quality and better service levels. It also will help international shipping better compete with other transport modes regardless of global economic swings. The price of an efficiency credit would be determined by the overall stringency of the program. **For more detail see Chapters: 7.1.1, 7.1.2, and 7.2.**
5.2.1.D	Tonne CO_2 abated/total (industry + Administrative) costs	We are still conducting analysis on this question, but a preliminary analysis using the updated IMO GHG study suggests a 10 to 30% reduction in 2020, relative to BAU. However this could be as high as a 40% reduction if speed reductions are included. Using data from the IMO study suggests that even a very stringent EIR would still result in a net cost savings of $51/tonne of CO_2 reduced. **For more detail see Chapters: 6-2, 6-3, and 7.1.2.2**
5.2.2.A	Projected impact on cost of transporting goods and raw materials by ship	The overall cost of compliance to the industry will depend on the stringency of the standard and the degree to which the IMO mechanism is seen by transport users as effective, robust, reliable and verifiable. However, as SECT is self-contained, all revenues would stay within the sector, helping ships become more efficient. This would have the impact of reducing fuel costs, thereby reducing shipping costs. The degree to which major users of transportation services (especially multi-national companies such as Wal-Mart) recognize the system as robust, environmentally effective, reliable and verifiable will induce increases in their utilization of maritime shipping at both the international and domestic levels. **For more detail see Chapters: 6.1, 6.4, 7.1.2.1, 7.2, 7.3, and 7.4**

ToR	Criteria	How US Proposal (SECT) Addresses Criterion
5.2.2.B	Impact on cost structure	SECT would reduce operating costs (fuel) and increase capital costs (investments in ship efficiency), although the IMO GHG study indicates that substantial negative-cost investments are available to ship owners. In recent years fuel costs have accounted for over 50% of daily operational costs of container ships (and other ship types as well). Because the capital costs for efficiency improvements under SECT are spread out over time and the fuel cost savings resulting from these improvements are immediate, the result is a more favourable balance sheet for ship owners and operators. The establishment of mandatory efficiency standards and the recognition and utilization of such IMO standards by major users of maritime shipping will create the proper conditions for ship owners and operators to look favourably on even long-term capital investments that can generate immediate and continuing fuel cost savings into the indefinite future. **For more detail see Chapters: 6.1, 6.4, 7.1.2.1, and 7.2.**
5.2.2.C	Impact on service availability	The impact on service availability will depend on the efficiency measures chosen, and whether these take place during construction or are retrofitted. Owners of inefficient ships always have the option to comply by purchasing credits, thereby not impacting their service availability at all. Ship owners who decide to retrofit their vessels to generate surplus credits in the future will take any resulting downtime into account in making this decision. In addition, beyond temporary availability constraints due to time spent in a shipyard, the fact that SECT positively impacts the profitability of any given ship will increase the ability of that ship to initiate or continue service of even marginal, small or otherwise inefficient markets (e.g., SIDS at the end of a route). Other IMO MBM proposals that do little or nothing to actually increase ship energy efficiency, in contrast, will have done nothing to improve ship profitability or service levels, particularly for small markets. **For more detail see Chapters: 6.1, 6.4, 7.1.2.1, and 7.2.**

ToR	Criteria	How US Proposal (SECT) Addresses Criterion
5.2.2.D	Impacts for end consumers, particularly in developing countries	As with all MBMs aiming to internalize the price of carbon into the cost of shipping, the net costs of reducing emissions may be passed on to end consumers, although this will depend on the cargo type. As most goods and commodities are destined for developed countries, it is expected that those consumers would carry a corresponding proportion of the costs. Note that any net costs from improving ship energy efficiency and reducing CO_2 emissions will not translate into proportional increases in the final delivered cost of the good or commodity in question. In most cases, the final delivered cost will change very little because the net costs associated with improving ship efficiency are relatively modest compared to many other pricing variables. However, we would note again that the IMO GHG study predicts substantial efficiency gains can be achieved at negative cost, before any positive costs are actually incurred. SECT is designed to allow ship owners to capture the monetary benefits of those efficiency improvements over a long period of time, because a very efficient ship will continue to save on fuel costs and also generate monetizable credits for a number of years. **For more detail see Chapter:6.1, 7.1.2.1, 7.1.2.2, 7.2, 7.3, and 7.4**
5.2.2.E	Potential for competitive distortion	Given that SECT would apply to ships from all countries engaged in international trade and given that SECT does not establish absolute limits on sectoral emissions (and thus sectoral activity levels), there would be no competitive distortion within the sector. Flag state and port state controls will ensure meaningfully robust participation and compliance by all ships covered by SECT. Moreover, the acceptance and utilization of the SECT by major transport users such as Wal-Mart will quickly add compelling economic motivation to the list of factors that we expect will minimize potential competitive distortion within international shipping. **For more detail see Chapter:7.3 and 7.4.**
5.2.2.F	Trade patterns and potential for modal shift	The impacts on trade are expected to be minimal as there is no cap on growth of the sector and in some cases the price of transportation may go down due to decreased fuel costs. As such, the impact on LDCS and SIDS is also expected to be minimal. The sooner the IMO establishes a mandatory ship energy efficiency regime the sooner international shipping will be better positioned to actually capture more business from other transport modes. The growing support for supply chain decarbonisation among world-class shippers (transport users) and domestic consumers in many countries will reward those capable of creating an effective, robust and verifiable scheme for international transportation. **For more detail see Chapter: 7.1.2.1, 7.2, 7.3, and 7.4**

ToR	Criteria	How US Proposal (SECT) Addresses Criterion
5.2.3.A	Impacts of MBMs on developing countries including administrative requirements, impact on local ship operators, potential for competitive distortion (link to Administrative requirements in 5.7 of the different MBM proposals and impact on ships in 5.8)	SECT would create new requirements for port state administrations and ship owners and operators in developing countries. However, our proposal builds on the EEDI, EEOI, and SEEMP employs administrative mechanisms already in place in MARPOL Annex VI, and the incremental effort to implement our proposal will be modest compared to other MBMs. The potential impact on "local ship operators" depends entirely on whether their ships are covered by SECT or another possible IMO MBM, and decisions on possible exemption thresholds yet to be taken by the IMO with respect to ship energy efficiency. **For more detail see Chapters: 2.2.3, 2.2.4, 5, 6.4, 7.1.2.2, and 7.2**
5.2.3.B	Countries/ports/ships/trades particularly affected	As our system is globally uniform, no countries, ports, or trades will be particularly affected. Port states. **For more detail see Chapters: 4, 7.1. 1, 71.2, and 7.2.1.**
5.2.3.C	Implications of threshold selected for ship size to which scheme would be applicable	The U.S. proposes that only ships of 400 gross tonnes and greater engaged on international voyages be included in this program. This is consistent with MARPOL Annex VI. This should automatically exclude most ships run by the "local ship operators" noted in 5.2.3.A above. **For more detail see Chapter: 5**
5.3	**The proposed MBM's potential to provide incentives to technological change and innovation – and the accommodation of current emission reduction and energy efficiency technologies**	By setting efficiency standards and then allowing both the in-sector capture of fuel cost savings and the compliance cost savings associated with efficiency credit trading, there is a strong regulatory and financial incentive to increase ship efficiency. The U.S. proposal does not prescribe what technologies to use or how to use them; instead it lets ship owners/operators decide what technologies work best for their ships. The ability to use credit trading motivates ship owners/operators to make some ships *even more efficient than is required* from a compliance standpoint, thus allowing them to sell extra efficiency credits for positive financial gain. Those ship owners/operators with less efficient ships have the option of choosing the most cost-effective route to becoming compliant with a required efficiency standard. Given that SECT would be exclusive to and self-contained within the maritime sector, it provides the highest possible incentive to develop and employ a variety of efficient technologies. It also establishes not insignificant market awareness and presence for the growing body of transport users (shippers such as Wal-Mart and final consumers) seeking to green and decarbonizes the supply chain, which also reinforces the incentive to develop and employ even more energy efficient ships and technologies. **For more detail see Chapters: 3.2, 3.2.1, 4.2, 4.3, and 6.1.**

ToR	Criteria	How US Proposal (SECT) Addresses Criterion
5.3.A	Provision of investment certainty	E-SECT is an efficiency trading system. A ship owner or operator knows what it needs to do in order to meet the standard and can plan accordingly. For example the owner/operator knows that implementing certain technologies beyond what is required from a compliance standpoint can make a ship a net source of efficiency credits and thereby a source of revenue. This creates a significant amount of investment certainty. The investment certainty is further strengthened by guaranteed streams of fuel cost savings following the installation of any given efficient technology. Further, should the ship ever be sold or chartered, the expected revenue from efficiency credits could be incorporated into the selling or charter price, ensuring that the owner/operator gets a return on investment even for efficiency technologies with a relatively long payback period. **For more detail see Chapters:2.1.1, 2.1.2, 2.1.3, 3.2, and 4.3**
5.3.B	Credit for early action	SECT would create an incentive for the early introduction of new efficiency measures because credits could be earned for improvements beyond the required efficiency index. In addition, the US proposal could potentially be implemented through amendments to MARPOL Annex VI, in which case it could enter into force relatively quickly. **For more detail see Chapters: 4.2, 7.1, 7.2, and 7.2.1**
5.3.C	Availability of technological and operational measures for CO_2 emission reduction	The updated IMO study suggests there are a variety of readily available technologies that could yield efficiency improvements as high as 40% at a negative or low cost. These technologies include: propeller/propulsion upgrades, hull coating and maintenance, auxiliary systems, hull improvements, and other retrofit options. Most of these are readily available but the study notes hurdles to implementation including long payback periods. SECT is specifically designed to address this problem by allowing the efficiency improvements to be monetized into a ship's sale or charter price, retaining fuel cost savings associated with efficiency improvements in the sector, and – through its trading scheme – motivating even greater development and use of efficient technologies and operational measures than would occur without a trading scheme. This has been the experience with every well-designed and operated emissions trading scheme to date. **For more detail see Chapter: 3.2. and 6.1.1**
5.3.D	Commercial availability and industry experience of implementing technology or operational measures	See Above. **For more detail see Chapter:3.2. and 6.1.1**

ToR	Criteria	How US Proposal (SECT) Addresses Criterion
5.3.E	Projected future costs of carbon (allowances, credits, contributions etc) vs costs of measures to reduce CO_2 emissions	The cost of a future efficiency credit is influenced by the stringency level of the standard. Accordingly, the actual cost of efficiency credits would depend solely on the marginal abatement cost in the sector. However, data from the updated IMO study suggests that even a very stringent EIR would still result in a net cost savings of $51/tonne of CO_2 reduced. **For more detail see Chapters: 6-2, 6-3, and 7.1.2.2**
5.4	**The practical feasibility of implementing the proposed MBM**	SECT would be relatively simple to implement as it builds on the significant work already undertaken by IMO on the EEDI, EEOI, and SEEMP. The administrative systems and procedures for efficiency credit trading would have to be created, but these would be a simplified version of what is needed to implement a full ETS. **For more detail see Chapters:2, 7.2, and 7.3**
5.4.A	Development time for new IMO instrument	If the SECT proposal were implemented under MARPOL Annex VI, it would take less time to develop than creating a new IMO instrument. This would be a significant advantage of the U.S. approach as IMO could begin implementation of this approach almost immediately. **For more detail see Chapters:5 and 7.1**
5.4.B	Experience from similar schemes	Over the past two decades, the United States has used in-sector averaging, banking, and trading (ABT) schemes for a wide range of environmental regulations for transportation sources. These credit trading schemes have provided manufacturers will product planning flexibility which has resulted in reduced compliance costs. In addition, because this flexibility allows for early introduction of new emission control technology to be phased-in over time, more stringent standards, with earlier implementation, were possible. **For more detail see Chapter: 4.6**

ToR	Criteria	How US Proposal (SECT) Addresses Criterion
5.4.C	Ease of implementation and potential for phased implementation	SECT would be relatively easy to implement as much of the technical work behind it has already been discussed in IMO. SECT does not currently envision a phased-in approach, but we would be open to exploring this idea. The mere creation and implementation of an IMO MBM would generate considerable market awareness and demand for robust compliance, given the growing global pressure among multinational companies and consumers to decarbonise the supply chain. This will help to motivate some maritime countries to reconsider any inclination they may feel not to become party to the IMO regime. Similarly, it will put pressure on flag and port states alike to ensure compliance by all ships subject to the IMO regime. The threat of carbon leakage under SECT is quite minimal. Most items shipped by sea are not suitable for other transport modes given their own capacity and cost structures. Moreover, given the very high share of fuel costs in daily operational costs for ships around the world, the ability of the SECT to reduce fuel costs and improve profitability should prompt ship owners and operators to ensure that their ships comply. Finally, as more and more ships participate in the trading scheme, there is ever greater variety of sources with differing compliance costs. This means ever greater possibilities for cost-effectively using trading to bring a ship into compliance, which in turn means ever greater improvements in the operational profitability and competitiveness of international shipping. **For more detail see Chapters: 2.2.2, 2.2.4, and 4.2**
5.4.C	Enforcement, potential for evasion and avoidance of carbon leakage	Enforcement would be undertaken consistent with port state and flag state obligations and jurisdiction. This could include reviewing documents and transactional records to verify compliance. This would presumably be handled in the same way as verifying EIAPP and IAPP certification of the NOx standard. **For more detail see Chapter: 4 and 5**

ToR	Criteria	How US Proposal (SECT) Addresses Criterion
5.5	**The need for technology transfer to, and capacity building within, developing countries, in particular LDCs and SIDS, in relation to implementation and enforcement of the proposed MBM, including the potential to mobilize climate change finance for mitigation and adaptation actions**	As the updated IMO GHG study indicates, substantial negative cost efficiency measures are available for the global shipping sector using existing commercialized technologies. By and large, technology transfer required by a developing country ship builder or ship operator can therefore be acquired through commercial means. In as much as SECT will require developing country administrations or ship owners to familiarize themselves with credit trading, the U.S. believes that support for capacity-building programs would be appropriate and straightforward to arrange. As for mobilizing climate change finance, we note that the original nine criteria for greenhouse gas measures to be adopted by the IMO (agreed at MEPC 57) did not include raising revenue for external benefit. Accordingly, SECT is designed to reduce emissions within the sector at minimal cost and to the benefit of the sector only. The SECT system is self-contained in that all costs to industry are spent on investments in their own vessel efficiency. To the degree that in-sector advances in technology occur in developing countries - where most ship yards now exist - there will be a further ripple effect involving a number of related industry sectors that support the maritime sector directly and indirectly. This wave of new demand will present many opportunities for new climate-related investments in both mitigation and adaptation, and it will be the maritime sector that generated this. **For more detail see Chapter: 4.2, 5, 6.1, 7.1, and 7.3**
5.5.A	Requirement for capacity building for implementation and enforcement of new instrument in developing countries (link to Administrative requirements in 5.7 of the different MBM proposals)	Inasmuch as SECT will require developing country administrations or ship owners to familiarize themselves with credit trading, the U.S. believes that support for capacity - building programs would be appropriate and straightforward to arrange. **For more detail see Chapter: 5**

ToR	Criteria	How US Proposal (SECT) Addresses Criterion
5.5.B	Technology transfer needs for developing countries to improve new ship and operational efficiencies	As the updated IMO GHG study indicates, substantial negative cost efficiency measures are available for the global shipping sector using existing commercialized technologies. By and large, technology transfer required by a developing country ship builder or ship operator can therefore be acquired through commercial means. Moreover, some developing countries already have established themselves as world powers in the development of high-quality ships and related maritime technologies. Thus, SECT would facilitate a considerable degree of South - South (inter-developing country) trade and capacity building in relevant maritime technologies and associated training. **For more detail see Chapter: 4.2, 6.1, 7.1, 7.3, and 7.4**
5.5.C	Availability of funds that could be used for climate change purposes in developing countries	We note that the original nine criteria for greenhouse gas measures to be adopted by the IMO (agreed at MEPC 57) did not include raising revenue for external benefit. Accordingly, SECT is designed to reduce emissions within the sector at minimal cost and to the benefit of the sector only. SECT system is self-contained in that all costs to industry are spent on investments in their own vessel efficiency. **For more detail see Chapter: 4.2, 5, 6.1, 71, and 7.3**
5.5.D	Predicted size of fund generated	N/A
5.6	**The MBM proposal's relation with other relevant conventions such as UNFCCC, Kyoto Protocol and WTO, as well as its compatibility with customary international law, as depicted in UNCLOS**	SECT fully compatible and consistent with international law. **For more detail see Chapter: 7.3**

ToR	Criteria	How US Proposal (SECT) Addresses Criterion
5.6 A	Compatibility with UNFCCC	The U.S. proposal is wholly consistent with the UNFCCC. Not only does it further the UNFCCC's objective, but it does so in a manner consistent with the provisions of the UNFCCC. Some countries maintain, incorrectly, that common but differentiated responsibilities and respective capabilities should be interpreted to mean they have no obligations to mitigate their emissions. We disagree; all UNFCCC Parties have an obligation to implement measures to mitigate climate change under, for example, Article 4(1)(b) of the UNFCCC. Moreover, all Parties have "common responsibilities" and should be acting in a manner commensurate with their respective capabilities. Here, the largest flag states are the countries with the greatest responsibility and the capability to address the issue. We also note that, in the context of the IMO, common but differentiated responsibilities and respective capabilities is not a governing concept. However, recognizing the importance of international shipping to the global economy and sustainable economic growth, the U.S. is proposing that the sector grow more efficiently rather than a hard cap on emissions. This efficiency approach is entirely consistent with global action to address climate change. Indeed, under the Copenhagen Accord many developing countries detailed the actions they will be taking to address their emissions and many of those actions are focused on increasing efficiency. **For more detail see Chapters: 2, 6.3, 7.1, 7.1.2.1, and 7.3**
5.6 B	Compatibility with Kyoto Protocol	Although we are not a Party to the Kyoto Protocol, we see no incompatibility.
5.6 C	Compatibility with WTO	We are not aware of any aspect of the U.S. proposal that would raise WTO concerns. **For more detail see Chapters:2, 5, 7.2, and 7.3**
5.6 D	Compatibility with UNCLOS	SECT is entirely compatible with customary international law, as reflected in UNCLOS. **For more detail see Chapters:2 and 7.3**
5.6 E	Relations with other climate finance institutions or initiatives	As SECT creates a closed efficiency market there is no relation to other climate finance institutions or initiatives other than that existing carbon market service providers would find it easy to facilitate efficiency credit transactions. **For more detail see Chapters:4.1 and 4.3**

ToR	Criteria	How US Proposal (SECT) Addresses Criterion
5.7	**The potential additional administrative burden, and the legal aspects for National Administrations by implementing and enforcing the proposed MBM**	SECT creates some additional work for owners/operators, flag states, and port states. However, we believe there is an additional burden for any market-based measure. The additional burden in the U.S. would be comparatively minor and would complement what is currently being undertaken under current Annex VI requirements. **For more detail see Chapter: 5**
5.7.A	Administrative requirements for implementation and enforcement	The new efficiency standards, including efficiency credits, could potentially be established through an amendment to MARPOL Annex VI. Specifically, this program builds on the EEDI standards being developed at IMO for inclusion in Annex VI. As such, the administrative requirements would be very similar to those already in place. **For more detail see Chapters: 2.1 and 5.2**
5.7.B	Additional workload for Flag States per ship	The new efficiency standards, including efficiency credits, would be incremental to the other requirements that already apply under MARPOL Annex VI. These provisions are very similar to those already in place, including review of documentation to verify that ships meet applicable requirements. **For more detail see Chapters: 2.1 and 5.2**
5.7.C	Impacts on Port State inspections and additional workload per call or inspected ship	Port states currently have the authority to inspect vessels to verify compliance with NOx emission standards (and other Annex VI requirements). Under new efficiency standards, they would be able to slightly expand their inspections to confirm compliance. **For more detail see Chapter: 5.2**
5.7.D	Availability of skilled human resources	The same inspectors reviewing compliance with NOx standards should be able to readily understand compliance issues related to efficiency standards. **For more detail see Chapter: 5.2**
5.7.E	Compatibility with national law	Similar to efforts that have been made regarding NOx emission standards with respect to national legal context, member states would be expected to amend statutory provisions as needed to incorporate efficiency standards into national law. **For more detail see Chapter: 7.3**
5.7.F	Sovereignty implications	SECT builds on the EEDI requirements under development for inclusion in Annex VI. These requirements are on ships not countries and countries can choose how they implement the regulations. As such, no sovereignty implications are anticipated. **For more detail see Chapters: 2.1 and 7.3**

ToR	Criteria	How US Proposal (SECT) Addresses Criterion
5.8	**The potential additional workload, economic burden and operational impact for individual ships, the shipping industry and the maritime sector as a whole, of implementing the proposed MBM**	SECT would require efficiency gains from ships. Although there would be additional workload to implement the efficiency measures, the efficiency gains would result in cost savings from reduced fuel consumption which would lead to positive market impacts for shipping. The credit trading program results in decreased costs and provides ship owners and operators with flexibility on their compliance approach to the proposed requirements Implementation of the SECT would present minimal burden for individual ships, and it could bring a positive impact on international trade supported by marine shipping. **For more detail see Chapters: 6.1, 6.3, 6.4, 7.1 and 7.2**
5.8.A	Administrative burden for ships and ship operators	With respect to the efficiency standards, the administrative burden would be no greater than for NOx or fuel sulphur standards. Like the anticipated EEDI requirements, certification and verification procedures would be similar to those already established in Annex VI. The proposed in-sector credit trading program would be relatively straight-forward to administer. Because SECT focuses on in-sector credits, it should be less complex to administer than an open-sector trading program. **For more detail see Chapters: 5, 7.2.2**
5.8.B	Other additional workload	SECT would require efficiency gains from ships. Although there would be additional workload to implement the efficiency measures, the efficiency gains would result in cost savings from reduced fuel consumption which would lead to positive market impacts for shipping. **For more detail see Chapters: 6.1, 6.3, 6.4, and 7.1**

ToR	Criteria	How US Proposal (SECT) Addresses Criterion
5.8.C	Implementation costs – capital and operating costs	SECT would require efficiency gains from ships. Although there would be additional workload to implement the efficiency measures, the efficiency gains would result in cost savings from reduced fuel consumption which would lead to positive market impacts for shipping. The credit trading program results in decreased costs and provides ship owners and operators with flexibility on their compliance approach to the proposed requirements. It is not possible to estimate implementation costs without agreement on stringency levels, timelines, and multiple other factors. What is known beyond any doubt, however, is that ship owners and operators that already have built or retrofitted their ships to be more energy efficient have found this to be a very worthwhile effort. Recent sessions of the MEPC have featured multiple briefings (e.g., by BMT SeaTech and RINA) documenting specific examples. The SECT proposal would establish a foundation for such behaviour across the international shipping sector. **For more detail see Chapters: 6.1, 6.3, 6.4, 7.1 and 7.2**
5.8.D	Need for new/additional tonnage	The stringency of SECT would be based on energy efficiency technologies and methodologies that can be applied to existing ships. It is not anticipated that there would be a need for new or additional tonnage capacity as a result of energy efficiency requirements. **For more detail see Chapters: 3.2, 6.1 and 6.2**
5.8.E	Cost implications for cargo owners and shippers	The impact of energy efficiency standards for ships is expected to result in little cost impact on cargo owners and shippers. Likely, cost savings will occur due to fuel savings. **For more detail see Chapters: 6.1, 6.3, 6.4, 7.1 and 7.2**
5.8.F	Impacts on others in maritime supply chain and industry (ports and port operators, fuel suppliers, brokers, agents, financial institutions etc)	Implementation of SECT would present minimal burden for individual ships, it will generate positive economic activity and employment opportunities in many industry sectors that support shipping and it could bring a positive impact on international trade supported by marine shipping. **For more detail see Chapters: 7.1 and 7.2**
5.9	**The MBM's compatibility with the existing enforcement and control provisions under the IMO legal framework**	SECT is compatible with the existing enforcement and control provisions under the IMO legal framework as it builds on work undertaken in Annex VI. **For more detail see Chapter: 5**

ToR	Criteria	How US Proposal (SECT) Addresses Criterion
5.9. A	Requirement for new IMO instrument	SECT could potentially be undertaken as amendments to MARPOL Annex VI, in which case it would not require a new legal instrument. Indeed, one of the greatest strengths of SECT is the speed in which it could potentially be implemented. **For more detail see Chapter: 5 and 7.1**
5.9. B	Central Administrative requirements, need for supranational organization to oversee scheme and/or need for market place (to trade emission credits, etc.)	SECT calls for the creation of an efficiency trading system, there will need to be a registry for maintaining balances of credits and recording the transfer of credits among operators. This is a comparatively simple system requirement with many precedents. In such a scenario, the IMO would develop the necessary regulations and oversight mechanisms but would not necessarily have to operate or implement the system. **For more detail see Chapter: 4.3**
5.9.C	Role of Flag State	The flag state's role would be consistent with its current rights and responsibilities under MARPOL and customary international law as reflected in UNCLOS. We envision that the flag state would be authorized to review documents and transactions. **For more detail see Chapter: 5**
5.9.D	Role of Port State	The port state's role would be consistent with its current rights and responsibilities under MARPOL and customary international law as reflected in UNCLOS. We envision that the Port state would be authorized to review documents and transactions. **For more detail see Chapter: 5**
5.9.E	Role of Recognized Organizations	Recognized organizations could play an important and helpful role in how efficiency improvements are measured and potentially in helping facilitate trading. **For more detail see Chapter: 2, 4.3**
5.9.F	Survey, Certification and other means of control	With respect to the survey, certification other means of control standards, the work would be similar to what is being done for NOx or fuel sulphur standards. Like the anticipated EEDI requirements, survey and certification procedures would be similar to those already established in Annex VI. The proposed in-sector credit trading program would be relatively straight-forward to administer. Because SECT focuses on in-sector credits, it should be less complex to administer than an open-sector trading program. **For more detail see Chapters: 5, 7.2.2**
5.9.G	Involvement of other authorities (e.g. Treasury)	Other authorities could play an important and helpful role in how efficiency improvements are measured and potentially in helping facilitate trading. **For more detail see Chapter: 2, 4.3**

Annex I: Description of Terms

Presented below is a list of terms used in the United States' submission to the 60th meeting of the Marine Environment Protection Committee of the International Maritime Organization. Included with each term are its definition and its use in the context of SECT.

a) *Activity* = A measure of the amount of cargo carried by a ship and its distance travelled (nautical miles) over a specific period; frequently given in tonne-miles. The magnitude of a ship's activity does not indicate its degree of energy efficiency. Activity, for purposes of SECT, would always be associated with the period for which Efficiency Credits are being determined.

b) *Baseline* = A representation of the average energy efficiency of a set of similar ships in the current worldwide fleet, considering ships built between specified years (such as between 1998 and 2007). Ship Energy Efficiency Design Index (EEDI) baselines are often depicted graphically with ship size as the X-axis and theoretical (calculated) EEDI as the Y-axis. Each point on a baseline graph is a snapshot of the efficiency of an individual ship at specified conditions. Baselines for several ship types have been developed by regressing the data and plotting a best-fit curve. An ideal baseline curve would have about half the points above and half below the line. Once a baseline is established, it is fixed for the given data and will not change over time. A baseline is not an enforceable standard and is independent of stringency.

c) *EC* = The amount of Efficiency Credits generated by a ship over a given period. This value may be either positive or negative, depending on whether the Attained Efficiency Index (EI_A) of the ship is less than or greater than the ship's Required Efficiency Index (EI_R) during that time period. The magnitude of EC depends both on the difference between these two efficiencies and the Activity. In SECT, a ship generating negative EC would be required to make technological or other changes to improve its EI_A and/or purchase EC from another source. The basic equation for calculation of Efficiency Credits is:

$$\pm\, Efficiency\ Credit\ (EC) = (EI_R - EI_A) \times Activity$$

A positive emission credit is calculated when a ship's efficiency (EI_A) is better (less) than the requirement (EI_R). Negative emission credits must be offset when EI_A is greater than EI_R for the compliance period.

d) *EI_R* = The Required Efficiency Index value that is assigned to an existing ship for a compliance period. In SECT, an EI_R would exist as a continuous curve that is a function of ship size, for each ship type for which a baseline is established. Each assigned EI_R would be relative to (% above or below) the EEDI baseline value associated with that ship type and size. The stringency of EI_R would change over time reflecting feasible, cost effective technologies and operational methods expected to be used on existing ships

e) *EI_A* = A ship's Attained Efficiency Index value as calculated by using the same equation that is used for the new ship EEDI. An importance difference is that some variables used in the equation would be based partially on formal sea-trial data and partially on current and historic operational data. This value would be associated with the period for which the data are obtained, most often the period for which Efficiency Credits are being determined. For this proposal, a maximum update periodicity of five years and an option for earlier updates to take advantage of a ship's technology or operational improvements should be considered. If multiple EI_A apply during an EC reporting period, the overall EI_A may be calculated by prorating the applicable values.

f) *$EEDI_R$* = A new ship's EEDI requirement to gain entry into the fleet at time of contract. With SECT, it would continue to serve an important role.

g) *$EEDI_A$* = A ship's attained EEDI during sea trial and compared to the EI_R to gain entry into the fleet at time of contract. In SECT, once a ship is placed in service, a predictive EI_A is established using the predictive values from its $EEDI_A$ calculation. For EC calculation, operational and historic data must replace the predicted values in the EEDI formula, as shown below:

$$EEDI = EI_A = \frac{\prod_{j=1}^{M} f_j \left(\sum_{i=1}^{nME} P_{ME(i)} C_{FME(i)} SFC_{ME(i)} \right) + (P_{AE} C_{FAE} SFC_{AE}) + \left(\left(\prod_{j=1}^{M} f_j \sum_{i=1}^{nPTI} P_{PTI(i)} - \sum_{i=1}^{nWHR} f_{eff(i)} P_{AEeff(i)} \right) C_{FAE} SFC_{AE} \right) - \left(\sum_{i=1}^{neff} f_{eff(i)} P_{eff(i)} C_{FME} SFC_{ME} \right)}{f_i \times Capacity \times V_{ref} \times f_W}$$

h) *Existing Ship* = In the U.S. proposal, an existing ship is any ship in the fleet subject to engine or fuel standards under MARPOL, regardless of age. Even without major conversion, existing ships would be subject to increasingly stringent EI_R over time.

i) *New Ship* = A ship for which the building contract is signed on or after the entry into force of an applicable EEDI standard to reduce GHG from ships, or other definition as set forth in the instrument identifying the standard. In SECT, after entering into service, a new ship would become "existing" and be subject to the currently applicable EI_R for its type and size.

j) *SECT* = The Ship Efficiency Credit Trading mechanism, proposed as a means for credit generators and purchasers to buy and sell EC, including an account registry, a trading platform and a clearing/settlement platform.

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