Draft Regulatory Impact Analysis: Control of Emissions of Air Pollution from Locomotive Engines and Marine Compression-Ignition Engines Less than 30 Liters per Cylinder

Chapter 7
Economic Impact Analysis

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CHAPTER 7: Economic Impact Analysis

We prepared an Economic Impact Analysis (EIA) to estimate the economic impacts of the proposed emission control program on the locomotive and marine diesel engine and vessel markets. In this chapter we describe the Economic Impact Model (EIM) we developed to estimate the market-level changes in prices and outputs for affected markets, the social costs of the program, and the expected distribution of those costs across stakeholders. We also present the result of our analysis.

We estimate the social costs of the proposed program to be approximately $600 million in 2030.[1, 2] The impact of these costs on society are expected to be minimal, with the prices of rail and marine transportation services estimated to increase by less about 0.4 percent for locomotive transportation services and about 0.6 percent for marine transportation services. The rail sector is expected to bear about 64 percent of the social costs of the program in 2030, and the marine sector is expected to bear about 36 percent. In each of these two sectors, these social costs are expected to be born primarily by producers and users of locomotive and marine transportation services (63.3 and 33.2 percent, respectively). The remaining 3.5 percent is expected to be borne by locomotive, marine engine, and marine vessel manufacturers and fishing and recreational vessel users.

With regard to market-level impacts in 2030, the average price of a locomotive is expected to increase about 2.6 percent ($49,100 per unit), but sales are not expected to decrease. In the marine markets, the expected impacts are different for engines above and below 800 hp. With regard to engines above 800 hp and the vessels that use them, the average price of an engine is expected to increase by about 8.4 percent for C1 engines and 18.7 percent for C2 engines ($13,300 and $48,700, respectively). However, the expected impact of these increased prices on the average price of vessels that use these engines is smaller, at about 1.1 percent and 3.6 percent respectively ($16,200 and $141,600). The decrease in engine and vessel production is expected to be negligible, at less than 10 units. For engines less than 800 hp and the vessels that use them, the expected price increase and quantity decrease are expected to be negligible, less than 0.1 percent. Finally, even with the increases in the prices of locomotives and large marine diesel engines, the expected impacts on prices in the locomotive and marine transportation service markets are small, at 0.4 and 0.6 percent, respectively.

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[1] All estimates presented in this section are in 2005$.

[2] The estimated 2030 social welfare cost of 267.3 million is based on an earlier version of the engineering costs of the rule which estimated $568.3 million engineering costs in 2030 (see table 5-17). The current engineering cost estimate for 2030 is $605 million. See 7.1.4 for an explanation of the difference. The estimated social costs of the program will be updated for the final rule.

7.1 Overview and Results

7.1.1 What is an Economic Impact Analysis?

An EIA is prepared to inform decision makers about the potential economic consequences of a regulatory action. The analysis consists of estimating the social costs of a regulatory program and the distribution of these costs across stakeholders. These estimated social costs can then be compared with estimated social benefits (as presented in Chapter 6). As defined in EPA's *Guidelines for Preparing Economic Analyses*, social costs are the value of the goods and services lost by society resulting from a) the use of resources to comply with and implement a regulation and b) reductions in output.[1] In this analysis, social costs are explored in two steps. In the *market analysis*, we estimate how prices and quantities of goods and services affected by the proposed emission control program can be expected to change once the program goes into effect. In the *economic welfare analysis*, we look at the total social costs associated with the program and their distribution across key stakeholders.

7.1.2 What Methodology Did EPA Use in this Economic Impact Analysis?

The EIM is the behavioral model we developed to estimate price and quantity changes and total social costs associated with the emission controls under consideration. The model relies on basic microeconomic theory to simulate how producers and consumers of products and services affected by the emission requirements can be expected to respond to an increase in production costs as a result of the proposed emission control program. The economic theory that underlies the model is described in detail in Section 7.2.

The EIM is designed to estimate the economic impacts of the proposed program by simulating economic behavior. This is done by creating a model of the initial, pre-control market for a product, shocking it by the estimated compliance costs, and observing the impacts on the market. At the initial, pre-control market equilibrium, a market is characterized by a price and quantity combination at which producers are willing to produce the same amount of a product that consumers are willing to purchase at that price (supply is equal to demand). The control program under consideration would increase the production costs of affected goods by the amount of the compliance costs. This generates a "shock" to the initial equilibrium market conditions. Producers of affected products will try to pass some or all of the increased production costs on to the consumers of these goods through price increases. In response to the price increases, consumers will decrease their demand for the affected good. Producers will react to the decrease in quantity demanded by decreasing the quantity they produce; the market will react by setting a higher price for those fewer units. These interactions continue until a new market equilibrium price and quantity combination is achieved. The amount of the compliance costs that can be passed on to consumers is ultimately limited by the price sensitivity of purchasers and producers in the relevant market (represented by the price elasticity of demand and supply). The EIM explicitly models these behavioral responses and estimates new equilibrium prices and output and the resulting distribution of social costs across these stakeholders (producers and consumers).

The EIM is a behavioral model. The estimated social costs of this emission control program are a function of the ways in which producers and consumers of the engines and equipment affected by the standards change their behavior in response to the costs incurred in complying with the standards. These behavioral responses are incorporated in the EIM through the price elasticity of supply and demand (reflected in the slope of the supply and demand curves), which measure the price sensitivity of consumers and producers. An "inelastic" price elasticity (less than one) means that supply or demand is not very responsive to price changes (a one percent change in price leads to less than one percent change in demand). An "elastic" price elasticity (more than one) means that supply or demand is sensitive to price changes (a one percent change in price leads to more than one percent change in demand). A price elasticity of one is unit elastic, meaning there is a one-to-one correspondence between a change in price and change in demand. The price elasticities used in this analysis are described in Section 7.3 and are either from peer-reviewed literature or were estimated using well-established econometric methods. It should be noted that demand in the locomotive and marine engine and vessel markets is internally derived from the rail and marine transportation service markets as part of the process of running the model. This is an important feature of the EIM, which allows it to link the engine and equipment components of each model and simulate how compliance costs can be expected to ripple through the affected market.

7.1.3 What Economic Sectors are Included in the Economic Impact Model?

In this EIA we estimate the impacts of the proposed emission control program on two broad sectors: rail and marine. The characteristics of the markets analyzed that are relevant to the EIM are summarized in Table 7-1 and described in more detail in Section 7.3.

Table 7-1. Summary of Markets in Economic Impact Model

Model Dimension	Rail Sector	Marine Sector

Model Dimension	Rail Sector	Marine Sector
Description of Markets: Supply	Locomotive: locomotive manufacturers (integrated manufacturers); 3 categories Line Haul Passenger Switcher Rail Transportation Services: Entities that provide rail transportation services (railroads, primarily Class I)	Engines: Marine Engine Manufacturers; 8 categories Small: < 50 hp Category 1: 50-200 hp 200-400 hp 400-800 hp 800-2,000 hp > 2,000 hp Category 2: 800-2,000 hp > 2,000 hp Marine Vessels: Marine vessel manufacturers; 7 categories Tug/tow/pushboats Cargo vessels Ferry vessels Supply/crew boats Other commercial vessels Fishing boats Recreational boats Marine Transportation Services: Entities that provide marine transportation services (excludes fishing and recreational vessels)
Description of Markets: Demand	Locomotive: Railroads (primarily Class I) Rail transportation services: Entities that use rail transportation services (power, chemical, agricultural companies; personal transportation)	Marine Engines: Vessel manufacturers Marine Vessels: Marine vessel users (owners of all types of marine vessels) Marine transportation services: Entities that use marine transportation services (power, chemical, agricultural companies; personal transportation)
Geographic Scope	50 states	50 states
Market Structure	Perfectly competitive	Perfectly competitive
Baseline Population	Same as locomotive inventory analysis	PSR 2002 OE Link Sales Database
Growth Projections	Based on projected fuel consumption from Energy Information Agency	Commercial marine: 0.9% (0.009); recreational marine based on EPA's Nonroad Model
Supply Elasticity	Locomotives (all): 2.7 (elastic) Rail Transportation Market: 0.6 (inealastic)	Engines: 3.8 (elastic) Vessels: 2.7 Commercial (elastic) 1.6 Recreational and Fishing (elastic) Marine Transportation Market: 0.6 (inelastic)

Model Dimension	Rail Sector	Marine Sector
Demand Elasticity	Locomotives (all): Derived Rail Transportation Market: -0.5 (inelastic)	Engines: Derived Vessels: Commercial: Derived Recreational and Fishing : -1.4 (elastic) Marine Transportation Market: -0.5 (inelastic)
Regulatory Shock	Locomotive Market: direct engine and equipment compliance costs cause shift in supply function Rail Transportation Market: direct operating and remanufacturing compliance costs, in addition to higher locomotive prices, cause shift in supply function	Marine diesel engine: direct engine compliance costs cause shift in supply function Marine vessels: direct vessel compliance costs, in addition to higher engine prices, cause shift in supply function Marine Transportation Market: direct operating costs in addition to higher vessel prices cause shift in supply function

7.1.3.1 Rail Sector Component

The rail sector component of the EIM is a two-level model consisting of suppliers and users of locomotives and rail transportation services.

Locomotive Market. The locomotive market consists of locomotive manufacturers (line haul, switcher, and passenger) on the supply side and railroads on the demand side. The vast majority of locomotives built in any given year are for line haul applications; a small number of passenger locomotives are built every year, and even fewer switchers. The locomotive market is characterized by integrated manufacturers (the engine and locomotive are made by the same manufacturer) and therefore the engine and equipment impacts are modeled together. The EIM does not distinguish between power bands for locomotives. This is because while there is some variation in power for different engine models, the range is not large. On average line haul locomotives are typically about 4,000 hp, passenger locomotives are about 3,000 hp, and switchers are about 2,000 hp.

Recently, a new switcher market is emerging in which manufacturers are expected to be less integrated, and the manufacturer of the engine is expected to be separate from the manufacturer of the switcher.[3] Because the characteristics of this new market are

[3] Until recently, switchers have typically been converted line haul locomotives and very few, if any, new dedicated switchers were built in any year. Recently, however, the power and other characteristics of line haul locomotives have made them less attractive for switcher usage. Their high power means they

speculative at this time, the switcher market component of the EIM is modeled in the same way as line haul locomotives (integrated manufacturers; same behavioral parameters), but uses separate baseline equilibrium prices and quantities. The compliance costs used for switchers reflect the expected design characteristics for these locomotives and their lower total power. Consistent with the cost analysis, the passenger market is combined with the switcher market in this EIA because we do not have separate compliance costs estimates for each of those two market segments.

Rail Transportation Services. The rail transportation services market consists of entities that provide and utilize rail transportation services. On this supply side, these are the railroads. On the demand side, these are rail transportation service users such as the chemical and agricultural industries and the personal transportation industry. Most of the goods moved by rail are bulk goods such as coal, chemicals, minerals, petroleum, and the like. About 26 percent of the carloads in 2004 were miscellaneous mixed shipments (mostly intermodal, e.g., containers) and about 6 percent were motor vehicles and equipment. This means that about 68 percent of the goods moved by rail are production inputs.[2] The EIM does not estimate the economic impact of the proposed emission control program on ultimate finished goods markets that use rail transportation services as inputs. This is because transportation services are only a small portion of the total variable costs of goods and services manufactured using these bulk inputs. Also, changes in prices of transportation services due to the estimated compliance costs are not expected to be large enough to affect the prices and output of goods that use rail transportation services as an input.

7.1.3.2 Marine Sector Component

The marine sector component of the EIM distinguishes between engine, vessel, and ultimate user markets (marine transportation service users, fishing users, recreational users). This is because, in contrast to the locomotive market, manufacturers in the diesel marine market are not integrated. Marine diesel engines and vessels are manufactured by different entities.

Marine Engine Market. The marine engine markets consist of marine engine manufacturers on the supply side and vessel manufacturers on the demand side. The model distinguishes between three types of engines, commercial propulsion, recreational propulsion, and auxiliary. Engines are broken out into eight categories based on horsepower and displacement.

- Small marine diesel engines
  - <50 hp
- C1 engines
  - 50-200 hp
  - 200-400 hp

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consume more fuel than smaller locomotives, and they have less attractive line-of-sight characteristics than what is needed for switchers. Therefore, the industry is anticipating a new market for dedicated switchers.

    - 400-800 hp
    - 800-2,000 hp
    - >2,000 hp
- C2 engines
    - 800-2,000 hp
    - >2,000 hp

For the purpose of the EIA, the C1/C2 threshold is 5 l/cyl displacement, even though the new C1/C2 threshold is proposed to be 7 l/cyl displacement. The 5 l/cyl threshold was used because it is currently applicable limit. In addition, there is currently only one engine family in the 5 to 7 l/cyl range, and it is not possible to project what future sales will be in that range or if more engine families will be added.

Marine Vessel Market. The marine vessel market consists of marine vessel manufacturers on the demand side and marine vessel users on the supply side. The model distinguishes between seven vessel categories. Each of these vessels would have at least one propulsion engine and at least one auxiliary engine:

- Recreational
- Fishing
- Tow/tug/push
- Ferry
- Supply/crew
- Cargo
- Other commercial

For fishing and recreational vessels, the purchasers of those vessels are the end users, and so the EIM is a two-level model for those two markets. For the fishing market, this approach is appropriate because demand for fishing vessels comes directly from the fishing industry; fishing vessels are a fixed capital input for that industry. For the recreational market, demand for vessels comes directly from households that use these vessels for recreational activities and acquire them for the personal enjoyment of the owner. For the other commercial vessel markets (tow/tug/push, ferry, supply/crew, cargo, other), demand is derived from the transportation services they provide, and so demand is from the transportation service market and the providers of those services more specifically. Therefore it is necessary to include the marine transportation services market in the model.

Marine Transportation Services. The marine transportation services market consists of entities that provide and utilize marine transportation services: vessel owners on the supply side and marine transportation service users on the demand side. The firms that use these marine transportation services are very similar to those that use locomotive transportation services: those needing to transport bulk chemicals and minerals, coal, agricultural products, etc. These transportation services are production inputs that depend on the amount of raw materials or finished products being transported and thus marine transportation costs are variable costs for the end user. Demand for these transportation services will determine the demand for vessels used to provide these services (tug/tow/pushboats, cargo, ferries, supply/crew, other commercial vessels).

7.1.3.3 Market Linkages

The individual levels of the rail and marine components of the EIM are linked to provide feedback between consumers and producers in the relevant markets. The locomotive and marine components of the EIM are not linked however, meaning there is no feedback mechanism between the locomotive and marine sectors. Although locomotives and marine vessels such as tugs, towboats, cargo, and ferries provide the same type of transportation service, the characteristics of these markets are quite different and are subject to different constraints that limit switching from one type of transportation service to the other. For example, switching from rail services to marine services requires having access to a port and the waterway system; if the production facility is not located on a waterway it would also be necessary to transport the goods to and from port. Similarly, users of marine transportation services typically transport bulk goods in large quantities (by barge or by container); these quantities may be more complicated and costly to transport by rail. Because the services provided by the locomotives and marine markets are not completely interchangeable, a change in the price of one is not expected to have an impact on the price for the other.

For the limited number of cases where there is direct competition between rail and marine transportation services, we do not expect this rule to change the dynamics of the choice between marine or rail providers of these services because 1) the estimated compliance costs imposed by this rule are relatively small in comparison with the total production costs of providing transportation services, and 2) both sectors would be subject to the new standards. So, for example, while an increase in the price of marine diesel engines may lead to an increase in the price of marine transportation services, this will not likely have much impact on the demand for rail services because the rail sector is also expected to see increased costs.

7.1.4 Summary of Results

The EIA consists of two parts: a market analysis and welfare analysis. The market analysis looks at expected changes in prices and quantities for affected products. The welfare analysis looks at economic impacts in terms of annual and present value changes in social costs.

We performed a market analysis for all years and all engines and equipment. The detailed results can be found in the appendices to this chapter. In this section we present summarized results for selected years.

Due to the structure of the program (see Section 7.3.3), the estimated market and social costs impacts of the program in the early years are small and are primarily due to the locomotive remanufacturing program. By 2016, the impacts of the program are more significant due to the operational costs associated with the Tier 4 standards (urea usage). Consequently, a large share of the social costs of the program after the Tier 4 standards to into effect fall on the marine and rail transportation service sectors. These operational costs are incurred by the providers of these services, but they are expected to pass along some of these costs to their customers.

The results of the economic impact analysis presented in this Chapter are based on an earlier version of the engineering costs developed for this rule. The engineering costs for 2030 presented in Chapter 5 are estimated to be $605 million, which is $37 million more than the compliance costs used in this EIA. Over the period from 2007 through 2040, the net present value of the engineering costs in Chapter 5 is $7.2 billion while the NPV of the estimated social costs over that period based on the compliance costs used in his chapter is $6.9 billion (3 percent discount rate). The differences are primarily in the form of operating costs ($22 million for the rail sector, $10 million for the marine sector). The variable costs for locomotives are slightly smaller ($4.0 million) and for marine are somewhat higher ($5.0 million). The difference for marine engines occurs in part because the engineering costs in Chapter 3 include Tier 4 costs for recreational marine engines over 2,000 kW. There are also small differences for the estimated operating costs. As a result of these differences, the amount of the social costs imposed on producers and consumers of rail and marine transportation services as a result of the proposed program would be larger than estimated in this section, while the impacts on the prices and quantities of locomotives would be slightly less. In addition, there would be larger social costs for the recreational marine sector. Nevertheless, the estimated market impacts and the distribution of the social costs among stakeholders would be about the same as those presented below.

7.1.4.1 Market Analysis Results

In the market analysis, we estimate how prices and quantities of goods affected by the proposed emission control program can be expected to change once the program goes into effect. The analysis relies on the baseline equilibrium prices and quantities for each type of equipment and the price elasticity of supply and demand. It predicts market reactions to the increase in production costs due to the new compliance costs (variable, operating, and remanufacturing costs). It should be noted that this analysis does not allow any other factors to vary. In other words, it does not consider that manufacturers may adjust their production processes or marketing strategies in response to the control program.

A summary of the market analysis results is presented in Table 7-2 for 2011, 2016, and 2030. These years were chosen because 2011 is the first year of the Tier 3 standards, 2016 is when the Tier 4 standards begin for most engines, and 2030 illustrates the long-term impacts of the program. Results for all years can be found in the appendices to this Chapter.

The estimated market impacts are designed to provide a broad overview of the expected market impacts that is useful when considering the impacts of the rule. Absolute price changes and relative price/quantity changes reflect production-weighted averages of the individual market-level estimates generated by the model for each group of engine/equipment markets. For example, the estimated marine diesel engine price changes are production-weighted averages of the estimated results for all of the marine diesel engine markets included in the group.[4] The absolute change in quantity is the sum of the decrease in units produced across sub-markets within each engine/equipment group. For example, the estimated marine diesel engine quantity changes reflect the total decline in marine diesel engines produced. The aggregated data presented in Table 7-2 is intended to provide a broad overview of the expected market impacts that is useful when considering the impacts of the rule on the economy as a whole and not the impacts on a particular engine or equipment category.

Locomotive Sector Impacts. On the locomotive side, the proposed program is expected to have a negligible impact on locomotive prices and quantities. In 2011, the expected impacts are mainly the result of the operating costs associated with locomotive remanufacturing standards. These standards impose an operating cost on railroad transportation providers and are expected to result in a slight increase in the price of locomotive transportation services (about 0.1 percent, on average) and a slight decrease in the quantity of services provided (about 0.1 percent, on average). The locomotive remanufacturing program is also expected to have a small impact on the new locomotive market. The remanufacturing program will increase railroad operating costs, which expected to result in an increase in the price of transportation services. This increase will results in a decrease in demand for rail transportation services and ultimately in a decrease in the demand for locomotives and a decrease in their price. In other words, the market will contract slightly. We estimate a reduction in the price of locomotives of about $425, or about 0.02 percent on average.

Beginning in 2016, the market impacts are affected by both the operating costs and the direct costs associated with the Tier 4 standards. As a result of both of these impacts, the price of a new locomotive is expected to increase by about 1.9 percent ($35,900), on average and the quantity produced is expected to decrease by about 0.1 percent, on average (less than 1 locomotive). Locomotive transportation service prices are expected to decrease by about 0.1 percent). By 2030, the price of new locomotives is expected to increase by about 2.6 percent ($49,000), on average, and the quantity expected to decrease by about 0.2 percent (less than 1 locomotive). The price of rail transportation services is expected to increase by about 0.4 percent.

Marine Sector Impacts. On the marine engine side, the expected impacts are different for engines above and below 800 hp. With regard to engines above 800 hp and the vessels that use them, the proposed program does not begin to affect market prices or quantities until the Tier 4 standards go into effect, which is in 2016 for most engines. For these engines, the price of a new engines in 2016 is expected to increase between 11.0 and 24.6 percent, on average ($17,300 for C1 engines above 800 hp and $64,100 for C2 engines above 800 hp), depending on the type of engine, and sales are expected to decrease less than 2.0 percent, on average. The price of vessels that use them is expected

[4] As a result, estimates for specific types of engines and equipment may be different than the reported group average. The detail results for markets are reported in the Appendices to Chapter 7 of the RIA.

to increase between 1.7 and 1.0 percent ($20,900 for vessels that use C1 engines above 800 hp and $188,600 for vessels that use C2 engines above 800 hp) and sales are expected to decrease less than 2.0 percent. The percent change in price in the marine transportation sector is expected to be about 0.1 percent. By 2030, the price of these engines is expected to increase between 8.4 and 18.7 percent, on average ($13,300 for C1 engines above 800 hp and $48,700 for C2 engine above 800 hp), depending on the type of engine, and sales are expected to decrease by less than 2 percent, on average. The price of vessels that use them is expected to increase between 1 and 3.6 percent ($16,200 for vessels that use C1 engines above 800 hp and $141,600 for vessels that use C2 engines above 800 hp) and sales are expected to decrease by less than 2 percent. The percent change in price in the marine transportation is expected to be about 0.6 percent.

With regard to engines below 800 hp, the market impacts of the program are expected to be negligible.[5] This is because there are no variable costs associated with the standards for these engines. The market impacts associated with the program are indirect effects that stem from the impacts on the marine service markets for the larger engines that would be subject to direct compliance costs. Changes in the equilibrium outcomes in those marine service markets may lead to reductions for marine services in other marine engine and vessel markets, including the markets for smaller marine diesel engines and vessels. The result is that in some years there may be small declines in the equilibrium price in the markets for marine diesel engines less than 800 hp. This would occur because an increase in the price and a decrease in the quantity of marine transportation services provided by vessels with engines above 800 hp that results in a change in the price of marine transportation services may have follow-on effects in other marine markets and lead to decreases in prices for those markets. For example, the large vessels used to provide transportation services are affected by the rule. Their compliance costs lead to a higher vessel price and a reduced demand for those vessels. This reduced demand indirectly affects other marine transportation services that support the larger vessels, and leads to a decrease in price for those markets as well.

Table 7-2. Summary of Estimated Market Impacts for 2011, 2016, 2030 (2005$)

Market	Average Variable Engineering Cost Per Unit	Change in Price		Change in Quantity	
		Absolute	Percent	Absolute	Percent
2011					
Rail Sector					
Locomotives	$0	-$425	-0.02%	0	-0.1%

[5] The market results for engines and vessels below 800 hp are provided in a Technical Support Document that can be found in the docket for this rule.

Market	Average Variable Engineering Cost Per Unit	Change in Price		Change in Quantity	
		Absolute	Percent	Absolute	Percent
Transportation Services	NA	NA[a]	0.1%	NA[a]	-0.1%
Marine Sector					
Engines					
C1>800 hp	$0	$0	0.00%	0	0.0%
C2>800 hp	$0	$0	0.00%	0	0.0%
Other marine	$0	$0	0.00%	0	0.0%
Vessels					
C1>800 hp	$0	$0	0.00%	0	0.0%
C2>800 hp	$0	$0	0.00%	0	0.0%
Other marine	$0	$0	0.00%	0	0.0%
Transportation Services	NA	NA[a]	0.00%	NA[a]	0.0%
2016					
Rail Sector					
Locomotives	$36,363	$35,929	1.9%	0	-0.1%
Transportation Services	NA	NA[a]	0.1%	NA[a]	-0.1%
Marine Sector [a]					
Engines					
C1>800 hp	$18,105	$17,330	11.0%	-7	-1.7%
C2>800 hp	$64,735	$64,073	24.6%	-1	-0.9%
Other marine	$0	$0	0.00%	0	0.0%
Vessels					
C1>800 hp	$2,980	$20,898	1.5%	-9	-1.7%
C2>800 hp	$6,515	$188,559	4.8%	-1	-0.9%
Other marine	$0	-$1	0.00%	-0	0.0%
Transportation Services	NA	NA[a]	0.1%	NA[a]	-0.1%
2030					
Rail Sector					
Locomotives	$50,291	$49,087	2.6%	0	-0.2%
Transportation Services	NA	NA[a]	0.4%	NA[a]	-0.2%
Marine Sector					
Engines					
C1>800 hp	$13,885	$13,261	8.4%	-6	-1.4%
C2>800 hp	$49,360	$48,692	18.7%	-1	-0.9%
Other marine	$0	$0	0.0%	0	0.0%
Vessels					
C1>800 hp	$2,979	$16,155	1.1%	-8	-1.5%
C2>800 hp	$6,516	$141,563	3.6%	-1	-0.9%
Other marine	$0	-$4	0.0%	-2	0.0%
Transportation Services	NA	NA[a]	0.6%	NA[a]	-0.3%

[a]The prices and quantities for transportation services are normalized ($1 for 1 unit of services provided) and therefore it is not possible to estimate the absolute change price or quanitity; see 7.3.1.5.

7.1.4.2 Economic Welfare Analysis

In the economic welfare analysis we look at the costs to society of the proposed program in terms of losses to key stakeholder groups that are the producers and consumers in the rail and marine markets. The estimated surplus losses presented below reflect all engineering costs associated with the proposed program (fixed, variable, operating, and remanufacturing costs). Detailed economic welfare results for the proposed program for all years are presented in the Appendices to this chapter and are summarized below.

A summary of the estimated annual net social costs is presented in Table 7-3 and Figure 7-1. Table 7-3 shows that total social costs for each year are slightly less than the total engineering costs. This is because the total engineering costs do not reflect the decreased sales of locomotives, engines and vessels that are incorporated in the total social costs. In addition, in the early years of the program the estimated social costs of the propose program are not expected to increase regularly over time. This is because the compliance costs for the locomotive remanufacture program are not constant over time.

Table 7-3 Estimated Annual Engineering and Social Costs Through 2040 (2005$, $million)

Year	Engineering Costs						Total Social Costs
	Marine operating costs	Marine engine and vessel costs	Rail operating costs	Rail remanuf. costs	Rail new loco-motive costs	Total	
2007	$0.0	$25.0	$0.0	$0.0	$3.2	$28.2	$28.2
2008	$0.0	$25.0	$1.3	$56.7	$3.2	$86.1	$86.1
2009	$0.0	$25.0	$1.4	$33.2	$3.2	$62.7	$62.7
2010	$0.0	$25.0	$3.8	$51.5	$7.3	$87.5	$87.5
2011	$0.0	$86.0	$7.9	$96.9	$10.8	$201.6	$201.5
2012	$0.0	$41.2	$9.7	$74.3	$12.3	$137.5	$137.5
2013	$0.0	$41.2	$12.0	$62.4	$12.3	$127.9	$127.9
2014	$2.8	$41.2	$12.6	$40.0	$16.9	$113.5	$113.5
2015	$5.6	$74.1	$14.9	$29.1	$48.8	$172.5	$172.5
2016	$14.8	$48.6	$19.0	$55.5	$55.3	$193.1	$192.6
2017	$23.9	$44.9	$32.7	$39.3	$66.5	$207.3	$206.7
2018	$36.0	$33.9	$44.6	$41.9	$67.9	$224.3	$223.9
2019	$48.0	$34.2	$56.5	$36.7	$61.9	$237.4	$236.9
2020	$60.0	$34.5	$68.5	$12.9	$64.0	$239.9	$239.5
2021	$72.0	$34.8	$80.8	$14.9	$66.2	$268.7	$268.2
2022	$83.9	$35.1	$93.6	$37.4	$68.1	$318.1	$317.6
2023	$95.7	$35.4	$106.7	$83.2	$69.8	$390.8	$390.2
2024	$107.5	$35.7	$120.1	$72.0	$70.8	$406.0	$405.4
2025	$119.1	$35.9	$133.8	$76.5	$72.5	$437.9	$437.2
2026	$130.6	$36.2	$147.7	$63.2	$73.5	$451.2	$450.4
2027	$141.9	$33.6	$161.5	$64.6	$74.7	$476.3	$475.5
2028	$153.0	$33.9	$175.5	$80.3	$75.6	$518.2	$517.3
2029	$163.3	$34.2	$189.4	$81.8	$76.3	$544.9	$544.0

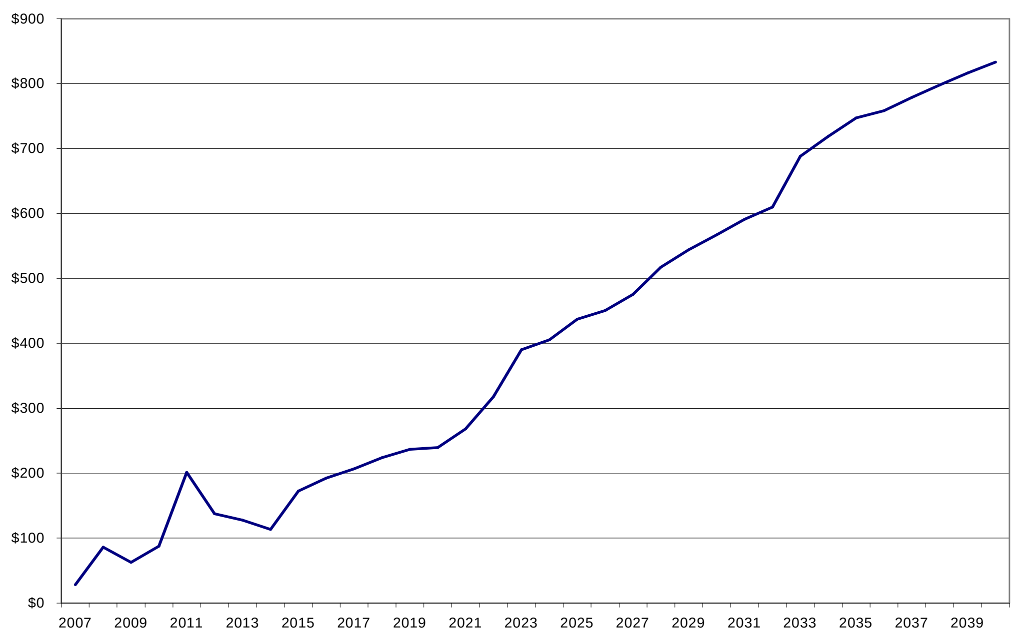
	Engineering Costs						
2030	$172.6	$34.5	$203.3	$81.2	$76.8	$568.3	$567.3
2031	$181.2	$34.8	$217.1	$81.4	$77.6	$592.1	$591.1
2032	$189.0	$35.1	$231.1	$77.2	$78.5	$610.9	$609.8
2033	$196.4	$35.4	$244.9	$133.5	$78.9	$689.2	$688.0
2034	$203.6	$35.7	$258.7	$142.6	$79.6	$720.1	$718.8
2035	$210.4	$36.0	$272.4	$150.1	$79.8	$748.8	$747.4
2036	$216.9	$36.4	$285.8	$143.2	$77.5	$759.7	$758.3
2037	$222.7	$36.7	$299.2	$145.9	$75.8	$780.3	$778.8
2038	$227.9	$37.0	$312.0	$148.8	$73.9	$799.6	$798.1
2039	$232.4	$37.3	$324.4	$152.0	$71.8	$818.0	$816.4
2040	$236.3	$37.7	$336.3	$155.0	$69.5	$834.7	$833.2
2040 NPV at 3%[a,b]						$6,907.8	$6,896.8
2040 NPV at 7% [a,b]						$3,107.7	$3,103.1
2030 NPV at 3% [a,b]						$3,938.7	$3,932.6
2030 NPV at 7% [a,b]						$2,175.5	$2,172.5

[a] EPA EPA presents the present value of cost and benefits estimates using both a three percent and a seven percent social discount rate. According to OMB Circular A-4, “the 3 percent discount rate represents the ‘social rate of time preference’… [which] means the rate at which ‘society’ discounts future consumption flows to their present value”; “the seven percent rate is an estimate of the average before-tax rate of return to private capital in the U.S. economy … [that] approximates the opportunity cost of capital.”

[b] Note: These NPV calculations are based on the period 2006-2040, reflecting the period when the analysis was completed. This has the consequence of discounting the current year costs, 2007, and all subsequent years are discounted by an additional year. The result is a smaller stream of social costs than by calculating the NPV over 2007-2040 (3% smaller for 3% NPV and 7% smaller for 7% NPV).

Table 7-4 shows how the social costs are expected to be shared across stakeholders, for selected years. According to these results, the rail sector is expected to bear most of the costs of the program, ranging from 57.3 percent in 2011 to 67.3 percent in 2016. Producers and consumers of locomotive transportation services are expected to bear most of those costs, ranging from 51.9 percent in 2011 to 63.3 percent in 2030. As explained above, these results assume the railroads absorb all remanufacture kit compliance costs (the remanufacture kit manufacturers pass all costs of the new standards to the railroads). The marine sector is expected to bear the remaining social costs, ranging from 42.7 percent in 2011 to 32.7 percent in 2016. Producers of marine diesel engines are expected to bear more of the program costs in the early years (42.7 percent in 2011), but by 2020 producers and consumers in the marine transportation services market

Figure 7-1. Estimated Annual Social Costs, 2007-2040 (2005$, $million)



are expected to bear a larger share of the social costs, 31.5 percent.

Table 7-4. Summary of Estimated Net Social Costs for 2011, 2016, 2020, 2030 (2005$, $million)

Stakeholder Group	2011		2016	
	Surplus Change	Percent	Surplus Change	Percent
Locomotives				
Locomotive producers	-$11.1	5.5%	-$13.4	7.0%

Stakeholder Group	2011		2016	
	Surplus Change	Percent	Surplus Change	Percent
Rail transportation service providers	-$47.5	23.6%	-$52.9	27.5%
Rail transportation service consumers	-$57.0	28.3%	-$63.5	33.0%
Total locomotive sector	*-$115.6*	*57.3%*	*-$129.7*	*67.3%*
Marine				
Marine engine producers	-$86.0	42.7%	-$0.9	0.5%
C1 > 800 hp	-$22.8		-$0.7	
C2 > 800 hp	-$27.8		-$0.2	
Other marine	-$35.4		-$0.0	
Marine vessel producers	-$0	0.0%	-$18.0	9.3%
C1 > 800 hp	-$0		-$13.6	
C2 > 800 hp	-$0		-$4.4	
Other marine	-$0		-$0.0	
Recreational and fishing vessel consumers	-$0	0.0%	-$9.6	5.0%
Marine transportation service providers	-$0	0.0%	-$15.6	8.1%
Marine transportation service consumers	-$0	0.0%	-$18.7	9.7%
Total marine sector	*-$86.0*	*42.7%*	*-$62.9*	*32.7%*
TOTAL PROGRAM	-$201.5		-$192.6	

Stakeholder Group	2020		2030	
	Surplus Change	Percent	Surplus Change	Percent
Locomotives				
Locomotive producers	-$0.7	0.3%	-$1.8	0.3%
Rail transportation service providers	-$65.8	27.5%	-$163.2	28.8%
Rail transportation service consumers	-$78.9	32.9%	-$195.9	34.5%
Total locomotive sector	*-$145.3*	*60.7%*	*-$360.9*	*63.6%*
Marine				
Marine engine producers	-$0.8	0.3%	-$0.9	0.2%
C1 > 800 hp	-$0.6		-$0.7	
C2 > 800 hp	-$0.2		-$0.2	
Other marine	-$0.0		-$0.0	
Marine vessel producers	-$10.1	4.2%	-$8.2	1.4%
C1 > 800 hp	-$7.8		-$6.4	
C2 > 800 hp	-$2.3		-$1.6	
Other marine	-$0.1		-$0.1	
Recreational and fishing vessel consumers	-$7.8	3.3%	-$8.5	1.5%
Marine transportation service providers	-$34.3	14.3%	-$85.8	15.1%
Marine transportation service consumers	-$41.2	17.2%	-$103.0	18.2%
Total marine sector	*-$94.1*	*39.3%*	*-$206.5*	*36.4%*
TOTAL PROGRAM	-$239.5	100.0%	-$567.3	100.0%

Table 7-5 provides additional detail about the sources of surplus changes, for 2020 when the per unit compliance costs are stable. On the marine side, this table shows that engine and vessel producers are expected to pass along much of the engine and vessel compliance costs to the marine transportation service providers who purchase marine vessels. These marine transportation service providers, in turn, are expected to pass some of the costs to their customers. This is also expected to be the case in the rail sector.

Table 7-5. Distribution of Estimated Surplus Changes by Market and Stakeholder for 2020 (2005$, $million)

	Total Engineering Costs	Surplus Change
Marine Markets		
Engine Producers	*$29.3*	*–$0.8*
Vessel Producers	*$5.2*	*–$10.1*
Engine price changes		–$8.1
Equipment cost changes		–$2.0
Recreational and Fishing Consumers		*-$7.8*
Engine price changes		-$6.2
Equipment cost changes		-$1.6
Transportation Service Providers	*$60.0*	*–$34.3*
Increased price vessels		–$6.9
Operating costs		–$27.4
Users of Transportation Service		*–$41.2*
Increased price vessels		–$8.2
Operating costs		–$32.9
Rail Markets		
Locomotive Producers	*$64.0*	*–$0.7*
Rail Service Providers	*$81.4*	*–$65.8*
Increased price new locomotives		–$28.8
Remanufacturing costs	$9.5	–$8.1
Operating costs	$63.6	–$28.9
Users of Rail Transportation Service		*–$78.9*
Increased price new locomotives		–$34.6
Remanufacturing costs		–$9.7
Operating costs		–$34.7
TOTAL	***$239.9***	***$239.6***

The present value of net social costs of the proposed standards through 2040, shown in Table 7-3, is estimated to be is estimated to be $6.9 billion (2005$).[6] This present value is calculated using a social discount rate of 3 percent and the stream of social welfare costs from 2006 through 2040. We also performed an analysis using a 7 percent

[6] Note: These NPV calculations are based on the period 2006-2040, reflecting the period when the analysis was completed. This has the consequence of discounting the current year costs, 2007, and all subsequent years are discounted by an additional year. The result is a smaller stream of social costs than by calculating the NPV over 2007-2040 (3% smaller for 3% NPV and 7% smaller for 7% NPV).

social discount rate.[7] Using that discount rate, the present value of the net social costs through 2040 is estimated to be $3.1 billion (2005$).

Error! Reference source not found. shows the distribution of total surplus losses for the program from 2006 through 2040. This table shows that the rail sector is expected to bear about 65 percent of the total program social costs through 2040, and that most of the costs are expected to be borne by the rail transportation service producers and consumers. On the marine side, most of the marine sector costs are expected to be borne by the marine transportation service providers and consumers. This is consistent with the structure of the program, which leads to high compliance costs for those stakeholder groups.

Table 7-6 Estimated Net Social Costs Through 2040 by Stakeholder ($million, 2005$)

Stakeholder Groups	Surplus Change NPV 3%	Percent of Total Surplus	Surplus Change NPV 7%	Percent of Total Surplus
Locomotives				
Locomotive producers	$92.8	1.3%	$63.5	2.0%
Rail transportation service providers	$1,988.8	28.8%	$878.1	28.3%
Rail transportation service consumers	$2,386.4	34.6%	$1,053.7	33.9%
Total locomotive sector	$4,468.1	64.8%	$1,995.4	64.4%
Marine				
Marine engine producers	$313.3	4.5%	$242.3	7.8%
C1 > 800 hp	$102.1		$73.9	
C2 > 800 hp	$112.4		$84.4	
Other marine	$98.7		$84.0	
Marine vessel producers	$143.8	2.1%	$71.3	2.3%
C1 > 800 hp	$110.1		$54.3	
C2 > 800 hp	$32.4		$16.5	
Other marine	$1.3		$0.5	
Recreational and fishing vessel consumers	$110.0	1.6%	$51.0	1.6%
Marine transportation service providers	$846.2	12.3%	$338.2	10.9%
Marine transportation service consumers	$1,015.4	14.7%	$405.9	13.1%
Total marine sector	$2,428.7	35.2%	$1,107.7	35.7%
TOTAL PROGRAM	$6,896.8		$3,103.1	

[7] EPA has historically presented the present value of cost and benefits estimates using both a 3 percent and a 7 percent social discount. The 3 percent rate represents a demand-side approach and reflects the time preference of consumption (the rate at which society is willing to trade current consumption for future consumption). The 7 percent rate is a cost-side approach and reflects the shadow price of capital.

7.2 Economic Methodology

Economic impact analysis uses a combination of theory and econometric modeling to evaluate potential behavior changes associated with a new regulatory program. As noted above, the goal is to estimate the impact of the regulatory program on markets (prices and quantities) and stakeholder groups (producers and consumers). This is done by creating a mathematical model based on economic theory and populating the model using publicly available price and quantity data. A key factor in this type of analysis is the responsiveness of the quantity of engines, equipment, and transportation services demanded by consumers or supplied by producers to a change in the price of that product. This relationship is called the price elasticity of demand or supply.

The EIM's methodology is rooted in applied microeconomic theory and was developed following the *OAQPS Economic Analysis Resource Document*.[3] This section discusses the economic theory underlying the modeling for this EIA and several key issues that affect the way the model was developed.

7.2.1 Behavioral Economic Models

Models incorporating different levels of economic decision making can generally be categorized as *with*-behavior responses or *without*-behavior responses. The EIM is a behavioral model.

Engineering cost analysis is an example of the latter and provides detailed estimates of the cost of a regulation based on the projected number of affected units and engineering estimates of the annualized costs. The result is an estimate of the total compliance costs for a program. However, these models do not attempt to estimate how a regulatory program will change the prices or output of an affected industry. Therefore, the results may over-estimate the total costs of a program because they do not take decreases in quantity produced into account. In addition, engineering cost analysis does not address which stakeholders are expected to bear the costs of the regulation.

The *with*-behavior response approach builds on the engineering cost analysis and incorporates economic theory related to producer and consumer behavior to estimate changes in market conditions. As Bingham and Fox note, this framework provides "a richer story" of the expected distribution of economic welfare changes across producers and consumers.[4] In behavioral models, manufacturers of goods affected by a regulation are economic agents who can make adjustments, such as changing production rates or altering input mixes, that will generally affect the market environment in which they operate. As producers change their production levels in response to a new regulation, consumers of the affected goods are typically faced with changes in prices that cause them to alter the quantity that they are willing to purchase. These changes in price and output resulting from the market adjustments are used to estimate the distribution of social costs between consumers and producers.

If markets are competitive and per-unit regulatory costs are small, the behavioral approach will yield approximately the same total cost impact as the engineering cost approach. However, the advantage of the *with*-behavior response approach is that it illustrates how the costs flow through the economic system and it identifies which stakeholders (producers and consumers) are most likely to be affected.

7.2.2 What is the Economic Theory Underlying the EIM?

The EIM is a multi-market partial equilibrium numerical simulation model that estimates price and quantity change in the intermediate run under competitive market conditions. Each of these model features is described in this section.

7.2.2.1 Partial Equilibrium Multi-Market Model

In the broadest sense, all markets are directly or indirectly linked in the economy, and a new regulatory program will theoretically affect all commodities and markets to some extent. However, not all regulatory programs have noticeable impacts on all markets. For example, a regulation that imposes significant per unit direct compliance costs on the production of an important manufacturing input, such as steel, would be expected to have a large impact on the national economy. However, a regulation that imposes a small direct compliance cost on an important input, or any direct compliance costs on an input that is only a small share of production costs would be expected to have less of an impact on all markets in the economy.

The appropriate level of market interactions to be included in an economic impact analysis is determined by the number of industries directly affected by the requirements and the ability of affected firms to pass along the regulatory costs in the form of higher prices. There are at least three alternative approaches for modeling interactions between economic sectors, which reflect three different levels of analysis.

In a *partial equilibrium* model, individual markets are modeled in isolation. The only factor affecting the market is the cost of the regulation on facilities in the industry being modeled; there are no interaction effects with other markets. Conditions in other markets are assumed either to be unaffected by a policy or unimportant for cost estimation.

In a *multi-market* model, a subset of related markets is modeled together, with sector linkages, and hence selected interaction effects, explicitly specified. This approach represents an intermediate step between a simple, single-market partial equilibrium approach and a full general equilibrium approach. This technique has most recently been referred to in the literature as "partial equilibrium analysis of multiple markets."[5]

In a *general equilibrium* model, all sectors of the economy are modeled together, incorporating interaction effects between all sectors included in the model. General equilibrium models operationalize neoclassical microeconomic theory by modeling not only the direct effects of control costs but also potential input substitution effects, changes in production levels associated with changes in market prices across all sectors, and the associated changes in welfare economy-wide. A disadvantage of general equilibrium modeling is that substantial time and resources are required to develop a new model or tailor an existing model for analyzing regulatory alternatives.

This analysis uses a multi-market partial equilibrium approach in that it models only those markets that are directly affected by the proposed emission control program: producers and consumers in the rail and marine sectors. These two sectors are modeled separately, and the locomotive and marine components of the EIM are not linked (there is no feedback mechanism between the locomotive and marine diesel market segments; see Section 7.1.3.3). The results of the analysis will be estimated price and quantity changes in the locomotive and rail transportation services markets and in the marine engine, vessel, and transportation services markets, as well as estimates of how the compliance costs will be shared between producers and consumers in the relevant markets.

The EIM does not estimate the economic impact of the proposed emission control program on finished goods that use rail or marine transportation services as inputs. For example, while we look at the impacts of the program on locomotive transportation costs, we do not look at the impacts on electricity produced using coal transported by rail, or on manufactured productions that use that electricity. Similarly, while we look at the impacts of the control program on the price of fishing vessels, we do not look at the impacts on the prices of food products that use fish as an input. This is because these inputs (trail transportation, fishing vessel) are only a small portion of the total inputs of the final goods and services produced using them. Therefore, a change in the price of these inputs on the order anticipated by this program would not be expected to significantly affect the prices and quantities of finished products that use locomotive or marine transportation services or marine vessels as an input.

It should also be noted that the economic impact model employed for this analysis estimates the aggregate economic impacts of the control program on the relevant markets. It is not a firm-level analysis and therefore the supply elasticity or individual compliance costs facing any particular manufacturer may be different from the market average. This difference can be important, particularly where the rule affects different firms' costs over different volumes of production. However, to the extent there are differential effects, EPA believes that the wide array of flexibilities provided in this rule are adequate to address any cost inequities that may arise.

7.2.2.2 Perfect Competition Model

For all markets that are modeled, the analyst must characterize the degree of competition within each market. The discussion generally focuses on perfect competition (price-taking behavior) versus imperfect competition (the lack of price-taking behavior). This EIM relies on an assumption of perfect competition. This means that consumers and firms are price takers and do not have the ability to influence market prices.

In a perfectly competitive market at equilibrium the market price equals the value society (consumers) places on the marginal product, as well as the marginal cost to society (producers). Producers are price takers, in that they respond to the value that consumers put on the product. It should be noted that the perfect competition assumption is not primarily about the number of firms in a market. It is about how the market operates: whether or not individual firms have sufficient market power to influence the market price. Indicators that allow us to assume perfect competition include absence of barriers to entry, absence of strategic behavior among firms in the market, and product differentiation.[8] Finally, according to contestable market theory, oligopolies and even monopolies will behave very much like firms in a competitive market if it is possible to enter particular markets costlessly (i.e., there are no sunk costs associated with market entry or exit). This would be the case, for example, when products are substantially similar (e.g., a recreational vessel and a commercial vessel).

In contrast, imperfect competition implies firms have some ability to influence the market price of output they produce. One of the classic reasons firms may be able to do this is their ability to produce commodities with unique attributes that differentiate them from competitors' products. This allows them to limit supply, which in turn increases the market price, given the traditional downward-sloping demand curve. Decreasing the quantity produced increases the monopolist's profits but decreases total social surplus because a less than optimal amount of the product is being consumed. In the monopolistic equilibrium, the value society (consumers) places on the marginal product, the market price, exceeds the marginal cost to society (producers) of producing the last unit. Thus, social welfare would be increased by inducing the monopolist to increase production. Social cost estimates associated with a proposed regulation are larger with monopolistic market structures and other forms of imperfect competition because the regulation exacerbates the existing social inefficiency of too little output from a social perspective. The Office of Management and Budget (OMB) explicitly mentions the need to consider these market power-related welfare costs in evaluating regulations under Executive Order 12866.[6]

Perfect competition is widely accepted for this type of analysis and only in rare cases are other approaches used.[7] For the markets under consideration in this EIA we assume the perfectly competitive market structure. This is because these markets do not exhibit evidence of noncompetitive behavior: there are no indications of barriers to entry, the firms in these markets are not price setters, and there is no evidence of high levels of strategic behavior in the price and quantity decisions of the firms.

On the marine side, the markets included in this analysis do not exhibit evidence of noncompetitive behavior. On the engine side, these markets are matured, as evidenced by unit sales growing at the rate of population increases. Pricing power in such markets is typically limited. There is also excess capacity, especially on the engine side. Marine diesel engines are typically marinized land-based highway or nonroad engines, and it is possible for marine diesel engine manufacturers to produce additional marine engines with minimal production constraints if a high demand is present. On the vessel side,

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[8] The number of firms in a market is not a necessary condition for a perfectly competitive market. See Robert H. Frank, Microeconomics and Behavior, 1991, McGraw-Hill, Inc., p 333.

there are hundreds of shipyards that can be engaged in the production of vessels, and vessels from one firm can be purchased instead of engines and vessels from another firm. Finally, there are hundreds of marine transportation service providers, ranging from individuals who own their own tug or supply boat to firms that employ a fleet. It is also not uncommon for owners to move vessels among coasts and waterways to take advantage of local markets. For all of these reasons it is appropriate to model the market markets as competitive.

The locomotive markets are also modeled as competitive. While there are two main locomotive producers, EMD and GE, their products are homogeneous and railroads can easily purchase locomotives from one or the other. The high cost of fuel for the rail transportation services sector also contributes to competition among locomotive manufacturers, in that railroads will shift their purchases from one manufacturer to the other if they can achieve a reduction in fuel costs. The new switcher market will add to the competitive pressure in this market as well. On the rail transportation side, although the Government Accountability Office (GAO) has expressed concerns regarding the amount of competition in the rail road industry due to mergers over the past decades, it also acknowledges that a more “rigorous analysis of competitive markets” was needed to show the industry was not competitive.[8] The Association of American Railroads (AAR), a trade group representing the freight railroads of North America, has suggested that mergers have actually made the rail road industry more competitive. According to the AAR, most mergers have been “end-to-end” mergers that reduce the need to interchange traffic to a connecting railroad (creating a single line service), as opposed to the merger of competing railroads with parallel lines. These mergers increase competition by creating more efficient, lower cost railway networks.[9] AAR also argues that recent mergers have not given railroads excessive market power that would come with uncompetitive markets. They note that productivity is up, prices are down, innovative new operating strategies are being tested, profits are not in excess of a competitive rate of return, and they do not have an excessive share of the national transportation market.[10]

7.2.2.3 Intermediate-Run Model

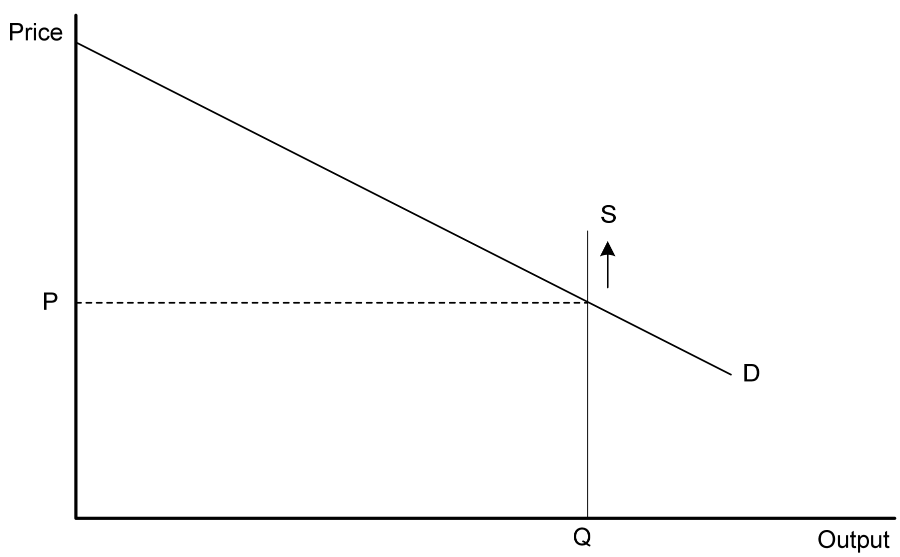
In developing a multi-market partial equilibrium model, the choices available to producers must be considered. For example, are producers able to increase their factors of production (e.g., increase production capacity) or alter their production mix (e.g., substitution between materials, labor, and capital)? These modeling issues are largely dependent on the time horizon for which the analysis is performed. Three benchmark time horizons are discussed below: the very short run, the long run, and the intermediate run. This discussion relies in large part on the material contained in the *OAQPS Economic Analysis Resource Guide*.[11]

The EIM models market impacts in the intermediate run. The use of the intermediate run means that some factors of production are fixed and some are variable. This modeling period allows analysis of the economic effects of the rule's compliance costs on current producers. As described below, a short-run analysis imposes all compliance costs on producers, while a long-run analysis imposes all costs on consumers.

The use of the intermediate time frame is consistent with economic practices for this type of analysis.

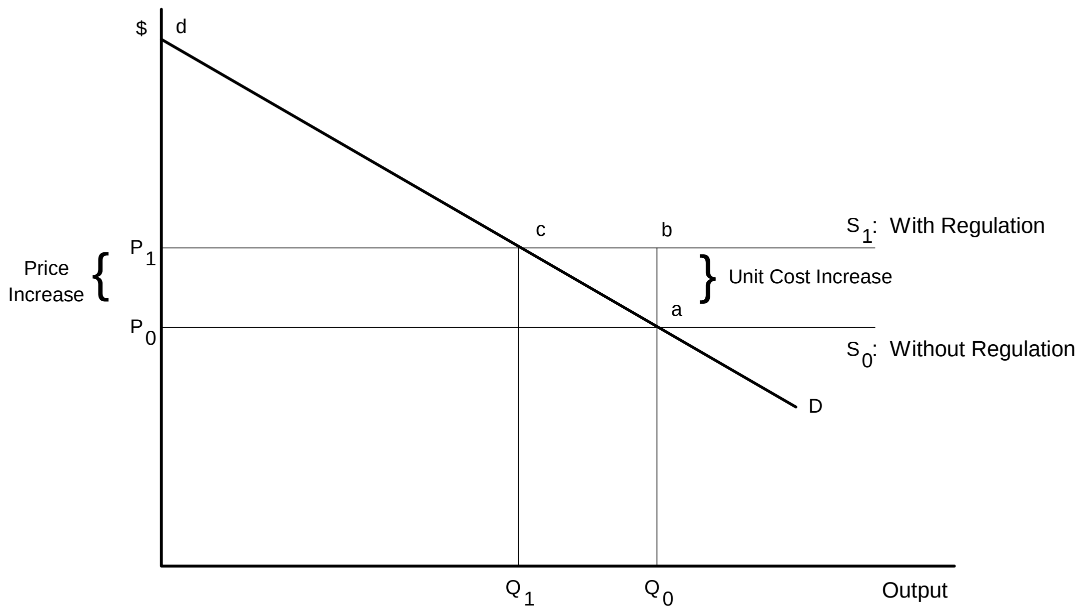
In the very short run, all factors of production are assumed to be fixed, leaving producers with no means to respond to the increased costs associated with the regulation (e.g., they cannot adjust labor or capital inputs). Within a very short time horizon, regulated producers are constrained in their ability to adjust inputs or outputs due to contractual, institutional, or other factors and can be represented by a vertical supply curve, as shown in Figure 7-2. In essence, this is equivalent to the nonbehavioral model described earlier. Neither the price nor quantity changes and the manufacturer's compliance costs become fixed or sunk costs. Under this time horizon, the impacts of the regulation fall entirely on the regulated entity. Producers incur the entire regulatory burden as a one-to-one reduction in their profit. This is referred to as the "full-cost absorption" scenario and is equivalent to the engineering cost estimates. Although there is no hard and fast rule for determining what length of time constitutes the very short run, it is inappropriate to use this time horizon for this type of analysis because it assumes economic entities have no flexibility to adjust factors of production.

Figure 7-2. Short Run: All Costs Borne By Producers



In the long run, all factors of production are variable, and producers can be expected to adjust production plans in response to cost changes imposed by a regulation (e.g., using a different labor/capital mix). Figure 7-3 illustrates a typical, if somewhat simplified, long-run industry supply function. The supply function is horizontal, indicating that the marginal and average costs of production are constant with respect to output.[9] This horizontal slope reflects the fact that, under long-run constant returns to scale, technology and input prices ultimately determine the market price, not the level of output in the market.

Figure 7-3 Long-Run: Full-Cost Pass-Through



Market demand is represented by the standard downward-sloping curve. The market is assumed here to be perfectly competitive; equilibrium is determined by the intersection of the supply and demand curves. In this case, the upward shift in the market supply curve represents the regulation's effect on production costs. The shift causes the market price to increase by the full amount of the per-unit control cost (i.e., from P_0 to P_1). With the quantity demanded sensitive to price, the increase in market price leads to a reduction in output in the new with-regulation equilibrium (i.e., Q_0 to Q_1). As a result, consumers incur the entire regulatory burden as represented by the loss in consumer surplus (i.e., the area P_0ac P_1). In the nomenclature of EIAs, this long-run scenario is typically referred to as "full-cost pass-through" and is illustrated in **Error! Reference source not found.**.

Taken together, impacts modeled under the long-run/full-cost-pass-through scenario reveal an important point: under fairly general economic conditions, a

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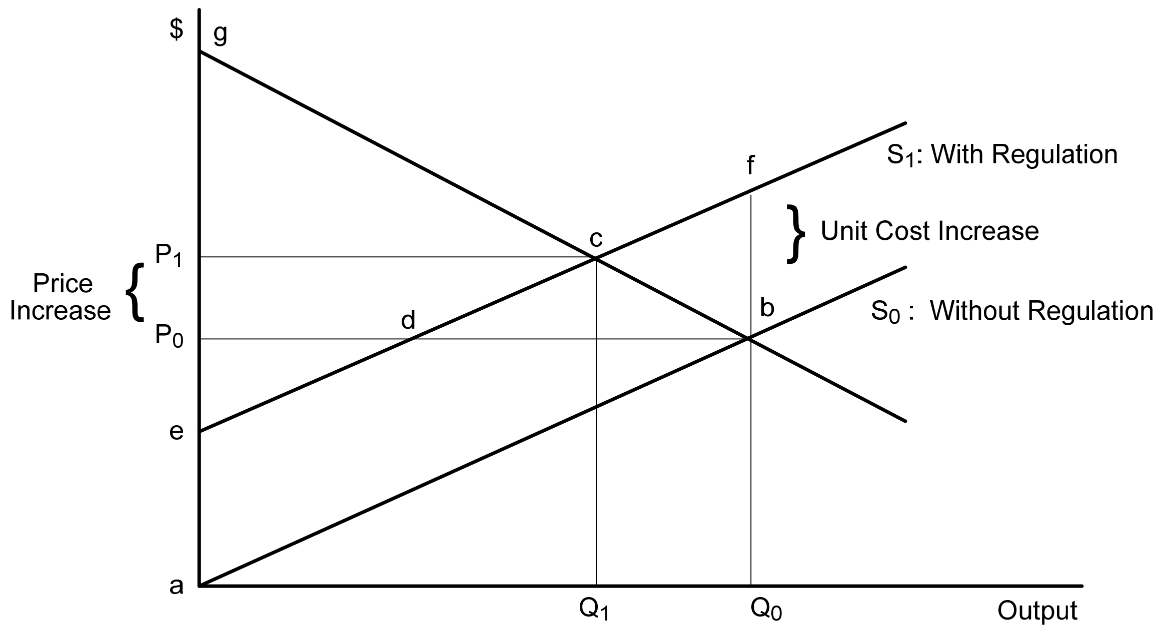
[9] The constancy of marginal costs reflects an underlying assumption of constant returns to scale of production, which may or may not apply in all cases.

regulation's impact on producers is transitory. Ultimately, the costs are passed on to consumers in the form of higher prices. However, this does not mean that the impacts of a regulation will have no impact on producers of goods and services affected by a regulation. For example, the long run may cover the time taken to retire today's entire capital equipment, which could take decades. Therefore, transitory impacts could be protracted and could dominate long-run impacts in terms of present value. In addition, to evaluate impacts on current producers, the long-run approach is not appropriate. Consequently a time horizon that falls between the very short-run/full-cost-absorption case and the long-run/full-cost-pass-through case is most appropriate for this EIA.

The intermediate run time frame allows examination of impacts of a regulatory program during the transition between the short run and the long run. In the intermediate run, there is some resource immobility which may cause producers to suffer producer surplus losses. Specifically, producers may be able to adjust some, but not all, factors of production, and they therefore will bear some portion of the costs of the regulatory program. The existence of fixed production factors generally leads to diminishing returns to those fixed factors. This typically manifests itself in the form of a marginal cost (supply) function that rises with the output rate, as shown in Figure 7-4.

Figure 7-4 Intermediat Run: Partial-Cost Pass-Through



Again, the regulation causes an upward shift in the supply function. The lack of resource mobility may cause producers to suffer profit (producer surplus) losses in the face of regulation; however, producers are able to pass through some of the associated costs to consumers, to the extent the market will allow. As shown, in this case, the market-clearing process generates an increase in price (from P_0 to P_1) that is less than the per-unit increase in costs, so that the regulatory burden is shared by producers (net reduction in profits) and consumers (rise in price). In other words, there is a loss of both producer and consumer surplus.

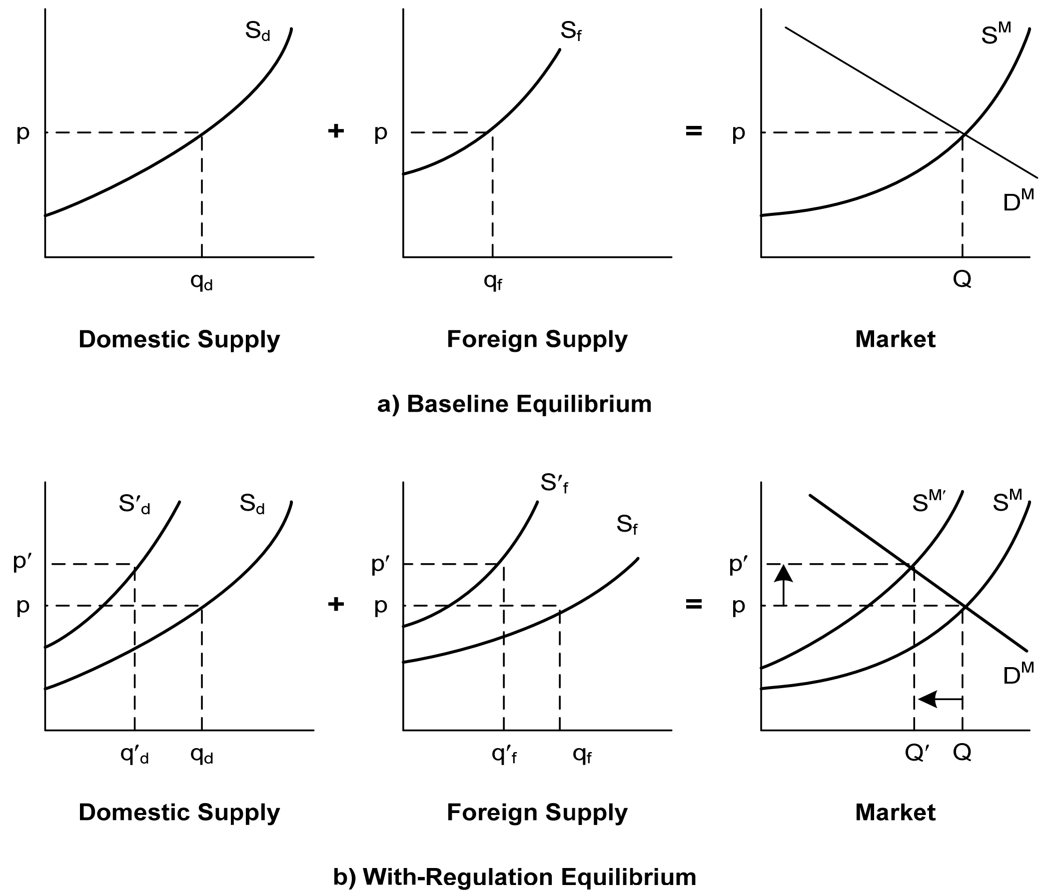
Consistent with other economic impact analyses performed by EPA, this EIM uses an intermediate run approach. This approach allows us to examine the market and social welfare impacts of the program as producers adjust their output and consumers adjust their consumption of affected products in response to the increased production costs. During this period, the distribution of the welfare losses between producer and consumer depends in large part on the relative supply and demand elasticity parameters used in the model. For example, if demand for marine vessels or locomotives is relatively inelastic (i.e., demand does not decrease much as price increases), then most of the direct compliance costs on vessel or locomotive manufacturers will be passed along to the owners and operators of this equipment in the form of higher prices.

7.2.3 How Is the EIM Used to Estimate Economic Impacts?

7.2.3.1 Estimation of Market Impacts (Single Market)

A graphical representation of a general economic competitive model of price formation, as shown in Figure 7-5 (a), posits that market prices and quantities are determined by the intersection of the market supply and market demand curves. Under the baseline scenario, a market price and quantity (p,Q) are determined by the intersection of the downward-sloping market demand curve (D^M) and the upward-sloping market supply curve (S^M). The market supply curve reflects the sum of the domestic (S_d) and import (S_f) supply curves.

Figure 7-5 Market Equilibrium Without and With Regulation



With the regulation, the costs of production increase for suppliers. The imposition of these regulatory control costs is represented as an upward shift in the supply curve for domestic and import supply by the estimated compliance costs. As a result of the upward shift in the supply curve, the market supply curve will also shift upward as shown in Figure 7-5(b) to reflect the increased costs of production.

At baseline without the proposed rule, the industry produces total output, Q, at price, p, with domestic producers supplying the amount q_d and imports accounting for Q minus q_d, or q_f. With the regulation, the market price increases from p to p′, and market output (as determined from the market demand curve) declines from Q to Q′. This reduction in market output is the net result of reductions in domestic and import supply.

As indicated in Figure 7-5, when the proposed standards are applied the supply curve will shift upward by the amount of the estimated compliance costs. The demand curve, however, does not shift in this analysis. This is explained by the dynamics underlying the demand curve. The demand curve represents the relationship between prices and quantity demanded. Changes in prices lead to changes in the quantity demanded and are illustrated by *movements along* a constant demand curve. In contrast, changes in any of the other variables would lead to change in demand and are illustrated as *shifts* in the position of the demand curve.[10] For example, an increase in the number of consumers in a market would cause the demand curve to shift outward because there are more individuals willing to buy the good at every price. Similarly, an exogenous increase in average income would also lead the demand curve to shift outward as people choose to buy more of a good at a given price. Changes in the prices of related good and tastes or preferences can also lead to demand curve shifts.

The proposed standards are expected to increase the costs of production in all the affected markets (locomotive, rail transportation services, marine engines, marine vessels, and marine transportation services) and ultimately lead to higher equilibrium prices in the affected markets. As these prices increase, the quantity demanded falls (i.e., the price change leads to a movement along the demand curve). However, the proposed program is not expected to lead to shifts in the locomotive and marine transportation service market demand curves for several reasons. First, the demand for transportation services is determined by the national economy. The growth in the size of the national economy determines the demand for transportation services. We presume the cost of the proposed program will not change the size of the national economy in measurable ways since these sectors are relatively small contributors to GDP. Therefore, we do not expect a change in demand in these sectors. Second, the business decisions of users of rail and marine transportation services will not be changed due to the proposed program. These users will still need to use rail and marine transportation services to ship their products to their destinations for intermediate or final users of those products. In this sense, transportation services are part of an integrated production process that will not be changed by this program. For all of these reasons, it would be inappropriate to shift the demand curve for this analysis.

7.2.3.2 Incorporating Multi-Market Interactions

The above description is typical of the expected market effects for a single product markets considered in isolation (for example the locomotive or engine markets). However, the markets considered in this EIA are more complicated because of the need to investigate impacts on each component of the affected markets (engine, vessel and transportation services on the marine side and locomotives and transportation services on the locomotive side) and the relationships between those components.

For example, with regard to the commercial vessel markets, the proposed regulatory program is expected to affect vessel producers in two ways. First, these producers are affected by higher input costs (increases in the price of marine diesel engines) associated with the rule. Second, the standards will also impose additional production costs on vessel producers associated with vessel changes necessary to accommodate compliant engines. Similarly, the rail and marine transportation services

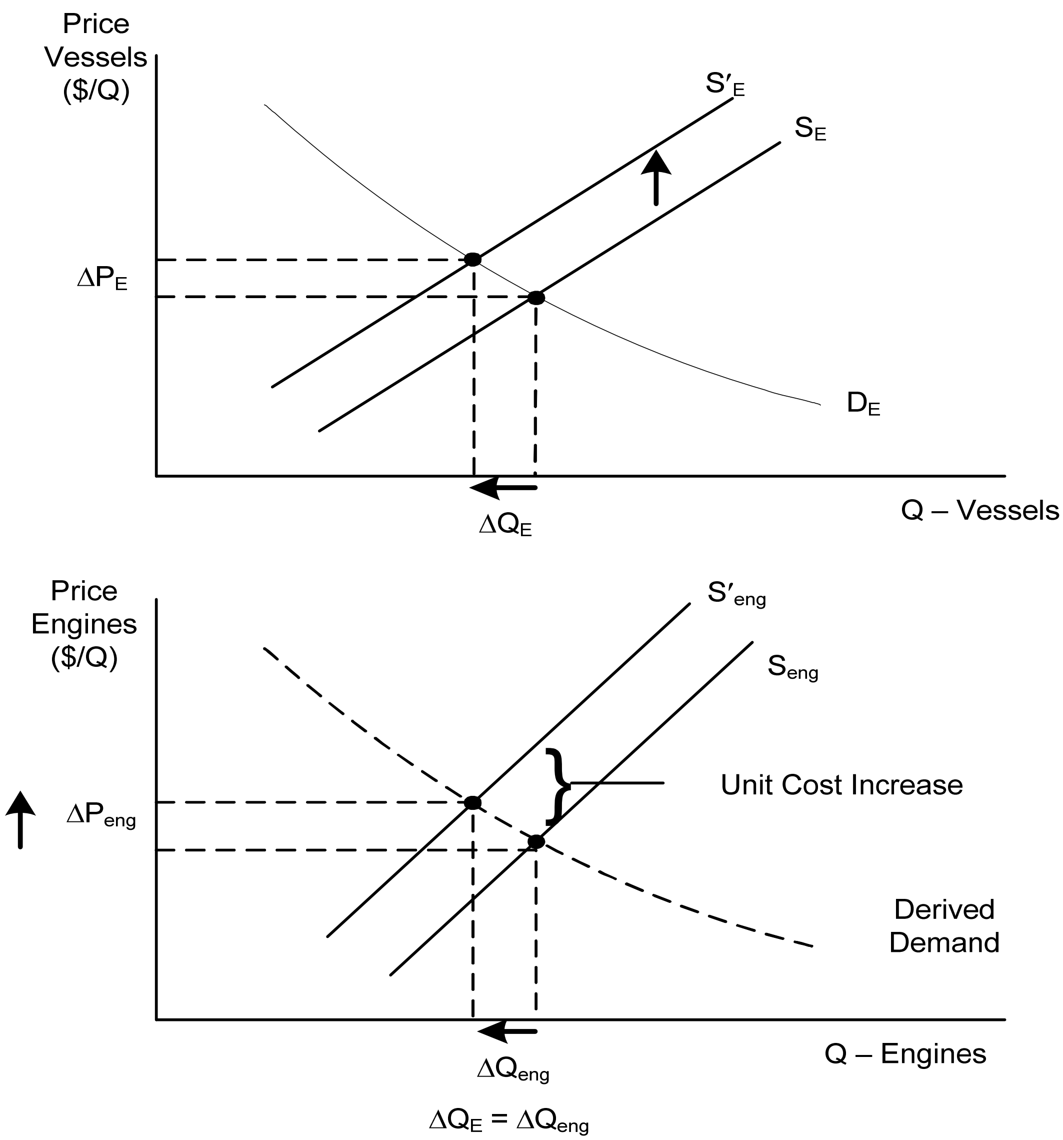
[10] An accessible detailed discussion of these concepts can be found in Chapters 5-7 of Nicholson's (1998) intermediate microeconomics textbook.

markets will be affected by increases in the price of engines and equipment (locomotives and marine vessels) as well as direct increases in operating costs.

In the marine market case, the demand for engines is directly linked to the production of vessels that uses those engines.[11] For this reason, it is reasonable to assume that the input-output relationship between the marine diesel engines and vessels is strictly fixed and that the demand for engines varies directly with the demand for vessels. A demand curve specified in terms of its downstream consumption is referred to as a derived demand curve. Figure 7-6 illustrates how a derived demand curve is identified.

[11] In the marine vessel market, one or two engines are used per vessel, depending on its intrinsic design, and this configuration is insensitive to small changes in the engine used.

Figure 7-6 Derived-Demand Curve for Engines



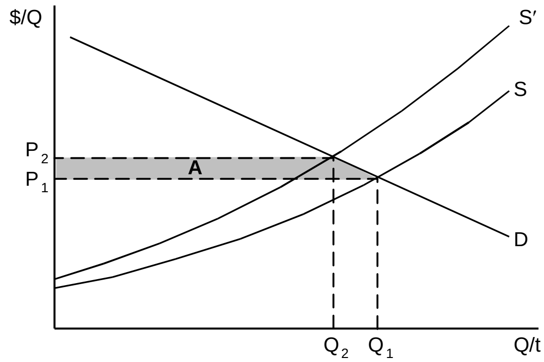
Consider an event in the marine equipment market (vessel market) that causes the price of equipment to increase by ΔP (such as an increase in the price of engines). This increase in the price of equipment will cause the supply curve in the equipment market to shift up, leading to a decreased quantity (ΔQ_E). The change in equipment production leads to a decrease in the demand for engines (ΔQ_{Eng}). The new point ($Q_E - \Delta Q_E$, $P - \Delta P$) traces out the derived demand curve. Note that the supply and demand curves in the marine equipment markets are needed to identify the derived demand in the engine market. All of the market supply and demand curves and the elasticity parameters are described in Appendix 7F.

7.2.3.3 Estimation of Social Costs

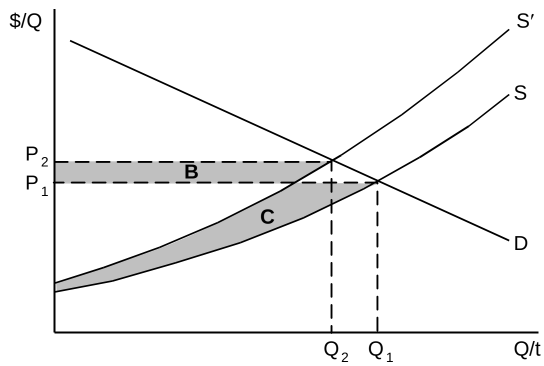
The economic welfare implications of the market price and output changes with the regulation can be examined by calculating consumer and producer net "surplus" changes associated with these adjustments. This is a measure of the negative impact of an environmental policy change and is commonly referred 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 demand and supply curves that are used to project market price and quantity impacts can be used to estimate the change in consumer, producer, and total surplus or social cost of the regulation (see Figure 7-7).

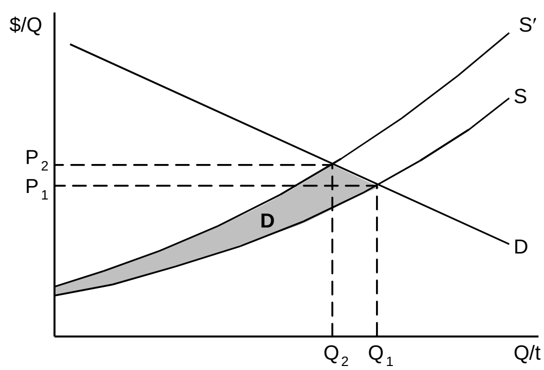
Figure 7-7. Economic Welfare Calculations: Changes in Consumer, Producer, and Total Surplus



(a) Change in Consumer Surplus with Regulation



(b) Change in Producer Surplus with Regulation



(c) Net Change in Economic Welfare with Regulation

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.

In

Figure 7-7, baseline equilibrium occurs at the intersection of the demand curve, D, and supply curve, S. Price is P_l with quantity Q_l. The increased cost of production with the regulation will cause the market supply curve to shift upward to S′. The new equilibrium price of the product is P_2. With a higher price for the product there is less consumer welfare, all else being unchanged. In

Figure 7-7(a), area A represents the dollar value of the annual net loss in consumers' welfare associated with the increased price. The rectangular portion represents the loss in consumer surplus on the quantity still consumed due to the price increase, Q_2, while the triangular area represents the foregone surplus resulting from the reduced quantity consumed, $Q_l - Q_2$.

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, Q_2. In

Figure 7-7(b), area B represents the increase in revenues due to this increase in price. The difference in the area under the supply curve up to the original market price, area C, measures the loss in producer surplus, which includes the loss associated with the quantity no longer produced. The net change in producers' welfare is represented by area B – C.

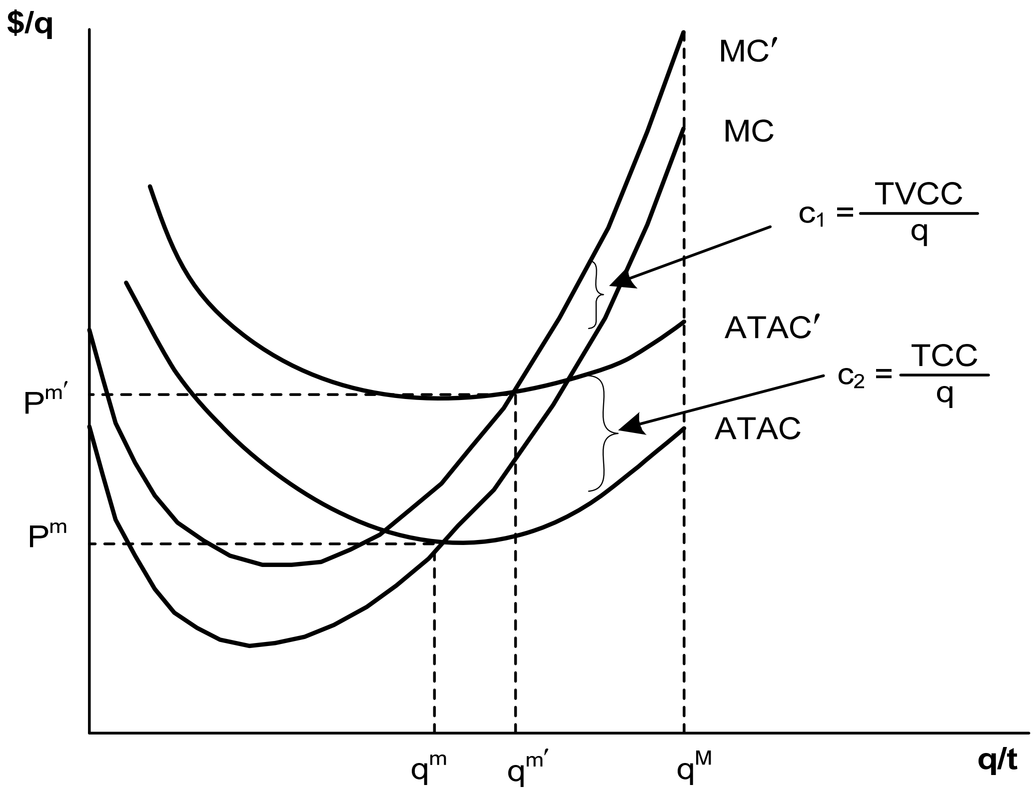
The change in economic welfare attributable to the compliance costs of the regulations is the sum of consumer and producer surplus changes, that is, –(A) + (B–C).

Figure 7-7(c) shows the net (negative) change in economic welfare associated with the regulation as area D.

7.2.3.4 Fixed and Variable Costs in a Competitive Market

The estimated engineering compliance costs, consisting of fixed costs (R&D capital/tooling, certification costs), variable costs, and operational costs provide an initial measure of total annual compliance costs without accounting for behavioral responses. The starting point for assessing the social costs and market impacts of a regulatory action is to incorporate the regulatory compliance costs into the production decision of the firm.

Figure 7-8 Modeling Fixed Regulatory Costs



In general, shifting the supply curve by the total cost per unit implies that both capital and operating costs vary with output levels. At least in the case of capital, this raises some questions. In the long run, all inputs (and their costs) can be expected to vary with output. But a short(er)-run analysis typically holds some capital factors fixed. For instance, to the extent that a market supply function is tied to existing facilities, there is an element of fixed capital (or one-time R&D). As indicated above, the current market supply function might reflect these fixed factors with an upward slope. As shown in Figure 7-8, the marginal cost (MC) curve will only be affected, or shift upwards, by the per-unit variable compliance costs (c_1=TVCC/q), while the average total cost (ATAC) curve will shift up by the per-unit total compliance costs (c_2=TCC/q). Thus, the variable costs will directly affect the production decision (optimal output rate), and the fixed costs will affect the closure decision by establishing a new higher reservation price for the firm (i.e., p_m'). In other words, the fixed costs are important in determining whether the firm will stay in this line of business (i.e., produce anything at all), and the variable costs determine the level (quantity) of production.

Depending on the industry type, fixed costs associated with complying with a new regulation are generally treated differently in an analysis of market impacts. In a competitive market, the industry supply curve is generally based on the market's marginal cost curve; fixed costs do not influence production decisions at the margin. Therefore, the market analysis for a competitive market is based on variable costs only.

Implicit in this approach is the assumption that manufacturers do not recover their production fixed costs by passing all or part of them to consumers through new price increases. Yet, production fixed costs must be recovered; otherwise, manufacturers would go out of business. Manufacturers in any industry are likely to have ongoing product development programs the costs of which are included in the current market price structure. It is expected that the resources for those programs would be re-oriented toward compliance with the regulatory program until those costs are recovered for each manufacturer. If this is the case, then the rule would have the effect of shifting product development resources to regulatory compliance from other market-based investment decisions. Thus, fixed costs are a cost to society because they displace other product development activities that may improve the quality or performance of engines and equipment. In this EIA, fixed costs are accounted for in the year in which they occur and are attributed to the respective locomotive, marine engine, and vessel manufacturers. These manufacturers are expected to see losses of producer surplus as early as 2007.

7.3 EIM Data Inputs and Model Solution

The EIM is a computer model comprised of a series of spreadsheet modules that simulate the supply and demand characteristics of the markets under consideration. The model equations, presented in Appendix 7E, are based on the economic relationships described in Section 7.2. The EIM analysis consists of four basic steps:

- Define the initial market equilibrium conditions of the markets under consideration (equilibrium prices and quantities and behavioral parameters; these yield equilibrium supply and demand curves).
- Introduce a policy "shock" into the model based on estimated compliance costs that shift the supply functions.
- Use a solution algorithm to estimate a new, with-regulation equilibrium price and quantity for all markets.
- Estimate the change in producer and consumer surplus in all markets included in the model.

Supply responses and market adjustments can be conceptualized as an interactive process. Producers facing increased production costs due to compliance are willing to supply smaller quantities at the baseline price. This reduction in market supply leads to an increase in the market price that all producers and consumers face, which leads to further responses by producers and consumers and thus new market prices, and so on. The new with-regulation equilibrium reflects the new market prices where total market supply equals market demand.

This section describes the markets and data used to construct the EIM: initial equilibrium market conditions (equilibrium prices and quantities), compliance cost inputs, and model elasticity parameters. Also included is a brief discussion of the solution algorithm used to estimate with-regulation market conditions.

7.3.1 Market Equilibrium Conditions

The starting point for the Economic Impact Analysis is initial market equilibrium conditions (prices and quantities) that exist prior to the implementation of the new standards. At pre-control market equilibrium conditions, consumers are willing to purchase the same amount of a product that producers are willing to produce at that market price.

7.3.1.1 Locomotive Initial Equilibrium Quantities

The EIM uses the same locomotive sales quantities that are used in the locomotive engineering cost analysis presented in Chapter 5. These sales were derived using the inputs for our locomotive emissions inventory analysis. In that analysis, we projected future locomotive populations and the number of locomotives remanufactured for given years. An estimated sales figure can be derived from those projected populations by comparing the given year's population to the prior year's population. The difference, after backing out the number of older locomotives that are projected to be removed from services, can be considered the new sales for the given year. Locomotive sales for all years of the analysis are contained in **Error! Reference source not found.**. Note that to be consistent with the engineering costs analysis, passenger locomotives are included with the switcher locomotives.

Table 7-7 Locomotive Sales (2007 through 2040)

Year	Line Haul Sales	Switcher/Passenger Sales
2007	646	112
2008	666	192
2009	693	128
2010	729	130
2011	751	133
2012	767	138
2013	765	251
2014	780	278
2015	816	299

Year	Line Haul Sales	Switcher/Passenger Sales
2016	854	311
2017	877	332
2018	894	344
2019	917	352
2020	948	369
2021	979	387
2022	1,007	398
2023	1,034	399
2024	1,048	407
2025	1,078	401
2026	1,096	394
2027	1,119	384
2028	1,136	378
2029	1,150	370
2030	1,158	368
2031	1,173	362
2032	1,190	358
2033	1,209	316
2034	1,223	303
2035	1,231	291
2036	1,197	279
2037	1,172	267
2038	1,144	255
2039	1,112	248
2040	1,078	234

7.3.1.2 Locomotive Initial Equilibrium Prices

The price used for new line-haul locomotives used in the EIM is $2 million (2005$). The price for the switcher/passenger category is $1.3 million (2005$). These prices are based on conversations with the locomotive manufacturers. These prices are used for all years of the analysis. The analysis assumes a constant (real) price of goods and services over time and the equilibrium prices for future years are the same as the initial year equilibrium prices. This is reasonable because, in the absence of shocks to the economy or the supply of raw materials, economic theory suggests that the equilibrium market price for goods and services should remain constant over time (see Appendix 7G for a discussion of the constant price assumption).

7.3.1.3 Marine Engine and Vessel Initial Equilibrium Quantities

The EIM uses the same marine engine sales quantities that are used in the marine engineering cost analysis presented in Chapter 5. These are based on the Power Systems Research OELink database. The sales for 2002 are reproduced in Table 7-8.

Table 7-8. Marine Diesel Engine Sales (2002)

Marine Diesel Engine Categories (by hp)	Annual Sales Auxiliary	Annual Sales Commercial Propulsion	Annual Sales Recreational Propulsion	Total
< 50 hp[a]	9,332	67	3,924	13,323
50-200 hp	4,019	2,665	6,294	12,978
200-400 hp	1,773	1,398	2,663	5,834
400-800 hp	956	1,634	4,220	6,810
C1 800-2,000 hp	142	472	598	1,212
C1 >2,000 hp	13	196	177	386
C2 800-2,000 hp	56	6	0	62
C2 >2,000 hp	86	125	0	211
Total	16,377	6,563	17,876	40,816

[a]The cost analysis does not differentiate between auxiliary, commercial propulsion, and recreational propulsion engines <50 hp; these engines were allocated to the engine categories based on PSR OELink sales splits for 2002.

The vessel sales data for 2002 were derived by apportioning the commercial propulsion engine sales in Table 7-8 to vessel types based on current vessel populations.[12] The vessel sales are reproduced in Table 7-9.

Table 7-9. Marine Vessel Sales (2002)

Hp Bin	Fishing	Tow/Tug / Push	Ferries	Supply/ Crew	Cargo	Other Commerc'l	Recreatn'l	Total
0-50	58	0	1	0	0	1	3,924	3,983
50–200	2,293	247	40	41	13	31	6,294	8,959
200–400	601	65	10	11	3	8	1,332	2,031
400–800	703	76	12	13	4	10	2,110	2,927
C1 800–2,000	203	22	4	4	1	3	299	535
C1 >2,000	84	9	1	2	0	1	89	187
C2 800–2,000	0	1	0	1	0	0	0	3
C2 >2,000	9	27	3	15	4	1	0	58
Total	3,951	447	71	86	26	54	14,047	18,683

The marine diesel engine sales used in the EIM for 2007 through 2040 were projected by applying a 1.009 growth factor to the 2002 sales, for commercial marine diesel engines, and by applying the NONROAD model growth rate to the 2002 for recreational marine engines.

The marine vessel sales used in the EIM for 2007 through 20404 were projected by creating a ratio of engines to vessels using the 2002 data and applying that to future years engine sales. The ratios used for commercial vessels are contained in Table 7-10.

Ratios were not estimated for recreational vessels because the Tier 3 standards do not require vessel modifications.[12]

Table 7-10 Ratio of Vessels to Engines

	fishing	tow	ferries	supply	cargo	other	Total
<50	0.97	0.00	0.02	0.00	0.00	0.01	1.00
50-200	0.86	0.09	0.01	0.02	0.00	0.01	1.00
200-400	0.86	0.09	0.01	0.02	0.00	0.01	1.00
400-800	0.86	0.09	0.01	0.02	0.00	0.01	1.00
800-2000	0.86	0.09	0.01	0.02	0.00	0.01	1.00
>2000	0.86	0.09	0.01	0.02	0.00	0.01	1.00
800-2000	0.15	0.46	0.04	0.26	0.07	0.01	1.00
>2000	0.15	0.46	0.04	0.26	0.07	0.01	1.00

7.3.1.4 Marine Engine and Vessel Initial Equilibrium Prices

The EIM uses baseline equilibrium engine prices for C1 commercial propulsion engines were obtained from an internet search of engine prices.[13] These prices are contained in Table 7-11. The C2 propulsion engine prices were obtained by multiplying the C1 commercial propulsion engines by about 1.5. This reflects the larger cylinder displacement of these engines and the fact that they are built for longer hours of use. The auxiliary engine prices were derived by dividing the propulsion engine prices by 2. This is because auxiliary marine diesel engines are often more similar to land-based engines and don't require the same types of modifications for use in the marine environment. They are also designed to operate at constant load and don't see the transients experienced by propulsion engines. The recreational engine prices were derived by multiplying the propulsion engines by 1.25, reflecting the fact that while recreational engines are often similar to commercial engines they are designed for higher power and use at higher engine load. Recreational engines also often have esthetic features (e.g., chrome fixtures) that set them apart from their recreational counterparts.

[12] This EIA was based on an earlier version of the cost analysis that did not include compliance costs for recreational vessels >2000 kW.

Table 7-11. Per Unit Marine Diesel Engine Prices (2005$)

Marine Diesel Engine Categories (by hp)	Commercial Propulsion	Recreational	Auxiliary
< 50 hp	$7,000	$8,750	$3,500
50-200 hp	$16,000	$20,000	$8,000
200-400 hp	$21,000	$26,250	$10,500
400-800 hp	$50,000	$62,500	$25,000
C1 800-2,000 hp	$155,000	$193,750	$77,500
C1 > 2,000 hp	$300,000	$375,000	$150,000
C2 800-2,000 hp	$230,000	NA	$115,000
C2 > 2,000 hp	$450,000	NA	$225,000

The baseline equilibrium marine vessel prices used in the EIM were derived from the engine prices by applying an assumed ratio of the price of the vessel to the price of the propulsion engines onboard. Table 7-12 sets out the ratios used to estimate the vessel prices, and Table 7-13 sets out the vessel prices used in the EIA.

Table 7-12. Ratio of Vessel Price to Marine Diesel Engine Price

Hp Bin	Fishing	Tow/Tug/ Push Boat	Ferries	Supply/ Crew	Cargo	Other Commercial	Recreational
0-50	5		6			5	6
50-200	5	6	6	6	6	5	6
200-400	3.5	4	4	8	4	3.5	4
400-800	3.5	4.5	4.5	9	4.5	3.5	4
C1 800-2,000	3.5	5	5	10	10	3.5	4
C1 >2,000	3.5	5	5	10	10	3.5	4
C2 800-2,000	3.5	5	5	10	10	3.5	4
C2 >2,000	3.5	5	5	10	10	3.5	4

Table 7-13. Per Unit Marine Vessel Prices (2005$)

Hp Bin	Fishing	Tow/Tug/ Push Boat	Ferries	Supply/ Crew	Cargo	Other Commercial	Recreational
0-50	$35,000		$42,000			$35,000	$52,500
50-200	$80,000	$96,000	$96,000	$96,000	$96,000	$80,000	$120,000
200-400	$147,000	$168,000	$168,000	$336,000	$168,000	$147,000	$210,000
400-800	$350,000	$450,000	$450,000	$900,000	$450,000	$350,000	$500,000
C1 800-2,000	$1,085,000	$1,550,000	$1,550,000	$3,100,000	$3,100,000	$1,085,000	$1,550,000
C1 >2,000	$2,100,000	$3,000,000	$3,000,000	$6,000,000	$6,000,000	$2,100,000	$3,000,000
C2 800-2,000	$1,610,000	$2,300,000	$2,300,000	$2,300,000	$4,600,000	$1,610,000	NA
C2 >2,000	$3,150,000	$4,500,000	$4,500,000	$4,500,000	$9,000,000	$3,150,000	NA

With respect to future prices, this analysis assumes a constant (real) price of goods and services over time and the equilibrium prices for future years are the same as the baseline equilibrium prices. This is reasonable because, in the absence of shocks to the economy or the supply of raw materials, economic theory suggests that the equilibrium market price for goods and services should remain constant over time (see Appendix 7G for a discussion of the constant price assumption).

7.3.1.5 Baseline Quantities and Equilibrium Prices for Transportation Markets

The nature of the locomotive and marine transportation services markets makes it difficult to identify the baseline equilibrium prices and quantities for this analysis. Instead of trying to estimate these values, the EIM uses an alternative approach based on total revenues for each sector. In this approach, annual revenue data is used as a proxy for production data. This data is normalized such that the baseline price is set equal to $1/unit and the baseline quantity is then equal to the annual revenue. This allows estimation of the relative price change and the relative quantity change due to the proposed program, although it does not allow estimation of the absolute price and absolute quantity change.

Baseline data for the EIM's railroad and marine service revenues are reported in Table 7-13. Revenue data for the rail transportation services freight revenue comes from the Association of American Railroads Freight Railroad Statistics, Condensed Income Statement, revenue for freight and passenger services.[14] Revenue data for the marine transportation services sector comes from the U.S. Census reports revenues for the marine service sector for 2002.[13] Revenue data for 2002 was obtained for the following NAICS codes: 483113 (coastal & great lakes freight), 483114 (coastal & great lakes passenger), 4832 (inland water transportation), 4872(Scenic & sightseeing transportation, water), plus a portion of 4883 (support activity for water transportation). The 2002 revenue data was adjusted for 2005 using the GDP deflator index.

Table 7-14. Railroad and Marine Service Markets Baseline Revenue Data ($billions)

Transportation Service Market	2002	Annual Growth Rate	2005
Railroad Services Market	NR	0.9%	$44.5
Marine Services Market	$13.8	0.9%	$14.2

To estimate production for 2005, we applied growth rates used for engine sales. Revenue for all future years of the analysis (2007 to 2040) were calculated by applying annual growth rates to the 2005 data set as follows:

$$Revenue_{200X} = Revenue_{2005} \times (1+0.009)^{(200X-2005)}$$

[13] We adjusted marine transportation service revenue to reflect 2005 dollars using the latest GDP deflator.

This data suggests that the rail transportation sector is much larger than the marine transportation sector. However, the difference in the amount of tons of goods moved is smaller. According to AAR, the rail transportation sector moved about 1,844.2 million tons of freight in 2004.[15] The marine sector accounted for about 1,047.1 million tons in that year.[16] So, while some of the difference in revenue is due to differences in the amount of freight transported, part of the difference is due to differences in the characteristics of each sector. For example, railroads are responsible for maintaining the rail system; they pass some of those costs to their customers through higher prices. The marine system, in contrast, is maintained by public authorities (U.S. Army Corps of Engineers, state and local governments), and so those costs would not be reflected in the prices of marine transportation services. Similarly, while rail yards are maintained by railroads, ports are owned and operated by various public and private authorities. Finally, marine transportation is somewhat more fuel efficient than rail, with one tug or towboat able to transport more goods than one locomotive.

7.3.2 Compliance Costs

The social costs of the proposed standards are estimated by shocking the initial market equilibrium conditions by the amount of the compliance costs. The EIM uses an earlier version of the engineering costs developed for this rule (see Section 7.1.4 above).

Table 7-15 summarizes how the compliance costs are applied to each component of the EIM to simulate the effect of the emission control program. There are no compliance costs for the demand side of these markets. This is because the program does not regulate consumers or impose direct compliance costs on them (see also Section 7.2.3.1).

Table 7-15. Summary of Types of Compliance Costs

Market	Category	Supply Shift			Demand Shift
		Entity	Direct Costs	Indirect Costs	
Rail	Locomotive	Loco Mfr	Variable costs	N/A	No demand shift; see 7.2.3.1
	Transportation Services	Railroad	Urea, Fuel, remanufacture kit	Higher locomotive prices	
Marine	<800 hp	Engine Mfr	Variable costs = 0	N/A	
		Vessel	Variable costs = 0	Higher engine prices	
	>800 hp	Engine mfr	Variable costs	N/A	
		Vessel	Variable costs	Higher engine prices	
	Transportation Services	Vessel Owner	Urea, fuel	Higher engine and vessel prices	

The compliance costs used in the EIM are based on the estimated engineering compliance costs described in Chapter 5. For marine diesel engine variable costs, we used the piece costs shown in Table 5-29 with a couple of exceptions. First, the EIA contains costs for closed crankcase ventilation systems which were subsequently removed from the cost analysis presented in Chapter 5. Second, the engine-related hardware costs here in the EIA do not include costs associated with urea SCR tanks and brackets which, we decided, should be considered vessel related hardware costs for the EIA. For marine diesel engine fixed costs in the EIA, we simply divided the annual engine fixed costs by the projected sales for the given year, rather than using the present value per engine costs presented in several tables throughout section 5.2.1. This makes the fixed costs per engine appear rather large in the EIA since those costs are being spread over a relatively small number of engines (only a few years of sales).

On the vessel side, we used the vessel hardware costs shown in Table 5-38, and added to that the costs for urea SCR tanks and brackets. Importantly, the costs associated with the urea tank and brackets are incurred for every engine (auxiliary and propulsion), while the vessel hardware costs shown in Table 5-38 are incurred for every vessel. To arrive at a per vessel cost for the EIA, we multiplied the urea tank and bracket costs by the projected number of engines (auxiliary and propulsion) and then divided by the projected number of vessels, then added the vessel hardware costs shown in Table 5-38. In the end, the vessel hardware costs presented here look different than those presented in Chapter 5 due to different accounting, but the total costs are not affected by that accounting difference. The vessel fixed costs are the annual redesign costs divided by the projected number of vessel sales during the given years. Note that the annual fixed costs have been allocated to power ranges based on the percentage of engines within the appropriate power range. Also note that the per-unit cost estimates are based on an average of 1.5 propulsion engines per vessel.

For locomotives, we used essentially the same methodology. The variable costs are taken from Tables 5-29 and 5-38, with the same difference associated with closed crankcase ventilation system costs noted above. Annual fixed costs are simply divided by the sales for the given year making them, once again, appear rather large on a per locomotive basis here in the EIA. In the EIA, since the locomotive and its engine are considered to be one in the same, there was no need to differentiate between purely engine costs and equipment costs.

For all markets, fixed costs are allocated to the year in which they occur. For this analysis, fixed costs are spread over five years in advance of the applicable standards with the exception of certification costs, which are allocated to the year before the standards are effective. Variable costs begin to be incurred only when the programs go into effect. For locomotives and marine diesel engines, this means a staggered set of fixed costs, as described in Table 7-16, with the compliance costs for the different Tiers overlapping in some years. It should be remembered that the EIA is based on an earlier version of the cost analysis and may not reflect changes to the way in which costs are allocated for the proposed program as described in Chapter 5. For marine vessels, there are no compliance costs associated with the Tier 3 standards since they are engine-based controls and will not affect the footprint of the engine. The marine vessel compliance costs for Tier 4 begin in 2015 and are incurred over a 15-year period that is derived from the number of vessel types that will have to be modified (see Chapter 5 for an explanation of how vessel costs are allocated; note that the final costs in Chapter 5 reflect these costs distributed over a shorter period).

Table 7-16 Locomotive and Marine Engine Compliance Costs Schedule

	Loco T3	Loco T4 PM	Loco T4 NO_x	Marine T3	Marine T4
2007	✓			✓	
2008	✓			✓	
2009	✓			✓	
2010	✓	✓		✓	
2011	✓	✓		✓	✓
2012	Effective Date	✓	✓	Effective Date	✓
2013		✓	✓		✓
2014		✓	✓		✓
2015		Effective Date	✓		✓
2016			✓		Effective Date
2017			Effective Date		

7.3.2.1 Locomotive Compliance Costs

The estimated per unit compliance costs for new locomotives used in the EIM are summarized in Table 7-17. These costs are dominated by fixed costs in the early years of the program. Variable costs do not occur until 2015, when the aftertreatment standards begin. This reflects the fact that there are no variable costs associated with the Tier 3 standards. Fixed costs reflect both the Tier 3 and Tier 4 costs. There is some overlap in these two programs, with the Tier 3 fixed costs applying in 2007 through 2011, and the Tier 4 fixed costs applying in 2010 through 2016. The latter period represents 5 years of fixed costs for the PM aftertreatment standards (2010 through 2014) and 5 years of fixed costs for the NO_x aftertreatment standards (2012 through 2016).

Table 7-17 Estimated Per Unit Compliance Costs – New Locomotives (2005$)

	Line Haul Locomotive			Switcher, Passenger Locomotive		
Year	Variable	Fixed	Total	Variable	Fixed	Total
2007	$0	$991	$991	$0	$22,767	$22,767
2008	$0	$991	$991	$0	$13,304	$13,304
2009	$0	$923	$923	$0	$19,938	$19,983
2010	$0	$3,197	$3,197	$0	$37,929	$37,929
2011	$0	$5,134	$5,134	$0	$51,419	$51,914
2012	$0	$6,678	$6,678	$0	$52,200	$52,200
2013	$0	$6,694	$5,694	$0	$28,777	$28,777

2014	$0	$9,329	$9,239	$0	$35,031	$35,031
2015	$44,390	$4,204	$48,594	$14,353	$16,179	$30,531
2016	$44,390	$6,465	$50,855	$14,353	$23,603	$37,956
2017	$68,544	$0	$68,544	$19,230	$0	$19,230
2018	$68,544	$0	$68,544	$19,230	$0	$19,230
2019+	$60,624	$0	$60,624	$17,770	$0	$19,230

7.3.2.2 Marine Diesel Engine Compliance Costs

The estimated per unit compliance costs for new marine diesel engines used in the EIM are summarized in Table 7-18 (C2 engines), Table 7-19 (C1 engines), Table 7-20 (recreational engines), and Table 7-21 (small engines). In the early years, 2007 through 2011, there are fixed costs associated with the Tier 3 standards. Beginning in 2012, there are no compliance costs associated with the Tier 3 standards. The Tier 4 standards apply only to engines above 800 hp. As a result, there are fixed costs attributed to those engines through 2015, after which time the only costs are variable costs associated with the aftertreatment devices.[14] Because this EIA is uses an earlier version of the compliance costs estimates that did not include Tier 4 standards for recreational engines above 2,000 kW, the costs for those engines and vessels are not included in these tables.

Table 7-18 Estimated Per Unit Compliance Costs - C2 Commercial Engines (2005$)

Hp Category	Cost Type	2007	2008	2009	2010	2011	2012
800-2,000	Variable	$0	$0	$0	$0	$0	$0
	Fixed	$14,571	$14,441	$14,312	$14,184	$93,647	$69,382
	Total	$14,571	$14,441	$14,312	$14,184	$93,647	$69,382
>2,000	Variable	$0	$0	$0	$0	$0	$0
	Fixed	$14,571	$14,441	$14,312	$14,184	$93,647	$69,382
	Total	$14,571	$14,441	$14,312	$14,184	$93,647	$69,382
Hp Category	Cost Type	2013	2014	2015	2016	2017	2018+
800-2,000	Variable	$0	$0	$0	$39,059	39,059	29,827
	Fixed	$68,763	$68,150	$97,398	$0	$0	$0
	Total	$68,763	$68,150	$97,398	$39,059	39,059	29,827
>2,000	Variable	$0	$0	$0	$72,301	$72,301	$55,121
	Fixed	$68,763	$68,150	$97,398	$0	$0	$0

[14] It should be noted that there is an inconsistency in the cost analysis, which applies the operational costs for these C2 engines in 2014 but does not include the compliance costs for engines or vessels until later years. While this affects the individual year results for early years, the differences disappear by 2016 by which year all marine diesel engines above 800 hp have aftertreatment standards.

	Total	$68,763	$68,150	$97,398	$72,301	$72,301	$55,121

Table 7-19 Estimated Per Unit Compliance Costs – C1 Commercial Engines (2005$)

Hp Category	Cost Type	2007	2008	2009	2010	2011	2012
50-200	Variable	$0	$0	$0	$0	$0	$0
	Fixed	$836	$829	$822	$814	$1,475	$0
	Total	$836	$829	$822	$814	$1,475	$0
200-400	Variable	$0	$0	$0	$0	$0	$0
	Fixed	$836	$829	$822	$814	$1,475	$0
	Total	$836	$829	$822	$814	$1,475	$0
400-800	Variable	$0	$0	$0	$0	$0	$0
	Fixed	$836	$829	$822	$814	$1,475	$0
	Total	$836	$829	$822	$814	$1,475	$0
800-2,000	Variable	$0	$0	$0	$0	$0	$0
	Fixed	$2,033	$2,015	$1,997	$1,979	$25,553	$22,720
	Total	$2,033	$2,015	$1,997	$1,979	$25,553	$22,720
>2,000	Variable	$0	$0	$0	$0	$0	$0
	Fixed	$2,033	$2,015	$1,997	$1,979	$25,553	$22,720
	Total	$2,033	$2,015	$1,997	$1,979	$25,553	$22,720
Hp Category	Cost Type	2013	2014	2015	2016	2017	2018+
50-200	Variable	$0	$0	$0	$0	$0	$0
	Fixed	$0	$0	$0	$0	$0	$0
	Total	$0	$0	$0	$0	$0	$0
200-400	Variable	$0	$0	$0	$0	$0	$0
	Fixed	$0	$0	$0	$0	$0	$0
	Total	$0	$0	$0	$0	$0	$0
400-800	Variable	$0	$0	$0	$0	$0	$0
	Fixed	$0	$0	$0	$0	$0	$0
	Total	$0	$0	$0	$0	$0	$0
800-2,000	Variable	$0	$0	$0	$15,319	$15,319	$11,763
	Fixed	$22,517	$22,316	$28,928	$0	$0	$0
	Total	$22,517	$22,316	$28,928	$15,319	$15,319	$11,763
>2,000	Variable	$0	$0	$0	$26,296	$26,926	$20,116
	Fixed	$22,517	$22,316	$28,928	$0	$0	$0
	Total	$22,517	$22,316	$28,928	$26,296	$26,926	$20,116

Table 7-20 Estimated Per Unit Compliance Costs – Recreational Engines (2005$)

Hp Category	Cost Type	2007	2008	2009	2010	2011	2012

50-200	Variable	$0	$0	$0	$0	$0	$0
	Fixed	$403	$393	$384	$375	$684	$0
	Total	$403	$393	$384	$375	$684	$0
200-400	Variable	$0	$0	$0	$0	$0	$0
	Fixed	$403	$393	$384	$375	$684	$0
	Total	$403	$393	$384	$375	$684	$0
400-800	Variable	$0	$0	$0	$0	$0	$0
	Fixed	$403	$393	$384	$375	$684	$0
	Total	$403	$393	$384	$375	$684	$0
800-2,000	Variable	$0	$0	$0	$0	$0	$0
	Fixed	$403	$393	$384	$375	$684	$0
	Total	$403	$393	$384	$375	$684	$0
>2,000	Variable	$0	$0	$0	$0	$0	$0
	Fixed	$403	$393	$384	$375	$684	$0
	Total	$403	$393	$384	$375	$684	$0
Hp Category	Cost Type	2013	2014	2015	2016	2017	2018+
50-200	Variable	$0	$0	$0	$0	$0	$0
	Fixed	$0	$0	$0	$0	$0	$0
	Total	$0	$0	$0	$0	$0	$0
200-400	Variable	$0	$0	$0	$0	$0	$0
	Fixed	$0	$0	$0	$0	$0	$0
	Total	$0	$0	$0	$0	$0	$0
400-800	Variable	$0	$0	$0	$0	$0	$0
	Fixed	$0	$0	$0	$0	$0	$0
	Total	$0	$0	$0	$0	$0	$0
800-2,000	Variable	$0	$0	$0	$0	$0	$0
	Fixed	$0	$0	$0	$0	$0	$0
	Total	$0	$0	$0	$0	$0	$0
>2,000	Variable	$0	$0	$0	$0	$0	$0
	Fixed	$0	$0	$0	$0	$0	$0
	Total	$0	$0	$0	$0	$0	$0

Table 7-21 Estimated Per Unit Compliance Costs – Small Marine Engines (2005$)

Hp Category	Cost Type	2007	2008	2009	2010	2011	2012
0-50	Variable	$0	$0	$0	$0	$0	$0
	Fixed	$126	$124	$123	$122	$245	$0
	Total	$126	$124	$123	$122	$245	$0
Hp Category	Cost Type	2013	2014	2015	2016	2017	2018+
0-50	Variable	$0	$0	$0	$0	$0	$0
	Fixed	$0	$0	$0	$0	$0	$0
	Total	$0	$0	$0	$0	$0	$0

7.3.2.3 Marine Vessel Compliance Costs

The estimated per unit compliance costs for marine vessels used in the EIM are summarized in Table 7-22 (C2 vessels, i.e., vessels with a C2 main propulsion engine), Table 7-23 (C1 vessels, i.e., vessels with a C1 main propulsion engine), **Error! Reference source not found.** (recreational vessels), and **Error! Reference source not found.** (small marine vessels). There are no vessel compliance costs associated with the Tier 3 standards. This means there are no vessel compliance costs at all for recreational vessels or Small vessels (those with a propulsion engine below 50 hp). This is because the Tier 3 engine footprint is not expected to be modified from the Tier 2 configuration. The sole vessel compliance costs are those associated with the Tier 4 aftertreatment standards. These begin in 2015, with the fixed costs, which continue through 2027.[15] Variable costs begin in 2016 and continue for all years of the analysis. Because this EIA is uses an earlier version of the compliance costs estimates that did not include Tier 4 standards for recreational engines above 2,000 kW, the costs for those engines and vessels are not included in these tables.

Table 7-22 Per Unit Compliance Costs – C2 Vessels (2005$)

Hp Category	Cost Type	2015	2016	2017	2018	2019	2020	2021
50-200	Variable	$0	$0	$0	$0	$0	$0	$0
	Fixed	$0	$0	$0	$0	$0	$0	$0
	Total	$0	$0	$0	$0	$0	$0	$0
200-400	Variable	$0	$0	$0	$0	$0	$0	$0
	Fixed	$0	$0	$0	$0	$0	$0	$0
	Total	$0	$0	$0	$0	$0	$0	$0
400-800	Variable	$0	$0	$0	$0	$0	$0	$0
	Fixed	$0	$0	$0	$0	$0	$0	$0
	Total	$0	$0	$0	$0	$0	$0	$0
800-2,000	Variable	$0	$3,964	$3,964	$3,964	$3,964	$3,964	$3,964
	Fixed	$50,000	$29,732	$19,645	$9,735	$9,648	$9,562	$9,477
	Total	$50,000	$33,697	$23,609	$13,699	$13,612	$13,526	$13,441
>2,000	Variable	$0	$7,155	$7,155	$7,155	$7,155	$7,155	$7,155
	Fixed	$50,000	$29,732	$19,645	$9,735	$9,648	$9,562	$9,477
	Total	$50,000	$36,887	$26,799	$16,889	$16,803	$16,716	$16,631

[15] It should be noted that there is an inconsistency in the cost analysis, which applies the operational costs for these C2 engines in 2014 but does not include the compliance costs for engines or vessels until later. years. While this affects the individual year results for early years, the differences disappear by 2016 by which year all marine diesel engines above 800 hp have aftertreatment standards.

Hp Category	Cost Type	2022	2023	2024	2025	2027	2028	2029+
50-200	Variable	$0	$0	$0	$0	$0	$0	$0
	Fixed	$0	$0	$0	$0	$0	$0	$0
	Total	$0	$0	$0	$0	$0	$0	$0
200-400	Variable	$0	$0	$0	$0	$0	$0	$0
	Fixed	$0	$0	$0	$0	$0	$0	$0
	Total	$0	$0	$0	$0	$0	$0	$0
400-800	Variable	$0	$0	$0	$0	$0	$0	$0
	Fixed	$0	$0	$0	$0	$0	$0	$0
	Total	$0	$0	$0	$0	$0	$0	$0
800-2,000	Variable	$3,964	$3,964	$3,964	$3,964	$3,964	$3,964	$3,964
	Fixed	$9,392	$9,308	$9,225	$9,143	$9,061	$0	$0
	Total	$13,356	$13,273	$13,190	$13,107	$13,026	$3,964	$3,964
>2,000	Variable	$7,155	$7,155	$7,155	$7,155	$7,155	$7,155	$7,155
	Fixed	$9,392	$9,308	$9,225	$9,143	$9,061	$0	$0
	Total	$16,547	$16,463	$16,380	$16,298	$16,216	$7,155	$7,155

Table 7-23 C1 Per Unit Compliance Costs – C1 Vessels (2005$)

Hp Category	Cost Type	2015	2016	2017	2018	2019	2020	2021
50-200	Variable	$0	$0	$0	$0	$0	$0	$0
	Fixed	$0	$0	$0	$0	$0	$0	$0
	Total	$0	$0	$0	$0	$0	$0	$0
200-400	Variable	$0	$0	$0	$0	$0	$0	$0
	Fixed	$0	$0	$0	$0	$0	$0	$0
	Total	$0	$0	$0	$0	$0	$0	$0
400-800	Variable	$0	$0	$0	$0	$0	$0	$0
	Fixed	$0	$0	$0	$0	$0	$0	$0
	Total	$0	$0	$0	$0	$0	$0	$0
800-2,000	Variable	$0	$2,385	$2,385	$2,385	$2,385	$2,385	$2,385
	Fixed	$25,000	$12,884	$6,876	$3,894	$3,859	$3,825	$3,791
	Total	$25,000	$15,269	$9,261	$6,279	$6,244	$6,210	$6,176
>2,000	Variable	$0	$4,672	$4,672	$4,672	$4,672	$4,672	$4,672
	Fixed	$25,000	$12,884	$6,876	$3,894	$3,859	$3,825	$3,791
	Total	$25,000	$17,556	$11,547	$8,565	$8,531	$8,496	$8,462

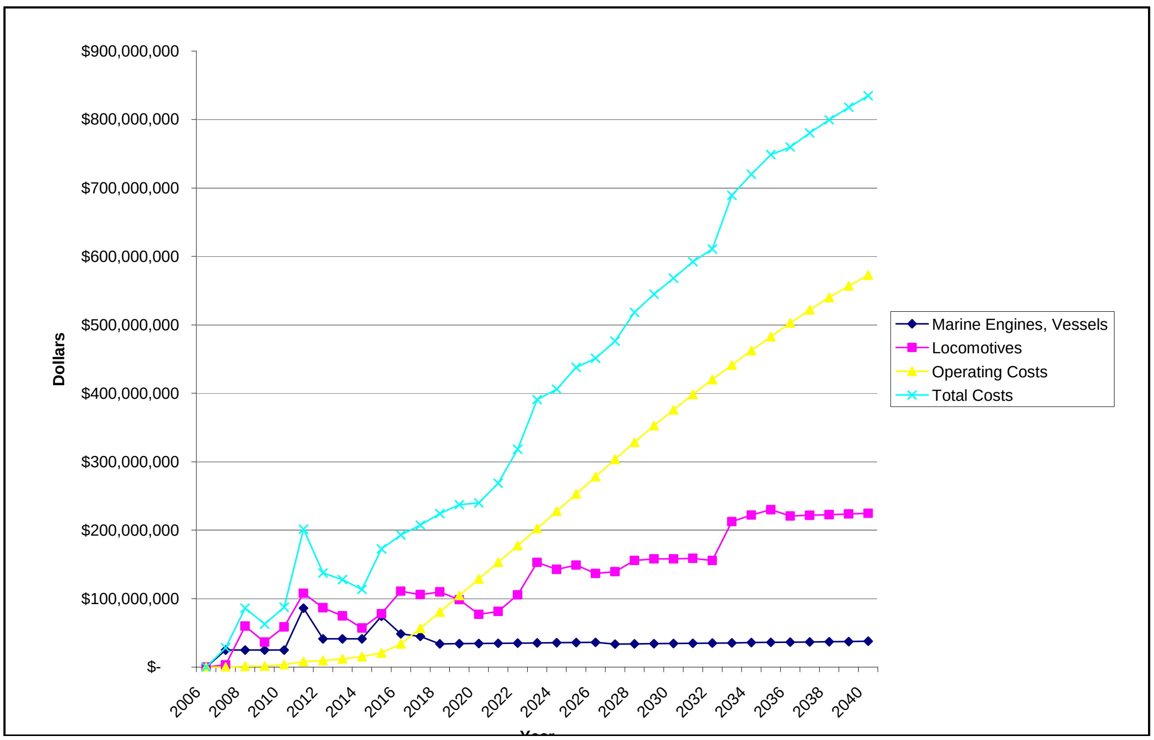
Hp Category	Cost Type	2022	2023	2024	2025	2027	2028	2029+
50-200	Variable	$0	$0	$0	$0	$0	$0	$0
	Fixed	$0	$0	$0	$0	$0	$0	$0
	Total	$0	$0	$0	$0	$0	$0	$0
200-400	Variable	$0	$0	$0	$0	$0	$0	$0
	Fixed	$0	$0	$0	$0	$0	$0	$0
	Total	$0	$0	$0	$0	$0	$0	$0
400-800	Variable	$0	$0	$0	$0	$0	$0	$0
	Fixed	$0	$0	$0	$0	$0	$0	$0
	Total	$0	$0	$0	$0	$0	$0	$0

800-2,000	Variable	$2,385	$2,385	$2,385	$2,385	$2,385	$2,385	$2,385
	Fixed	$3,757	$3,723	$3,690	$3,657	$3,625	$0	$0
	Total	$6,142	$6,108	$6,075	$6,042	$6,010	$2,385	$2,385
>2,000	Variable	$4,672	$4,672	$4,672	$4,672	$4,672	$4,672	$4,672
	Fixed	$3,757	$3,723	$3,690	$3,657	$3,625	$0	$0
	Total	$8,428	$8,395	$8,362	$8,329	$8,296	$4,672	$4,672

7.3.2.4 Operating Costs

There are two types of operating costs that are affected by the control program: the additional costs associated with operating vessels and locomotives equipped with the emission control technologies that would be required by the program, and the additional costs associated with the locomotive remanufacture program.

Figure 7-9. Estimated TotalCompliance Costs by Type, 2007-2040



Operating Costs. As explained in Chapter 5, we anticipate three sources of increased costs associated with operating vessels and locomotives equipped with the emission control technologies that would be required by the program: urea use, DPF maintenance, fuel consumption. The costs associated with urea use would affect only those locomotives or vessels equipped with a urea SCR engine. Maintenance costs associated with the DPF (for periodic cleaning of accumulated ash resulting from unburned material that acculuates in the DPF) would occur only in those locomotives or vessels equipped with a DPF engine. Thus, those costs are limited to Tier 4 engines. The fuel consumption impact is expected to occur more broadly, for both Tier 4 locomotives and engines and for remanufactured Tier 0 locomotives. As illustrated in Figure 7-9, the estimated operating costs are substantial when compared with the compliance costs associated with engine and equipment modifications.

The EIM applies the operational costs to the rail and marine transportation services markets, by shifting the transportation service sector supply curves by the amount of the operating costs for that sector for that year. This was done by dividing the total operating costs for each service sector by the revenue for that year, where revenue represents the quantity produced in each service sector (due to normalized costs; see 7.3.1.4). The operating costs per unit are then interpreted as costs per dollar of output.

Applying these costs to the locomotive transportation market, in the rail sector case, is appropriate because all locomotives built after the Tier 4 standards go into effect will incur these operating costs. On the marine side, the EIM uses a simplifying assumption that applies all marine operating costs to the marine transportation services market. This approach was taken because the operating costs (fuel and urea consumption) were estimated based on fuel consumption and we believe that most of the fuel consumed in the marine sector is by vessels in the marine transportation services sector. While many of the new non-recreational vessels built each year are fishing vessels, the use of fishing vessels is highly seasonal and hence they would not be expected to use as much fuel as the other commercial vessels (tug/tow/pushboats, ferries, cargo vessels, and supply/crew boats) that are used extensively all year around. As a result of this assumption, the impacts on the marine transportation service market may be somewhat over-estimated.

Table 7-24 Marine and Locomotive Operating Costs 2007-2040 (2005$)

	Marine C1>800Hp	Marine C2	Loco-Line haul	Loco-Switcher & Passenger	Total
2006	$0	$0	$0	$0	$0
2007	$0	$0	$0	$0	$0
2008	$0	$0	$1,221,312	$40,179	$1,261,491
2009	$0	$0	$1,210,900	$160,835	$1,371,735
2010	$0	$0	$3,515,299	$280,687	$3,795,986
2011	$0	$0	$7,551,076	$392,336	$7,943,411
2012	$0	$0	$9,225,485	$435,933	$9,661,419
2013	$0	$0	$11,514,508	$472,292	$11,986,800
2014	$0	$2,811,138[a]	$12,052,336	$501,894	$15,365,368
2015	$0	$5,629,325[a]	$14,325,890	$559,055	$20,514,270
2016	$3,748,711	$11,007,676	$18,337,278	$670,590	$33,764,256
2017	$7,493,511	$16,385,211	$30,926,013	$1,737,068	$56,541,803

	Marine C1>800Hp	Marine C2	Loco-Line haul	Loco-Switcher & Passenger	Total
2018	$14,199,915	$21,762,262	$41,788,824	$2,767,721	$80,518,723
2019	$20,882,573	$27,139,987	$52,700,319	$3,820,549	$104,543,428
2020	$27,527,317	$32,504,807	$63,571,104	$4,915,367	$128,518,594
2021	$34,133,758	$37,868,806	$74,765,580	$6,052,613	$152,820,757
2022	$40,682,747	$43,220,176	$86,363,005	$7,215,420	$177,481,347
2023	$47,173,642	$48,558,846	$98,350,736	$8,390,480	$202,473,704
2024	$53,573,572	$53,885,232	$110,512,199	$9,592,182	$227,563,184
2025	$59,881,593	$59,200,774	$123,059,778	$10,783,930	$252,926,074
2026	$66,065,578	$64,518,680	$135,694,126	$11,963,396	$278,241,780
2027	$72,088,258	$69,826,073	$148,437,564	$13,108,658	$303,460,553
2028	$77,882,344	$75,125,645	$161,217,797	$14,247,139	$328,472,925
2029	$82,861,888	$80,389,769	$174,009,828	$15,376,721	$352,638,206
2030	$86,995,449	$85,630,509	$186,753,267	$16,509,822	$375,889,047
2031	$90,362,827	$90,821,351	$199,510,957	$17,637,122	$398,332,257
2032	$93,020,024	$95,974,911	$212,291,194	$18,764,807	$420,050,936
2033	$95,380,145	$101,051,358	$225,111,725	$19,796,404	$441,339,632
2034	$97,498,765	$106,062,320	$237,920,399	$20,801,857	$462,283,341
2035	$99,411,516	$110,968,576	$250,602,975	$21,784,330	$482,767,397
2036	$101,151,649	$115,727,740	$263,081,520	$22,741,774	$502,702,683
2037	$102,751,192	$119,955,873	$275,486,662	$23,684,289	$521,878,016
2038	$104,242,148	$123,625,344	$287,475,707	$24,563,660	$539,906,858
2039	$105,628,120	$126,752,201	$299,021,332	$25,393,609	$556,795,262
2040	$106,922,034	$129,386,543	$310,117,313	$26,160,790	$572,586,680

[a] It should be noted that there is an inconsistency in the cost analysis, which applies the operational costs for these C2 engines in 2014 but does not include the compliance costs for engines or vessels until later years. While this affects the individual year results for early years, the differences disappear by 2016 by which year all marine diesel engines above 800 hp have aftertreatment standards.

Remanufacturing Costs. Railroads are also subject to costs associated with the periodic remanufacturing of their locomotives. They are currently required to use certified remanufacture kits when they rebuild engines originally built in 1973 through 2001 (called Tier 0 locomotives). This program will extend the remanufacturing requirements both to tighten the standards associated with Tier 0 locomotives and to add requirements for engines built after 2001 (Tier 1 and Tier 2 locomotives). In the EIM, these remanufacture costs are treated as operating costs and applied to the railroads along with their urea costs. This approach was chosen because these costs are periodic and recurring. Specifically, they apply to every engine, but only at five to seven year intervals. An important consequence of this modeling approach is that it assumes that the locomotive owner bears the full cost of the remanufacturing kit and the kit provider does not bear any of the cost. However, we believe this simplifying assumption is appropriate. The mandatory nature of the requirement would result in a price elasticity of demand that is close to zero (inelastic) because if a railroad owns a Tier 0, Tier 1, or Tier 2 locomotive it very simply must purchase a kit or it can no longer operate the locomotive. The cost of a remanufacture kit would have to be very high before the option of pulling the locomotive out of service or purchasing a new one would become attractive.

As explained in Chapter 5, the remanufacturing costs for Tier 0 and Tier 1 locomotives represent the difference between the cost of current remanufacture kits and those that will be required pursuant to the standards. For these kits, first time rebuilds will require additional fuel system components that are not required in subsequent rebuilds and therefore the cost for the initial rebuild is more than for future rebuilds. For Tier 2 locomotives, there are additional costs for the initial rebuild, but not for future rebuilds. There are no additional costs associated with Tier 3 rebuilds because these locomotives have all of the essential components when they are built new. Finally, there are rebuild costs for Tier 4 locomotives associated with the aftertreatment devices. Tier 4 locomotives begin to be rebuilt in 2023.

There is no corresponding remanufacture requirement for marine diesel engines (see Chapter 8 for a discussion of a programmatic alternative that would set such a requirement in place for marine diesel engines above 800 hp).

Table 7-25 Per Unit Locomotive Remanufacture Costs – Line Haul

	Tier 0	Tier 1	Tier 2	Tier 3	Tier 4
2007	$0	$0	$0	$0	$0
2008	$33,800	$0	$0	$0	$0
2009	$33,800	$33,800	$0	$0	$0
2010	$33,800	$33,800	$0	$0	$0
2011	$33,800	$33,800	$0	$0	$0
2012	$33,800	$33,800	$0	$0	$0
2013	$33,800	$33,800	$11,749	$0	$0
2014	$33,800	$33,800	$11,749	$0	$0
2015	$33,800	$33,800	$11,749	$0	$0
2016	$33,800	$33,800	$11,749	$0	$0
2017	$22,300	$22,300	$11,749	$0	$0
2018	$22,300	$22,300	$11,749	$0	$0
2019	$22,300	$22,300	$11,749	$0	$0
2020	$22,300	$22,300	$0	$0	$0
2021	$22,300	$22,300	$0	$0	$0
2022	$22,300	$22,300	$0	$0	$0
2023+	$22,300	$22,300	$0	$0	$66,421

Table 7-26 Per Unit Locomotive Remanufacture Costs – Switcher and Passenger

	Tier 0	Tier 1	Tier 2	Tier 3	Tier 4
2007	$0	$0	$0	$0	$0
2008	$33,800	$33,800	$0	$0	$0

	Tier 0	Tier 1	Tier 2	Tier 3	Tier 4
2009	$33,800	$33,800	$0	$0	$0
2010	$33,800	$33,800	$0	$0	$0
2011	$33,800	$33,800	$0	$0	$0
2012	$33,800	$33,800	$0	$0	$0
2013	$33,800	$33,800	$0	$0	$0
2014	$33,800	$33,800	$0	$0	$0
2015	$33,800	$33,800	$8,728	$0	$0
2016	$33,800	$33,800	$8,728	$0	$0
2017	$22,300	$22,300	$8,728	$0	$0
2018	$22,300	$22,300	$8,728	$0	$0
2019	$22,300	$22,300	$8,728	$0	$0
2020	$22,300	$22,300	$8,728	$0	$0
2021	$22,300	$22,300	$0	$0	$0
2022	$22,300	$22,300	$0	$0	$0
2023	$22,300	$22,300	$0	$0	$0
2024	$22,300	$22,300	$0	$0	$0
2025+	$22,300	$22,300	$0	$0	$21,872

7.3.3 Behavioral Parameters

A key feature of the EIM is that it is a behavioral model in that it incorporates economic theory related to producer and consumer behavior to estimate changes in market conditions. As explained in 7.2.1, a behavioral model allows us to examine how manufacturers of affected goods make out adjustments in response to higher production costs due to complying with the control program, and how consumers can be expected to change their consumption choices in response to higher prices resulting from producers passing along at least some part of the compliance costs. The result of these market interactions determines both the new market equilibrium price and quantity and the portion of the compliance costs that will be born by producers and consumers. Thus, the price elasticity of supply and demand are important parameters in behavioral models such as the EIM because they represent how much production and consumption can be expected to change as a result of a price increase.

Table 7-27 and Table 7-28 provide a summary of the demand and supply elasticities used to estimate the economic impact of the proposed standards. Elasticities from peer-reviewed literature were used when possible. Otherwise, the elasticities were estimated using accepted empirical methods (i.e. econometrically; see Appendix 7F) or are derived internally by the EIM. It should be noted that the elasticities in these tables reflect intermediate run behavioral changes. In the long run, supply and demand are expected to be more elastic since more changes can be made to production processes.

7.3.3.1 Demand Elasticities

The EIM requires demand elasticities for the rail and marine transportation markets and the recreational and fishing vessel markets. The demand elasticities for the locomotive, commercial vessels, and marine diesel engine markets are derived in the model. This is another behavioral feature of the model that allows linkages between the different components of the model.

The elasticity for rail transportation services demand is from the peer-reviewed literature and is inelastic (-0.5).[17] This means that the quantity demanded is not expected to be sensitive to price. This is reasonable because, as described above, users of these transportation services typically chose them because they are the best solution for transporting their goods. The decision to choose rail transportation services is a function of many things and the price may not be the most important factor.

We were unable to find the demand elasticity for the marine transportation sector in the peer-reviewed literature. Due to difficulties in gathering the appropriate data to estimate this elasticity, we decided instead to use the same demand elasticity as the rail transportation services market. This is reasonable because a significant portion of the marine transportation sector is engaged in the same basic activity, although with different geographic constraints. Cargo, ferries, supply/crew and tow/tug/pushboats are engaged in transporting materials and people, and the demand for those services is likely to be inelastic because the users have few, if any, alternatives.

For the recreational vessel market, we used a price elasticity of demand that was estimated in 1987 for the National Marine Manufacturers Association.[18] At -1.4, this demand elasticity is elastic, meaning that consumers are expected to be sensitive to a change in price. This is reasonable because recreational marine vessels are a discretionary purchase and consumers have other recreational alternatives.

There were no previously estimated demand elasticities available for the fishing vessel market. Because the demand elasticity for commercial vessels is intenally derived in the EIM, it was not possible to use the commercial vessel market as a proxy. Therefore, we used the estimated demand elasticity for recreationals vessel to approximate the demand elasticity for fishing vessels. The results would be a conservative case, as we would not expect the fishing vessel market to be so elastic since the vessel is an important input to fishing production.

7.3.3.2 Supply Elasticities

Unlike the demand elasticities, it is necessary to estimate a supply elasticity for each of the affected markets.

For the rail transportation service market we use the supply elasticity from our previous economic impact analysis for the Clean Air Nonroad Diesel (Nonroad Tier 4) rule (EPA420-R-04-007). That supply elasticity, from the peer-reviewed literature, is

0.6. This supply elasticity is in elastic, meaning that rail service providers are expected to be insensitive to a price change.

For the line-haul locomotives, we used a calibration method approach to estimate the supply elasticity (see Appendix 7F). At 2.7, this elasticity is elastic, meaning that producers are expected to be sensitive to changes in price. The EIM uses the same supply elasticity for switcher/passenger locomotives. This approach was taken because the market for switchers is currently not very developed. Even if data were available to estimate this supply elasticity, the switcher/passenger locomotive market is expected to change (see Chapter 1 and the discussion earlier in this chapter). Because it is not possible to know how this market will develop, we determined that our best estimate would be the line haul supply elasticity.

We were unable to find published supply elasticity estimates for marine transportation services and therefore the EIM uses the same supply elasticity as for rail transportation services. Again, this is reasonable because the marine transportation service sector provides a similar service, although with different geographic constraints.

For commercial marine vessels, we use the same approach as for line haul locomotives and used the calibration method to estimate the supply elasticity. At 2.3, this elasticity is elastic, meaning that producers are expected to be sensitive to changes in price.

For recreational marine vessels, we used the supply elasticity we estimated in our 2002 recreational vehicle rule.[19] At 1.6, this supply elasticity is elastic, meaning that producers are sensitive to changes in price. They are less sensitive to price changes than commercial vessel manufacturers, however. This is reasonable since recreational vessels are typically serially produced with no specific buyer in mind, using fiberglass molds. Therefore a price increase may have to be higher before affecting production. Also, to some extent, these vessels are more “portable” and can be inventoried, although model year and design may limit the ability of manufacturers to inventory large numbers of these vessels.

There are no prior estimates of the supply elasticity of fishing vessels. The EIM uses the same supply elasticity as recreational vessels. This is reasonable because fishing vessels often have many of the same characteristics as recreational vessels (high-speed planning vessels with fiberglass hulls) and so their production techniques would be similar. At the high end of the market, however, this market may behave more like the commercial vessel market.

The supply elasticity for marine diesel engines is taken from our 2004 Clean Air Nonroad Diesel rule.[20] This is reasonable because the vast majority of marine diesel engines affected by this rule are derived from land-based marine or highway diesel engines. At 3.8, this supply elasticity is elastic, meaning that engine producers are expected to be sensitive to price increases.

Because the demand and supply elasticity estimates are key inputs to the model, a sensitivity analysis was performed to consider the uncertainty that is associated with the estimation process. The results are presented in Appendix 7H.

Table 7-27. Market Demand Elasticities Used in EIM

Market	Estimate	Source	Method	Data Source
Rail				
Rail Transp. Svcs	-0.5	Literature Estimate	Literature Review	Boyer, K.D. 1997. *Principles of Transportation Economics*. Reading, MA: Addison-Wesley.
Locomotives	Derived			
Marine				
Marine Transp. Svcs	-0.5	Literature Estimate	Assumed value	Uses the same elasticity as the locomotive transportation services sector.
Vessels—Commercial	Derived			
Vessels—Fishing	-1.4	Econometric Estimate	Assumed value	Uses the same elasticity as the recreation vessels sector.
Vessels—Recreational	-1.4	Econometric Estimate	Previous EPA Economic Analysis	U.S. Environmental Protection Agency (EPA). 2002. *Final Regulatory Support Document: Control of Emissions from Unregulated Nonroad Engines*. EPA420-R-02-022. Available at <http://www.epa.gov/otaq/regs/nonroad/2002/r02022.pdf>.
Engines	Derived			

Table 7-28. Supply Elasticities Used in EIM

Market	Estimate	Source	Method	Input Data Source
Rail				
Rail Transp. Svcs	0.6	Literature Estimate	Previous EPA Economic Analysis	U.S. Environmental Protection Agency (EPA). 2004. *Final Regulatory Impact Analysis: Control of Emissions from Nonroad Diesel Engines*. EPA420-R-04-007. Available at <http://www.epa.gov/nonroad-diesel/2004fr/420r04007.pdf>.

Locomotives	2.7	EPA Estimate	Calibration Method	U.S. Bureau of the Census. 2004a. “Railroad Rolling Stock Manufacturing: 2002.” *2002 Economic Census Manufacturing Industry Series*. EC02-31I-336510 (RV). Washington, DC: U.S. Bureau of the Census. Table 1. U.S. Bureau of the Census. 2005. “Statistics for Industry Groups and Industries: 2004.” *Annual Survey of Manufacturers.* M04(AS)-1. Washington, DC: U.S. Bureau of the Census. Table 2.
Marine				
Marine Transp. Svcs	0.6		Assumed value	Uses the same elasticity as the rail transportation services sector.
Vessels—Commercial	2.3	EPA Estimate	Calibration Method	U.S. Bureau of the Census. 2004a. “Railroad Rolling Stock Manufacturing: 2002.” *2002 Economic Census Manufacturing Industry Series*. EC02-31I-336611 (RV). Washington, DC: U.S. Bureau of the Census. Table 1. U.S. Bureau of the Census. 2005. “Statistics for Industry Groups and Industries: 2004.” *Annual Survey of Manufacturers.* M04(AS)-1. Washington, DC: U.S. Bureau of the Census. Table 2.
Vessels—Fishing	1.6	Assumed value	Assumed value	Uses the same elasticity as the recreation vessels sector.
Vessels—Recreational	1.6	Econometric Estimate	Previous EPA Economic Analysis	U.S. Environmental Protection Agency (EPA). 2002. *Final Regulatory Support Document: Control of Emissions from Unregulated Nonroad Engines*. EPA420-R-02-022. Available at <http://www.epa.gov/otaq/regs/nonroad/2002/r02022.pdf>.
Engines	3.8	Econometric Estimate	Previous EPA Economic Analysis	U.S. Environmental Protection Agency (EPA). 2004. *Final Regulatory Impact Analysis: Control of Emissions from Nonroad Diesel Engines*. EPA420-R-04-007. Available at <http://www.epa.gov/nonroad-diesel/2004fr/420r04007.pdf>.

7.3.4 Economic Impact Model Structure

7.3.3.1 Estimating With-Regulation Equilibrium Conditions

The economic impact analysis is conducted using the data and the supply and demand framework described above. The price and quantity data, along with the supply and demand elasticities, are used to identify the market supply and demand curves. The regulatory costs are then used to shift the supply curve, and the resulting new equilibrium determines the market impacts and distribution of social impacts.

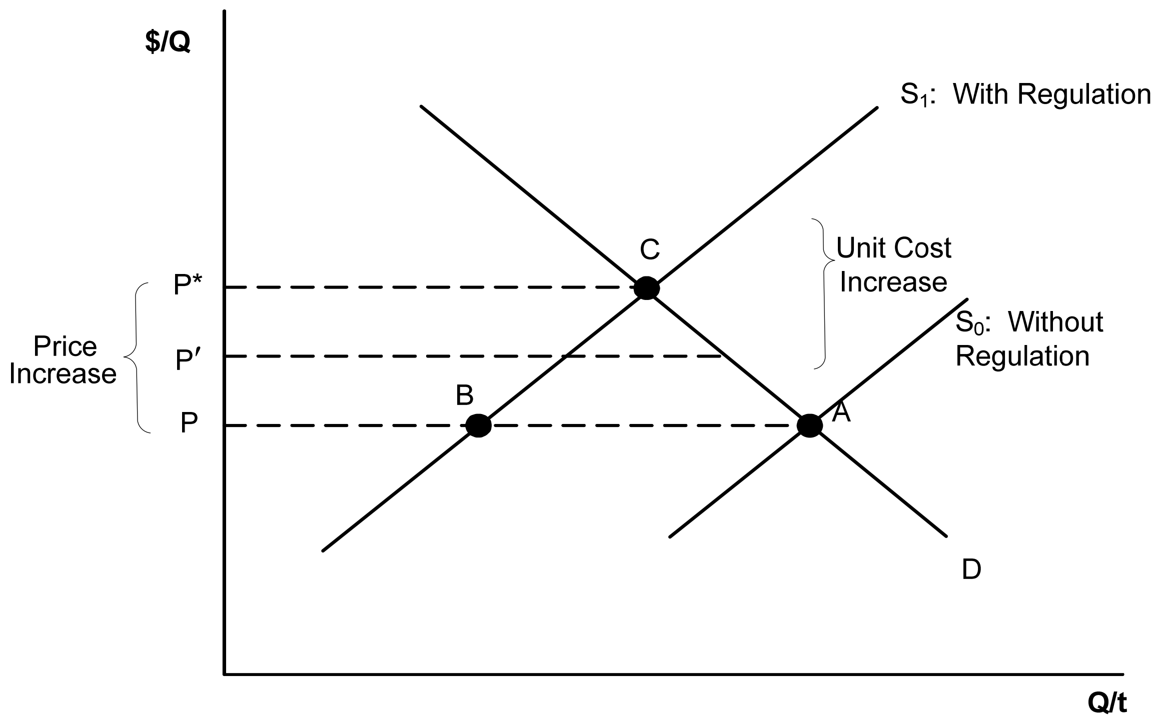
Figure 7-10 illustrates the economic impact modeling structure. Point A represents the initial baseline equilibrium price and quantity (corresponding to the prices and quantities presented in section 7.3.1). The slope of the supply and demand curves passing through the baseline point A are determined by applying the appropriate supply and demand elasticities presented in section 7.3.2.6. These slopes reflect the responsiveness of producers and consumers when prices change and determine how much of the compliance costs producers are able to pass along to consumers in the with-regulation equilibrium.

The compliance costs associated with the regulation (presented in Section 7.3.2) enter the model expressed as per-unit costs and result in an upward shift in the supply curve from S_0 to S_1 in Figure 7-10. Note that the demand curve does not shift because consumer preferences and income are not affected by the regulation (see Section 7.3.2.1)

With the addition of the compliance costs, if prices were not allowed to adjust demanders would still want to consume the quantity at point A, but suppliers would only be willing to supply the quantity at point B (i.e., demand exceeds supply at the baseline price, P). The model then solves for the new equilibrium price (P*) where the quantity demanded equals the quantity supplied. The movement from the baseline equilibrium point A to with-regulation equilibrium point C determines the market impacts (changes in price and quantity) as well as the distribution of social costs. Appendix 7E describes the set of supply and demand equations included in the model. Given the number of equations included in the model, the solution algorithm described below is used to identify the new with-regulation set of equilibrium prices and quantities (Point C).

The analysis illustrated in Figure 7-10 is repeated for each year included in the period of analysis. For future years, a projected time series of prices and quantities are developed and used as the baseline (point A) from which market changes are evaluated. The engineering cost analysis provides quantities for future years using historical annual growth rates. In contrast, there is much more uncertainty surrounding future prices for these markets. As a result, we use a constant 2005 observed prices for the relevant markets during the period of analysis.

Figure 7-10 Estimating With-Regulation Equilibrium



7.3.3.2 Solution Algorithm

Supply responses and market adjustments can be conceptualized as an interactive process. Producers facing increased production costs due to compliance are willing to supply smaller quantities at the baseline price. This reduction in market supply leads to an increase in the market price that all producers and consumers face, which leads to further responses by producers and consumers and thus new market prices, and so on. The new with-regulation equilibrium is the result of a series of iterations in which price is adjusted and producers and consumers respond, until a set of stable market prices arises where total market supply equals market demand. Market price adjustment takes place based on a price-revision rule, described below, that adjusts price upward (downward) by a given percentage in response to excess demand (excess supply).

The EIM model uses a similar type of algorithm for determining with-regulation equilibria and the process can be summarized by six recursive steps:

1. Impose the control costs on affected supply segments, thereby affecting their supply decisions.

2. Recalculate the market supply in each market. Excess demand currently exists.

3. Determine the new prices via a price revision rule. We use a rule similar to the factor price revision rule described by Kimbell and Harrison (1986). P_i is the market price at iteration I, q_d is the quantity demanded, and q_s is the quantity supplied. The parameter z influences the magnitude of the price revision and speed of convergence. The revision rule increases the price when excess demand exists, lowers the price when excess supply exists, and leaves the price unchanged when market demand equals market supply. The price adjustment is expressed as follows:

$$P_{i+1} = P_1 \bullet \left(\frac{q_d}{q_s} \right)^z$$

4. Recalculate market supply with new prices,

5. Compute market demand in each market.

6. Compare supply and demand in each market. If equilibrium conditions are not satisfied, go to Step 3, resulting in a new set of market prices. Repeat until equilibrium conditions are satisfied (i.e., the ratio of supply and demand is arbitrarily close to one). When the ratio is appropriately close to one, the market-clearing condition of supply equals demand is satisfied.

7.3.4 Estimating Impacts

Using the static partial equilibrium analysis, the EIM model loops through each year calculating new market equilibriums based on the projected baseline economic conditions and compliance cost estimates that shift the supply curves in the model. The model calculates price and quantity changes and uses these measures to estimate the social costs of the rule and partition the impact between producers and consumers. This approach follows the classical treatment of tax burden distribution in the public finance literature.[21]

7.4 Methods for Describing Uncertainty

Every economic impact analysis examining the market and social welfare impacts of a regulatory program is limited to some extent by limitations in model capabilities, deficiencies in the economic literatures with respect to estimated values of key variables necessary to configure the model, and data gaps. In this EIA, there are three main potential sources of uncertainty: (1) uncertainty resulting from the way the EIM is designed, particularly from the use of a partial equilibrium model; (2) uncertainty resulting from the values for key model parameters, particularly the price elasticity of supply and demand; and (3) uncertainty resulting from the values for key model inputs, particularly baseline equilibrium price and quantities. Sources of uncertainty that have a bearing on the results of the EIA for the proposed program are listed and described in more detail in Table 7-29.

The values used for the price elasticities of supply and demand are critical parameters in the EIM. The values of these parameters have an impact on both the estimated change in price and quantity produced expected as a result of compliance with the proposed standards and on how the burden of the social costs will be shared among producer and consumer groups. In selecting the values to use in the EIM it is important that they reflect the behavioral responses of the industries under analysis.

The first source of values for elasticities of supply and demand is the published economic literature. These estimates are peer reviewed and generally constitute reasonable estimates for the industries in question. In this anlaysis, we use a published demand elasticity for recreational marine (Raboy) and for rail trainsportation services (Boyer). On the supply side, we were able to find published elasticities for only the rail transportation sector (Ivaldi and McCollough).

When published elasticities of supply or demand are not available, it is necessary to estimate these values econometrically. In this analysis, we used estimated values for the price elasticity of supply for engines and recreational vessels (see Appendix 7F). These estimates, which were performed for earlier rulemakings (2004 NRT4 rule; 2002 recretional vehicle rule), reflect a production function approach using data at the aggregate industry level. This method was chosen because of limitations with the available data: we were not able to obtain firm-level or plant-level production data for companies that operate in the affected sectors. However, the use of aggregate industry level data may not be appropriate or an accurate way to estimate the price elasticity of supply compared to firm-level or plant-level data. This is because, at the aggregate industry level, the size of the data sample is limited to the time series of the available years and because aggregate industry data may not reveal each individual firm or plant production function (heterogeneity). There may be significant differences among the firms that may be hidden in the aggregate data but that may affect the estimated elasticity. In addition, the use of time series aggregate industry data may introduce time trend effects that are difficult to isolate and control.

To address these concerns, EPA intends to investigate estimates for the price elasticity of supply for the affected industries for which published estimates are not available, using alternative methods and data inputs. This research program will use the cross-sectional data model at either the firm-level or plant level from the U.S. Census Bureau to estimate these elasticities. We plan to use the results of this research provided the results are robust and that they are available in time for the analysis for the final rule.

Table 7-29 Primary Sources of Uncertainty in the Economic Impact Analysis

Source of Uncertainty	Description	Potential Impact
UNCERTAINTIES ASSOCIATED WITH ECONIMIC IMPACT MODEL STRUCTURE		
Partial equilibrium model –	The EIM domain is limited to the economic sectors directly affected by the emission control program; impacts on secondary markets are not accounted for. However, the impacts are not expected to be large as directly affected products and services (locomotives and marine engines and vessels) are production inputs (transportation services) and are not a large share of total production costs for final goods and services, or are final goods for household consumption	Results understate social costs; magnitude of impact is uncertain
National level model	The EIM considers only national-level impacts; regional impacts are not modeled. This is appropriate because locomotive and marine engine and vessel markets are national markets. While there may be some regional differences these are likely to be small due to the competitive nature of the transportation industry.	Impacts uncertain
Supply side assumptions	On the supply side, industries are assumed to be mature and behave linearly within the range of analysis; no substitution between production inputs. This is appropriate because per unit compliance costs are not large enough to prompt a major change in product design or assembly.	Impacts uncertain
Demand side assumptions	On the demand side, end consumer preferences or consumption patterns are assumed to be constant and behave linearly within the range of analysis. This is appropriate because all other factors in the demand function will not be changed by the proposed rule.	Impacts uncertain
Constant price assumption	Prices are assumed to be constant across the period of analysis. This is a reasonable assumption since it is not possible to predict changes in these prices over time (see Appendix 7H)..	Impacts uncertain
Period of analysis	Each period of analysis is assumed to be independent of previous period and producers are assumed to not engage in long-term planning. This means the impacts of multi-tier standards are not smoothed among periods . Because the new engine standards will not go into effect for several years after the program is finalized, producers may in fact take the full program into account in production plans to minimize their costs	Estimated price changes may be too high for early periods, too low for later periods; magnitude of impact is uncertain

Market shock	In the EIM, the market shocked by variable costs only; fixed costs do not disturb the market equilibrium. This is a result of the perfect competition assumption implies market supply curve is the industry average marginal cost curve. This is appropriate because producers in these industries generally plan for R&D and model changes. A sensitivity analysis performed that includes fixed costs in supply shift	Results may overstate distribution of social costs to some producers, understate market impacts; magnitude of impact is uncertain *Sensitivity analysis performed*
UNCERTAINTIES ASSOCIATED WITH PRICE ELASTICITY ESTIMATION		
	Uncertainty resulting from the functional form used in the estimation, the data used (aggregate or firm-level), the time period involved, sample size.	Impacts on distribution of social costs among stakeholders (e.g., higher supply elasticity would result in less social costs for manufacturers and more social costs for consumers) Impacts on market analysis (change in price, change in quantity produced) ; magnitude of impact is uncertain *Sensitivity analysis performed*
UNCERTAINTIES ASSOCIATED WITH DATA INPUTS		
Submarket groupings	Submarket data is assumed to be representative and capture the range of affected equipment. However, the product groupings in NAICS or SIC 4-digit categories may include other engines or equipment that may not have the same production or consumption characteristics; these groupings not behave the same way as the directly-affected industries.	Impacts on social welfare and market analyses uncertain

Baseline equilibrium prices	Estimated baseline equilibrium prices are assumed to be representative and capture the range of affected equipment, and reflect actual transaction prices. However, the actual prices paid by consumers may be different. Also, the mix of products included in price analysis may not be representative of the population.	Impacts on market analysis uncertain
Baseline equilibrium quantities	Estimated baseline equilibrium quantities and future quantities assumed to be representative; these are the same as the cost analysis	Impacts on market analysis uncertain

To explore the effects of key sources of uncertainty, we performed a sensitivity analysis in which we examine the results of using alternative values for the price elasticity of supply and demand, alternative methods to shock to the market equilibrium (fixed and variable costs) and alternative methods to incorporate operational costs (across a larger group of marine vessels). The results of these analyses are contained in Appendix 7H. A summary of the results are presented in Table 7-30.

Table 7-30. Results of Sensitivity Analysis

Parameter	Year	Change in Value	Impact
Price Elasticity of Supply	2020	More elastic	Negligible impact on expected price increase and quantity decrease Higher value associated with increase in social cost burden for users of rail and marine transportation services
	2020	Less elastic	Negligible impact on expected price increase and quantity decrease Lower value associated with increase in social cost burden for suppliers of marine vessels and providers of rail and marine transportation services
Price Elasticity of Demand	2020	More elastic	Negligible impact on expected price increase and quantity decrease Higher value associated with increase in social cost burden for suppliers of marine vessels and providers of rail and marine transportation services
	2020	Less elastic	Negligible impact on expected price increase and quantity decrease Lower value associated with increase in social cost burden for users of rail and marine transportation services
Market Supply Shift	2011, 2015	Include fixed and variable costs	2011: Price increase larger than primary case but decrease in quantity produced remains small, less than 2.5 percent (less than 15 units) for commercial marine engines and vessels and less than 1 percent (about 200 engines and vessels) for recreational marine engines and vessels. Negligible change in locomotive markets. Distribution of social costs shifts from manufacturers to user groups. 2015: Price increase larger than primary case, but decrease in quantity produced remains small, less than 2.0 percent (less than 10 units) for commercial marine engines and vessels and less than 0.1 percent (less than 15 engines and vessels) for recreational marine engines and vessels. Negligible change in locomotive markets. Distribution of social costs shifts from manufacturers to user groups.
Operating Costs	2020	Alternate distribution	Negligible change in results; increase in social cost burden for recreational and fishing vessel consumers

Appendix 7A: Impacts on Marine Engine Markets

This appendix provides the time series of impacts from 2007 through 2040 for selected auxiliary and propulsion marine engines markets. Table 7A-1 through Table 7A-8 provide the time series of impacts and include the following:

- average engineering costs (variable) per engine
- absolute change in the market price ($)
- relative change in market price (%)
- relative change in market quantity (%)
- total engineering costs (variable and fixed) associated with each engine market
- changes in engine manufacturer surplus

All prices, costs, and surplus changes are presented in 2005 dollars, and real engine or equipment prices are assumed to be constant during the period of analysis. Net present values for 2006 were calculated using social discount rates of 3% and 7% over the 2007 and 2040 time period.

Results are presented for only those markets that are expected to incur direct variable costs under Tier 3 or Tier 4 standards. This means that results are not presented for marine engine markets less than 800 hp or for recreational propulsion engine markets.[16] For these engine markets, the results are expected to be negligible and any change in price or quantity would be incidental to the changes in the larger engine markets. It should also be noted that all engine markets would incur fixed costs. However, as explained in 7.2.3.4, fixed costs are not included in the EIM. The sensitivity analysis in Appendix 7H includes a case that applies both fixed and variable costs to the relevant markets.

The NPV calculations presented in this Appendix are based on the period 2006-2040, reflecting the period when the analysis was completed. This has the consequence of discounting the current year costs, 2007, and all subsequent years are discounted by an additional year. The result is a smaller stream of social costs than by calculating the NPV over 2007-2040 (3% smaller for 3% NPV and 7% smaller for 7% NPV).

[16] This version of the EIA is based on an earlier version of the marine emission control program that did not apply Tier 4 standards to any recreational marine diesel engines.

Table 7A-1. Impact on C1 Commercial Auxiliary Engine Market: 800–2000 hp (Average Price per Engine = $77,500)[a,b]

Year	Variable Engineering Cost/Unit	Absolute Change in Price ($)	Change in Price (%)	Change in Quantity (%)	Total Engineering Costs (million $)	Change in Engine Manufacturers'' Surplus (million $)
2007	$0	$0	0.0%	0.0%	$0.3	-$0.3
2008	$0	$0	0.0%	0.0%	$0.3	-$0.3
2009	$0	$0	0.0%	0.0%	$0.3	-$0.3
2010	$0	$0	0.0%	0.0%	$0.3	-$0.3
2011	$0	$0	0.0%	0.0%	$3.9	-$3.9
2012	$0	$0	0.0%	0.0%	$3.5	-$3.5
2013	$0	$0	0.0%	0.0%	$3.5	-$3.5
2014	$0	$0	0.0%	0.0%	$3.5	-$3.5
2015	$0	$0	0.0%	0.0%	$4.6	-$4.6
2016	$15,319	$14,958	19.3%	-1.8%	$2.5	-$0.1
2017	$15,319	$14,958	19.3%	-1.8%	$2.5	-$0.1
2018	$11,763	$11,478	14.8%	-1.4%	$1.9	Loss less than $0.1
2019	$11,763	$11,478	14.8%	-1.4%	$1.9	Loss less than $0.1
2020	$11,763	$11,478	14.8%	-1.4%	$2.0	Loss less than $0.1
2021	$11,763	$11,477	14.8%	-1.4%	$2.0	Loss less than $0.1
2022	$11,763	$11,477	14.8%	-1.4%	$2.0	Loss less than $0.1
2023	$11,763	$11,476	14.8%	-1.4%	$2.0	Loss less than $0.1
2024	$11,763	$11,476	14.8%	-1.4%	$2.0	Loss less than $0.1
2025	$11,763	$11,475	14.8%	-1.4%	$2.1	Loss less than $0.1
2026	$11,763	$11,475	14.8%	-1.4%	$2.1	-$0.1
2027	$11,763	$11,474	14.8%	-1.4%	$2.1	-$0.1
2028	$11,763	$11,474	14.8%	-1.4%	$2.1	-$0.1
2029	$11,763	$11,473	14.8%	-1.4%	$2.1	-$0.1
2030	$11,763	$11,473	14.8%	-1.4%	$2.1	-$0.1
2031	$11,763	$11,473	14.8%	-1.4%	$2.2	-$0.1
2032	$11,763	$11,473	14.8%	-1.4%	$2.2	-$0.1
2033	$11,763	$11,473	14.8%	-1.4%	$2.2	-$0.1
2034	$11,763	$11,472	14.8%	-1.4%	$2.2	-$0.1
2035	$11,763	$11,472	14.8%	-1.4%	$2.2	-$0.1
2036	$11,763	$11,472	14.8%	-1.4%	$2.3	-$0.1
2037	$11,763	$11,472	14.8%	-1.4%	$2.3	-$0.1
2038	$11,763	$11,472	14.8%	-1.4%	$2.3	-$0.1
2039	$11,763	$11,471	14.8%	-1.4%	$2.3	-$0.1
2040	$11,763	$11,472	14.8%	-1.4%	$2.3	-$0.1
NPV at 3%					$44.0	-$16.9
NPV at 7%					$24.8	-$12.4

[a] Figures are in 2005 dollars.

[b] Net present values for 2006 are calculated using a social discount rate of 3% and 7% over the 2007 to 2040 time period.

Table 7A-2 Impact on C1 Commercial Auxiliary Engine Market: >2000 hp (Average Price per Engine = $150,000)[a,b]

Year	Variable Engineering Cost/Unit	Absolute Change in Price ($)	Change in Price (%)	Change in Quantity (%)	Total Engineering Costs (million $)	Change in Engine Manufacturers'' Surplus (million $)
2007	$0	$0	0.0%	0.0%	$0.0	Loss less than $0.1
2008	$0	$0	0.0%	0.0%	$0.0	Loss less than $0.1
2009	$0	$0	0.0%	0.0%	$0.0	Loss less than $0.1
2010	$0	$0	0.0%	0.0%	$0.0	Loss less than $0.1
2011	$0	$0	0.0%	0.0%	$0.4	–$0.4
2012	$0	$0	0.0%	0.0%	$0.3	–$0.3
2013	$0	$0	0.0%	0.0%	$0.3	–$0.3
2014	$0	–$3	0.0%	0.0%	$0.3	–$0.3
2015	$0	–$6	0.0%	0.0%	$0.4	–$0.4
2016	$26,294	$26,194	17.4%	–0.5%	$0.4	Loss less than $0.1
2017	$26,295	$26,185	17.4%	–0.5%	$0.4	Loss less than $0.1
2018	$20,115	$20,012	13.3%	–0.5%	$0.3	Loss less than $0.1
2019	$20,114	$19,999	13.3%	–0.6%	$0.3	Loss less than $0.1
2020	$20,118	$19,991	13.2%	–0.6%	$0.3	Loss less than $0.1
2021	$20,113	$19,975	13.2%	–0.7%	$0.3	Loss less than $0.1
2022	$20,114	$19,964	13.2%	–0.7%	$0.3	Loss less than $0.1
2023	$20,113	$19,952	13.2%	–0.8%	$0.3	Loss less than $0.1
2024	$20,117	$19,945	13.2%	–0.8%	$0.3	Loss less than $0.1
2025	$20,113	$19,931	13.2%	–0.9%	$0.3	Loss less than $0.1
2026	$20,113	$19,921	13.2%	–0.9%	$0.3	Loss less than $0.1
2027	$20,118	$19,917	13.2%	–1.0%	$0.3	Loss less than $0.1
2028	$20,116	$19,905	13.1%	–1.0%	$0.3	Loss less than $0.1
2029	$20,117	$19,898	13.1%	–1.1%	$0.3	Loss less than $0.1
2030	$20,117	$19,891	13.1%	–1.1%	$0.3	Loss less than $0.1
2031	$20,116	$19,883	13.1%	–1.1%	$0.3	Loss less than $0.1
2032	$20,113	$19,874	13.1%	–1.2%	$0.3	Loss less than $0.1
2033	$20,114	$19,870	13.1%	–1.2%	$0.3	Loss less than $0.1
2034	$20,114	$19,865	13.1%	–1.2%	$0.3	Loss less than $0.1
2035	$20,117	$19,865	13.1%	–1.2%	$0.4	Loss less than $0.1
2036	$20,114	$19,857	13.1%	–1.3%	$0.4	Loss less than $0.1
2037	$20,114	$19,854	13.1%	–1.3%	$0.4	Loss less than $0.1
2038	$20,113	$19,850	13.1%	–1.3%	$0.4	Loss less than $0.1
2039	$20,116	$19,851	13.1%	–1.3%	$0.4	Loss less than $0.1
2040	$20,117	$19,850	13.1%	–1.3%	$0.4	Loss less than $0.1
NPV at 3%					$5.8	–$1.5
NPV at 7%					$3.1	–$1.1

[a] Figures are in 2005 dollars.

[b] Net present values for 2006 are calculated using a social discount rate of 3% and 7% over the 2007 to 2040 time period.

Table 7A-3 Impact on C2 Commercial Auxiliary Engine Market: 800–2,000 hp (Average Price per Engine = $115,000)[a,b]

Year	Variable Engineering Cost/Unit	Absolute Change in Price ($)	Change in Price (%)	Change in Quantity (%)	Total Engineering Costs (million $)	Change in Engine Manufacturers'' Surplus (million $)
2007	$0	$0	0.0%	0.0%	$0.9	-$0.9
2008	$0	$0	0.0%	0.0%	$0.9	-$0.9
2009	$0	$0	0.0%	0.0%	$0.9	-$0.9
2010	$0	$0	0.0%	0.0%	$0.9	-$0.9
2011	$0	$0	0.0%	0.0%	$5.7	-$5.7
2012	$0	$0	0.0%	0.0%	$4.2	-$4.2
2013	$0	$0	0.0%	0.0%	$4.2	-$4.2
2014	$0	-$1	0.0%	0.0%	$4.2	-$4.2
2015	$0	-$2	0.0%	0.0%	$6.1	-$6.1
2016	$39,059	$38,759	33.7%	-1.0%	$2.5	Loss less than $0.1
2017	$39,058	$38,755	33.7%	-1.0%	$2.5	Loss less than $0.1
2018	$29,827	$29,587	25.7%	-0.8%	$1.9	Loss less than $0.1
2019	$29,827	$29,581	25.7%	-0.8%	$1.9	Loss less than $0.1
2020	$29,827	$29,577	25.7%	-0.8%	$2.0	Loss less than $0.1
2021	$29,827	$29,573	25.7%	-0.8%	$2.0	Loss less than $0.1
2022	$29,827	$29,568	25.7%	-0.9%	$2.0	Loss less than $0.1
2023	$29,827	$29,564	25.7%	-0.9%	$2.0	Loss less than $0.1
2024	$29,826	$29,560	25.7%	-0.9%	$2.0	Loss less than $0.1
2025	$29,826	$29,555	25.7%	-0.9%	$2.1	Loss less than $0.1
2026	$29,827	$29,552	25.7%	-0.9%	$2.1	Loss less than $0.1
2027	$29,827	$29,546	25.7%	-0.9%	$2.1	Loss less than $0.1
2028	$29,827	$29,543	25.7%	-0.9%	$2.1	Loss less than $0.1
2029	$29,826	$29,539	25.7%	-1.0%	$2.1	Loss less than $0.1
2030	$29,827	$29,537	25.7%	-1.0%	$2.1	Loss less than $0.1
2031	$29,827	$29,534	25.7%	-1.0%	$2.2	Loss less than $0.1
2032	$29,827	$29,532	25.7%	-1.0%	$2.2	Loss less than $0.1
2033	$29,827	$29,530	25.7%	-1.0%	$2.2	Loss less than $0.1
2034	$29,827	$29,528	25.7%	-1.0%	$2.2	Loss less than $0.1
2035	$29,826	$29,526	25.7%	-1.0%	$2.2	Loss less than $0.1
2036	$29,826	$29,525	25.7%	-1.0%	$2.3	Loss less than $0.1
2037	$29,827	$29,524	25.7%	-1.0%	$2.3	Loss less than $0.1
2038	$29,827	$29,523	25.7%	-1.0%	$2.3	Loss less than $0.1
2039	$29,827	$29,523	25.7%	-1.0%	$2.3	Loss less than $0.1
2040	$29,827	$29,522	25.7%	-1.0%	$2.3	Loss less than $0.1
NPV at 3%					$50.3	-$22.7
NPV at 7%					$29.7	-$17.1

[a] Figures are in 2005 dollars.

[b] Net present values for 2006 are calculated using a social discount rate of 3% and 7% over the 2007 to 2040 time period.

Table 7A-4 Impact on C2 Commercial Auxiliary Engine Market: >2,000 hp (Average Price per Engine = $225,000)[a,b]

Year	Variable Engineering Cost/Unit	Absolute Change in Price ($)	Change in Price (%)	Change in Quantity (%)	Total Engineering Costs (million $)	Change in Engine Manufacturers'' Surplus (million $)
2007	$0	$0	0.0%	0.0%	$1.3	-$1.3
2008	$0	$0	0.0%	0.0%	$1.3	-$1.3
2009	$0	$0	0.0%	0.0%	$1.3	-$1.3
2010	$0	$0	0.0%	0.0%	$1.3	-$1.3
2011	$0	$0	0.0%	0.0%	$8.7	-$8.7
2012	$0	$0	0.0%	0.0%	$6.5	-$6.5
2013	$0	$0	0.0%	0.0%	$6.5	-$6.5
2014	$0	-$2	0.0%	0.0%	$6.5	-$6.5
2015	$0	-$5	0.0%	0.0%	$9.4	-$9.4
2016	$72,301	$71,824	31.9%	-0.8%	$7.0	Loss less than $0.1
2017	$72,301	$71,816	31.9%	-0.8%	$7.1	Loss less than $0.1
2018	$55,120	$54,733	24.3%	-0.7%	$5.5	Loss less than $0.1
2019	$55,121	$54,724	24.3%	-0.7%	$5.5	Loss less than $0.1
2020	$55,121	$54,715	24.3%	-0.7%	$5.6	Loss less than $0.1
2021	$55,121	$54,706	24.3%	-0.7%	$5.6	Loss less than $0.1
2022	$55,121	$54,697	24.3%	-0.7%	$5.7	Loss less than $0.1
2023	$55,120	$54,688	24.3%	-0.7%	$5.7	Loss less than $0.1
2024	$55,120	$54,680	24.3%	-0.7%	$5.8	Loss less than $0.1
2025	$55,121	$54,672	24.3%	-0.8%	$5.8	Loss less than $0.1
2026	$55,121	$54,664	24.3%	-0.8%	$5.9	Loss less than $0.1
2027	$55,121	$54,656	24.3%	-0.8%	$5.9	Loss less than $0.1
2028	$55,121	$54,649	24.3%	-0.8%	$6.0	-$0.1
2029	$55,120	$54,642	24.3%	-0.8%	$6.0	-$0.1
2030	$55,121	$54,637	24.3%	-0.8%	$6.1	-$0.1
2031	$55,121	$54,632	24.3%	-0.8%	$6.1	-$0.1
2032	$55,120	$54,627	24.3%	-0.8%	$6.2	-$0.1
2033	$55,120	$54,623	24.3%	-0.8%	$6.3	-$0.1
2034	$55,121	$54,620	24.3%	-0.8%	$6.3	-$0.1
2035	$55,121	$54,616	24.3%	-0.9%	$6.4	-$0.1
2036	$55,120	$54,613	24.3%	-0.9%	$6.4	-$0.1
2037	$55,121	$54,610	24.3%	-0.9%	$6.5	-$0.1
2038	$55,121	$54,608	24.3%	-0.9%	$6.5	-$0.1
2039	$55,121	$54,607	24.3%	-0.9%	$6.6	-$0.1
2040	$55,121	$54,605	24.3%	-0.9%	$6.7	-$0.1
NPV at 3%					$113.5	-$35.1
NPV at 7%					$62.2	-$26.4

[a] Figures are in 2005 dollars.

[b] Net present values for 2006 are calculated using a social discount rate of 3% and 7% over the 2007 to 2040 time period.

Table 7A-5 Impact on C1 Commercial Propulsion Engine Market: 800–2,000 hp (Average Price per Engine = $155,000)[a,b]

Year	Variable Engineering Cost/Unit	Absolute Change in Price ($)	Change in Price (%)	Change in Quantity (%)	Total Engineering Costs (million $)	Change in Engine Manufacturers'' Surplus (million $)
2007	$0	$0	0.0%	0.0%	$1.0	-$1.0
2008	$0	$0	0.0%	0.0%	$1.0	-$1.0
2009	$0	$0	0.0%	0.0%	$1.0	-$1.0
2010	$0	$0	0.0%	0.0%	$1.0	-$1.0
2011	$0	$0	0.0%	0.0%	$13.1	-$13.1
2012	$0	$0	0.0%	0.0%	$11.7	-$11.7
2013	$0	$0	0.0%	0.0%	$11.7	-$11.7
2014	$0	$0	0.0%	0.0%	$11.7	-$11.7
2015	$0	-$1	0.0%	0.0%	$15.3	-$15.3
2016	$15,319	$14,597	9.4%	-1.8%	$8.2	-$0.4
2017	$15,319	$14,596	9.4%	-1.8%	$8.3	-$0.4
2018	$11,763	$11,194	7.2%	-1.4%	$6.4	-$0.3
2019	$11,763	$11,193	7.2%	-1.4%	$6.5	-$0.3
2020	$11,763	$11,192	7.2%	-1.4%	$6.5	-$0.3
2021	$11,763	$11,191	7.2%	-1.4%	$6.6	-$0.3
2022	$11,763	$11,190	7.2%	-1.4%	$6.6	-$0.3
2023	$11,763	$11,189	7.2%	-1.4%	$6.7	-$0.3
2024	$11,763	$11,188	7.2%	-1.4%	$6.8	-$0.3
2025	$11,763	$11,187	7.2%	-1.4%	$6.8	-$0.3
2026	$11,763	$11,186	7.2%	-1.4%	$6.9	-$0.3
2027	$11,763	$11,185	7.2%	-1.4%	$6.9	-$0.3
2028	$11,763	$11,185	7.2%	-1.4%	$7.0	-$0.3
2029	$11,763	$11,184	7.2%	-1.4%	$7.1	-$0.3
2030	$11,763	$11,183	7.2%	-1.4%	$7.1	-$0.3
2031	$11,763	$11,183	7.2%	-1.4%	$7.2	-$0.4
2032	$11,763	$11,182	7.2%	-1.4%	$7.3	-$0.4
2033	$11,763	$11,182	7.2%	-1.4%	$7.3	-$0.4
2034	$11,763	$11,181	7.2%	-1.4%	$7.4	-$0.4
2035	$11,763	$11,181	7.2%	-1.4%	$7.5	-$0.4
2036	$11,763	$11,181	7.2%	-1.4%	$7.5	-$0.4
2037	$11,763	$11,180	7.2%	-1.4%	$7.6	-$0.4
2038	$11,763	$11,180	7.2%	-1.4%	$7.7	-$0.4
2039	$11,763	$11,180	7.2%	-1.4%	$7.7	-$0.4
2040	$11,763	$11,180	7.2%	-1.4%	$7.8	-$0.4
NPV at 3%					$146.3	-$58.3
NPV at 7%					$82.3	-$42.2

[a] Figures are in 2005 dollars.

[b] Net present values for 2006 are calculated using a social discount rate of 3% and 7% over the 2007 to 2040 time period.

Table 7A-6 Impact on C1 Commercial Propulsion Engine Market: >2,000 hp (Average Price per Engine = $300,000)[a,b]

Year	Variable Engineering Cost/Unit	Absolute Change in Price ($)	Change in Price (%)	Change in Quantity (%)	Total Engineering Costs (million $)	Change in Engine Manufacturers'' Surplus (million $)
2007	$0	$0	0.0%	0.0%	$0.4	-$0.4
2008	$0	$0	0.0%	0.0%	$0.4	-$0.4
2009	$0	$0	0.0%	0.0%	$0.4	-$0.4
2010	$0	$0	0.0%	0.0%	$0.4	-$0.4
2011	$0	$0	0.0%	0.0%	$5.4	-$5.4
2012	$0	$0	0.0%	0.0%	$4.9	-$4.9
2013	$0	$0	0.0%	0.0%	$4.9	-$4.9
2014	$0	$0	0.0%	0.0%	$4.9	-$4.9
2015	$0	-$1	0.0%	0.0%	$6.4	-$6.4
2016	$26,296	$25,082	8.4%	-1.5%	$5.8	-$0.3
2017	$26,296	$25,081	8.4%	-1.5%	$5.9	-$0.3
2018	$20,115	$19,157	6.4%	-1.2%	$4.5	-$0.2
2019	$20,115	$19,155	6.4%	-1.2%	$4.6	-$0.2
2020	$20,116	$19,154	6.4%	-1.2%	$4.6	-$0.2
2021	$20,116	$19,152	6.4%	-1.2%	$4.7	-$0.2
2022	$20,115	$19,150	6.4%	-1.2%	$4.7	-$0.2
2023	$20,116	$19,146	6.4%	-1.2%	$4.8	-$0.2
2024	$20,115	$19,144	6.4%	-1.2%	$4.8	-$0.2
2025	$20,115	$19,143	6.4%	-1.2%	$4.8	-$0.2
2026	$20,116	$19,142	6.4%	-1.2%	$4.9	-$0.2
2027	$20,116	$19,141	6.4%	-1.2%	$4.9	-$0.2
2028	$20,115	$19,140	6.4%	-1.2%	$5.0	-$0.2
2029	$20,116	$19,136	6.4%	-1.2%	$5.0	-$0.2
2030	$20,115	$19,136	6.4%	-1.2%	$5.1	-$0.2
2031	$20,115	$19,135	6.4%	-1.2%	$5.1	-$0.2
2032	$20,116	$19,136	6.4%	-1.2%	$5.1	-$0.2
2033	$20,115	$19,133	6.4%	-1.2%	$5.2	-$0.3
2034	$20,116	$19,133	6.4%	-1.2%	$5.3	-$0.3
2035	$20,116	$19,133	6.4%	-1.2%	$5.3	-$0.3
2036	$20,115	$19,131	6.4%	-1.2%	$5.4	-$0.3
2037	$20,116	$19,131	6.4%	-1.2%	$5.4	-$0.3
2038	$20,115	$19,129	6.4%	-1.2%	$5.5	-$0.3
2039	$20,115	$19,130	6.4%	-1.2%	$5.5	-$0.3
2040	$20,116	$19,131	6.4%	-1.2%	$5.5	-$0.3
NPV at 3%					$88.0	-$25.4
NPV at 7%					$46.6	-$18.1

[a] Figures are in 2005 dollars.

[b] Net present values for 2006 are calculated using a social discount rate of 3% and 7% over the 2007 to 2040 time period.

Table 7A-7 Impact on C2 Commercial Propulsion Engine Market: 800–2,000 hp (Average Price per Engine = $232,500)[a,b]

Year	Variable Engineering Cost/Unit	Absolute Change in Price ($)	Change in Price (%)	Change in Quantity (%)	Total Engineering Costs (million $)	Change in Engine Manufacturers' Surplus (million $)
2007	$0	$0	0.0%	0.0%	$0.1	-$0.1
2008	$0	$0	0.0%	0.0%	$0.1	-$0.1
2009	$0	$0	0.0%	0.0%	$0.1	-$0.1
2010	$0	$0	0.0%	0.0%	$0.1	-$0.1
2011	$0	$0	0.0%	0.0%	$0.7	-$0.7
2012	$0	$0	0.0%	0.0%	$0.5	-$0.5
2013	$0	$0	0.0%	0.0%	$0.5	-$0.5
2014	$0	-$2	0.0%	0.0%	$0.5	-$0.5
2015	$0	-$5	0.0%	0.0%	$0.7	-$0.7
2016	$39,057	$38,458	16.7%	-1.0%	$0.3	Loss less than $0.1
2017	$39,057	$38,451	16.7%	-1.0%	$0.3	Loss less than $0.1
2018	$29,829	$29,347	12.8%	-0.8%	$0.2	Loss less than $0.1
2019	$29,829	$29,338	12.8%	-0.8%	$0.2	Loss less than $0.1
2020	$29,829	$29,329	12.8%	-0.8%	$0.2	Loss less than $0.1
2021	$29,829	$29,320	12.7%	-0.8%	$0.2	Loss less than $0.1
2022	$29,829	$29,312	12.7%	-0.9%	$0.2	Loss less than $0.1
2023	$29,829	$29,303	12.7%	-0.9%	$0.2	Loss less than $0.1
2024	$29,829	$29,295	12.7%	-0.9%	$0.2	Loss less than $0.1
2025	$29,829	$29,287	12.7%	-0.9%	$0.2	Loss less than $0.1
2026	$29,829	$29,279	12.7%	-0.9%	$0.2	Loss less than $0.1
2027	$29,825	$29,263	12.7%	-0.9%	$0.2	Loss less than $0.1
2028	$29,825	$29,256	12.7%	-0.9%	$0.2	Loss less than $0.1
2029	$29,825	$29,250	12.7%	-1.0%	$0.2	Loss less than $0.1
2030	$29,825	$29,244	12.7%	-1.0%	$0.2	Loss less than $0.1
2031	$29,825	$29,239	12.7%	-1.0%	$0.2	Loss less than $0.1
2032	$29,825	$29,235	12.7%	-1.0%	$0.2	Loss less than $0.1
2033	$29,825	$29,231	12.7%	-1.0%	$0.2	Loss less than $0.1
2034	$29,825	$29,228	12.7%	-1.0%	$0.2	Loss less than $0.1
2035	$29,825	$29,225	12.7%	-1.0%	$0.2	Loss less than $0.1
2036	$29,825	$29,222	12.7%	-1.0%	$0.2	Loss less than $0.1
2037	$29,825	$29,219	12.7%	-1.0%	$0.2	Loss less than $0.1
2038	$29,825	$29,217	12.7%	-1.0%	$0.2	Loss less than $0.1
2039	$29,825	$29,216	12.7%	-1.0%	$0.2	Loss less than $0.1
2040	$29,825	$29,215	12.7%	-1.0%	$0.2	Loss less than $0.1
NPV at 3%					$5.5	-$2.6
NPV at 7%					$3.3	-$1.9

[a] Figures are in 2005 dollars.

[b] Net present values for 2006 are calculated using a social discount rate of 3% and 7% over the 2007 to 2040 time period.

Table 7A-8 Impact on C2 Commercial Propulsion Engine Market: >2,000 hp (Average Price per Engine = $450,000)[a,b]

Year	Variable Engineering Cost/Unit	Absolute Change in Price ($)	Change in Price (%)	Change in Quantity (%)	Total Engineering Costs (million $)	Change in Engine Manufacturers' Surplus (million $)
2007	$0	$0	0.0%	0.0%	$1.9	-$1.9
2008	$0	$0	0.0%	0.0%	$1.9	-$1.9
2009	$0	$0	0.0%	0.0%	$1.9	-$1.9
2010	$0	$0	0.0%	0.0%	$1.9	-$1.9
2011	$0	$0	0.0%	0.0%	$12.7	-$12.7
2012	$0	$0	0.0%	0.0%	$9.5	-$9.5
2013	$0	$0	0.0%	0.0%	$9.5	-$9.5
2014	$0	-$5	0.0%	0.0%	$9.5	-$9.5
2015	$0	-$9	0.0%	0.0%	$13.7	-$13.7
2016	$72,301	$71,346	15.9%	-0.8%	$10.2	-$0.1
2017	$72,301	$71,332	15.9%	-0.8%	$10.3	-$0.1
2018	$55,121	$54,346	12.1%	-0.7%	$8.0	-$0.1
2019	$55,121	$54,327	12.1%	-0.7%	$8.0	-$0.1
2020	$55,121	$54,309	12.1%	-0.7%	$8.1	-$0.1
2021	$55,121	$54,291	12.1%	-0.7%	$8.2	-$0.1
2022	$55,121	$54,273	12.1%	-0.7%	$8.2	-$0.1
2023	$55,121	$54,256	12.1%	-0.7%	$8.3	-$0.1
2024	$55,121	$54,239	12.1%	-0.7%	$8.4	-$0.1
2025	$55,120	$54,223	12.0%	-0.8%	$8.5	-$0.1
2026	$55,120	$54,207	12.0%	-0.8%	$8.5	-$0.1
2027	$55,120	$54,192	12.0%	-0.8%	$8.6	-$0.1
2028	$55,121	$54,178	12.0%	-0.8%	$8.7	-$0.1
2029	$55,121	$54,165	12.0%	-0.8%	$8.8	-$0.2
2030	$55,120	$54,153	12.0%	-0.8%	$8.9	-$0.2
2031	$55,120	$54,143	12.0%	-0.8%	$8.9	-$0.2
2032	$55,121	$54,134	12.0%	-0.8%	$9.0	-$0.2
2033	$55,121	$54,126	12.0%	-0.8%	$9.1	-$0.2
2034	$55,120	$54,118	12.0%	-0.8%	$9.2	-$0.2
2035	$55,120	$54,111	12.0%	-0.9%	$9.3	-$0.2
2036	$55,121	$54,105	12.0%	-0.9%	$9.3	-$0.2
2037	$55,121	$54,100	12.0%	-0.9%	$9.4	-$0.2
2038	$55,120	$54,095	12.0%	-0.9%	$9.5	-$0.2
2039	$55,121	$54,093	12.0%	-0.9%	$9.6	-$0.2
2040	$55,120	$54,090	12.0%	-0.9%	$9.7	-$0.2
NPV at 3%					$165.0	-$52.0
NPV at 7%					$90.4	-$38.9

[a] Figures are in 2005 dollars.

[b] Net present values for 2006 are calculated using a social discount rate of 3% and 7% over the 2007 to 2040 time period.

Appendix 7B: Impacts on the Equipment Markets

This appendix provides the time series of impacts from 2007 through 2040 for selected equipment markets (vessels and locomotives). Results are presented for 26 separate equipment markets: 2 locomotive markets (line-haul and switchers) and 24 vessel markets. Table 7B-1 through Table 7B-26 provide the time series of impacts and include the following:

- average engineering costs (variable) per equipment
- absolute change in the market price ($)
- relative change in market price (%)
- relative change in market quantity (%)
- total engineering costs (variable and fixed) associated with each engine market
- changes in equipment manufacturer surplus (selected commercial vessel and locomotive markets)
- changes in consumer surplus (recreational and fishing markets only)
- changes in total surplus (recreational and fishing markets only)

All prices, costs, and surplus changes are presented in 2005 dollars, and real equipment prices are assumed to be constant during the period of analysis. Net present values for 2006 were calculated using social discount rates of 3% and 7% over the 2007 and 2040 time period.

Results are presented for only those markets that are expected to incur direct variable costs under Tier 3 or Tier 4 standards. This means that results are not presented for marine vessel markets for vessels that have propulsion engines less than 800 hp or for recreational vessel markets.[17] For these vessel markets, the results are expected to be negligible and any change in price or quantity would be incidental to the changes in the larger vessel markets. It should also be noted that fixed costs are limited to only the Tier 4 standards. There are no fixed costs associated with the Tier 3 standards because Tier 3 engines are expected to have the same engine footprint as Tier 2 engines. For Tier 4 vessels, as explained in 7.2.3.4, fixed costs are not included in the EIM. The sensitivity analysis in Appendix 7H includes a case that applies both fixed and variable costs to the relevant markets.

[17] This version of the EIA is based on an earlier version of the marine emission control program that did not apply Tier 4 standards to any recreational marine diesel engines.

The NPV calculations presented in this Appendix are based on the period 2006-2040, reflecting the period when the analysis was completed. This has the consequence of discounting the current year costs, 2007, and all subsequent years are discounted by an additional year. The result is a smaller stream of social costs than by calculating the NPV over 2007-2040 (3% smaller for 3% NPV and 7% smaller for 7% NPV).

Table 7B-1. Impact on Locomotive Market: Line-Haul (Average Price per Locomotive = $2,000,000)[a,b]

Year	Variable Engineering Cost/Unit	Absolute Change in Price ($)	Change in Price (%)	Change in Quantity (%)	Total Engineering Costs (million $)	Change in Equipment Manufacturers' Surplus (million $)
2007	$0	$0	0.0%	0.0%	$0.6	-$0.6
2008	$0	-$255	0.0%	0.0%	$0.6	-$0.8
2009	$0	-$151	0.0%	0.0%	$0.6	-$0.7
2010	$0	-$239	0.0%	0.0%	$2.3	-$2.5
2011	$0	-$449	0.0%	-0.1%	$3.9	-$4.2
2012	$0	-$357	0.0%	0.0%	$5.1	-$5.4
2013	$0	-$313	0.0%	0.0%	$5.1	-$5.4
2014	$0	-$219	0.0%	0.0%	$7.2	-$7.4
2015	$44,390	$44,041	2.2%	0.0%	$39.7	-$3.7
2016	$44,390	$43,911	2.2%	-0.1%	$43.4	-$5.9
2017	$68,544	$67,982	3.4%	-0.1%	$60.1	-$0.5
2018	$68,544	$67,923	3.4%	-0.1%	$61.3	-$0.6
2019	$60,624	$60,006	3.0%	-0.1%	$55.6	-$0.6
2020	$60,624	$60,050	3.0%	-0.1%	$57.5	-$0.5
2021	$60,624	$59,991	3.0%	-0.1%	$59.3	-$0.6
2022	$60,624	$59,852	3.0%	-0.1%	$61.0	-$0.8
2023	$60,624	$59,626	3.0%	-0.1%	$62.7	-$1.0
2024	$60,624	$59,623	3.0%	-0.1%	$63.5	-$1.0
2025	$60,624	$59,557	3.0%	-0.1%	$65.3	-$1.1
2026	$60,624	$59,561	3.0%	-0.1%	$66.5	-$1.2
2027	$60,624	$59,509	3.0%	-0.2%	$67.8	-$1.2
2028	$60,624	$59,407	3.0%	-0.2%	$68.9	-$1.4
2029	$60,624	$59,359	3.0%	-0.2%	$69.7	-$1.5
2030	$60,624	$59,321	3.0%	-0.2%	$70.2	-$1.5
2031	$60,624	$59,279	3.0%	-0.2%	$71.1	-$1.6
2032	$60,624	$59,253	3.0%	-0.2%	$72.1	-$1.6
2033	$60,624	$59,017	3.0%	-0.2%	$73.3	-$1.9
2034	$60,624	$58,950	2.9%	-0.2%	$74.2	-$2.0
2035	$60,624	$58,891	2.9%	-0.2%	$74.6	-$2.1
2036	$60,624	$58,892	2.9%	-0.2%	$72.5	-$2.1
2037	$60,624	$58,858	2.9%	-0.2%	$71.0	-$2.1
2038	$60,624	$58,827	2.9%	-0.2%	$69.4	-$2.1
2039	$60,624	$58,798	2.9%	-0.2%	$67.4	-$2.0
2040	$60,624	$58,772	2.9%	-0.3%	$65.4	-$2.0
NPV at 3%					$886.5	-$44.5
NPV at 7%					$408.7	-$27.7

[a] Figures are in 2005 dollars.

[b] Net present values for 2006 are calculated using a social discount rate of 3% and 7% over the 2007 to 2040 time period.

Table 7B-2. Impact on Locomotive Market: Switchers (Average Price per Locomotive = $1,300,000)[a,b]

Year	Variable Engineering Cost/Unit	Absolute Change in Price ($)	Change in Price (%)	Change in Quantity (%)	Total Engineering Costs (million $)	Change in Equipment Manufacturers' Surplus (million $)
2007	$0	$0	0.0%	0.0%	$2.6	-$2.6
2008	$0	-$166	0.0%	0.0%	$2.6	-$2.6
2009	$0	-$98	0.0%	0.0%	$2.6	-$2.6
2010	$0	-$155	0.0%	0.0%	$4.9	-$5.0
2011	$0	-$292	0.0%	-0.1%	$6.9	-$7.0
2012	$0	-$232	0.0%	0.0%	$7.2	-$7.2
2013	$0	-$203	0.0%	0.0%	$7.2	-$7.3
2014	$0	-$142	0.0%	0.0%	$9.7	-$9.8
2015	$14,353	$14,126	1.1%	0.0%	$9.1	-$4.9
2016	$14,353	$14,042	1.1%	-0.1%	$11.8	-$7.4
2017	$19,230	$18,865	1.5%	-0.1%	$6.4	-$0.1
2018	$19,230	$18,827	1.4%	-0.1%	$6.6	-$0.1
2019	$17,770	$17,368	1.3%	-0.1%	$6.3	-$0.1
2020	$17,770	$17,396	1.3%	-0.1%	$6.6	-$0.1
2021	$17,770	$17,358	1.3%	-0.1%	$6.9	-$0.2
2022	$17,770	$17,268	1.3%	-0.1%	$7.1	-$0.2
2023	$17,770	$17,121	1.3%	-0.1%	$7.1	-$0.3
2024	$17,770	$17,119	1.3%	-0.1%	$7.2	-$0.3
2025	$17,770	$17,076	1.3%	-0.1%	$7.1	-$0.3
2026	$17,770	$17,078	1.3%	-0.1%	$7.0	-$0.3
2027	$17,770	$17,045	1.3%	-0.2%	$6.8	-$0.3
2028	$17,770	$16,978	1.3%	-0.2%	$6.7	-$0.3
2029	$17,770	$16,947	1.3%	-0.2%	$6.6	-$0.3
2030	$17,770	$16,922	1.3%	-0.2%	$6.5	-$0.3
2031	$17,770	$16,895	1.3%	-0.2%	$6.4	-$0.3
2032	$17,770	$16,878	1.3%	-0.2%	$6.4	-$0.3
2033	$17,770	$16,725	1.3%	-0.2%	$5.6	-$0.3
2034	$17,770	$16,681	1.3%	-0.2%	$5.4	-$0.3
2035	$17,770	$16,643	1.3%	-0.2%	$5.2	-$0.3
2036	$17,770	$16,644	1.3%	-0.2%	$4.9	-$0.3
2037	$17,770	$16,622	1.3%	-0.2%	$4.7	-$0.3
2038	$17,770	$16,602	1.3%	-0.2%	$4.5	-$0.3
2039	$17,770	$16,582	1.3%	-0.2%	$4.4	-$0.3
2040	$17,770	$16,566	1.3%	-0.3%	$4.2	-$0.3
NPV at 3%					$128.0	-$48.4
NPV at 7%					$73.6	-$35.8

[a] Figures are in 2005 dollars.

[b] Net present values for 2006 are calculated using a social discount rate of 3% and 7% over the 2007 to 2040 time period.

Table 7B-3. Impact on C1 Tow/Tug/Push Vessel Market: 800–2,000 hp (Average Price per Vessel = $1,550,000)[a,b]

Year	Variable Engineering Cost/Unit	Absolute Change in Price ($)	Change in Price (%)	Change in Quantity (%)	Total Engineering Costs (million $)	Change in Equipment Manufacturers' Surplus (million $)
2007	$0	$0	0.0%	0.0%	$0.0	Loss less than $0.1
2008	$0	$0	0.0%	0.0%	$0.0	Loss less than $0.1
2009	$0	$0	0.0%	0.0%	$0.0	Loss less than $0.1
2010	$0	$0	0.0%	0.0%	$0.0	Loss less than $0.1
2011	$0	$0	0.0%	0.0%	$0.0	Loss less than $0.1
2012	$0	$0	0.0%	0.0%	$0.0	Loss less than $0.1
2013	$0	$0	0.0%	0.0%	$0.0	Loss less than $0.1
2014	$0	-$27	0.0%	0.0%	$0.0	Loss less than $0.1
2015	$0	-$55	0.0%	0.0%	$0.9	-$0.9
2016	$2,384	$29,430	1.9%	-0.1%	$0.5	-$0.5
2017	$2,386	$29,346	1.9%	-0.1%	$0.3	-$0.3
2018	$2,385	$22,900	1.5%	-0.1%	$0.2	-$0.2
2019	$2,386	$22,791	1.5%	-0.1%	$0.2	-$0.2
2020	$2,384	$22,682	1.5%	-0.1%	$0.2	-$0.2
2021	$2,385	$22,578	1.5%	-0.1%	$0.2	-$0.2
2022	$2,385	$22,477	1.5%	-0.2%	$0.2	-$0.2
2023	$2,386	$22,377	1.4%	-0.2%	$0.2	-$0.2
2024	$2,386	$22,280	1.4%	-0.2%	$0.2	-$0.2
2025	$2,386	$22,186	1.4%	-0.2%	$0.2	-$0.2
2026	$2,386	$22,094	1.4%	-0.2%	$0.2	-$0.2
2027	$2,386	$22,005	1.4%	-0.2%	$0.1	-$0.1
2028	$2,385	$21,920	1.4%	-0.3%	$0.1	-$0.1
2029	$2,384	$21,843	1.4%	-0.3%	$0.1	-$0.1
2030	$2,386	$21,778	1.4%	-0.3%	$0.1	-$0.1
2031	$2,385	$21,718	1.4%	-0.3%	$0.1	-$0.1
2032	$2,386	$21,668	1.4%	-0.3%	$0.1	-$0.1
2033	$2,385	$21,619	1.4%	-0.3%	$0.1	-$0.1
2034	$2,386	$21,576	1.4%	-0.3%	$0.1	-$0.1
2035	$2,386	$21,537	1.4%	-0.3%	$0.1	-$0.1
2036	$2,384	$21,498	1.4%	-0.3%	$0.1	-$0.1
2037	$2,384	$21,467	1.4%	-0.3%	$0.1	-$0.1
2038	$2,384	$21,443	1.4%	-0.3%	$0.1	-$0.1
2039	$2,384	$21,423	1.4%	-0.3%	$0.1	-$0.1
2040	$2,384	$21,409	1.4%	-0.3%	$0.1	-$0.1
NPV at 3%					$3.1	-$2.5
NPV at 7%					$1.7	-$1.4

[a] Figures are in 2005 dollars.

[b] Net present values for 2006 are calculated using a social discount rate of 3% and 7% over the 2007 to 2040 time period.

Table 7B-4. Impact on C1 Tow/Tug/Push Vessel Market: >2,000 hp (Average Price per Vessel = $3,000,000)[a,b]

Year	Variable Engineering Cost/Unit	Absolute Change in Price ($)	Change in Price (%)	Change in Quantity (%)	Total Engineering Costs (million $)	Change in Equipment Manufacturers' Surplus (million $)
2007	$0	$0	0.0%	0.0%	$0.0	Loss less than $0.1
2008	$0	$0	0.0%	0.0%	$0.0	Loss less than $0.1
2009	$0	$0	0.0%	0.0%	$0.0	Loss less than $0.1
2010	$0	$0	0.0%	0.0%	$0.0	Loss less than $0.1
2011	$0	$0	0.0%	0.0%	$0.0	Loss less than $0.1
2012	$0	$0	0.0%	0.0%	$0.0	Loss less than $0.1
2013	$0	$0	0.0%	0.0%	$0.0	Loss less than $0.1
2014	$0	-$53	0.0%	0.0%	$0.0	Loss less than $0.1
2015	$0	-$106	0.0%	0.0%	$0.3	-$0.3
2016	$4,675	$49,380	1.6%	-0.1%	$0.2	-$0.2
2017	$4,674	$49,214	1.6%	-0.1%	$0.1	-$0.1
2018	$4,673	$38,375	1.3%	-0.1%	$0.1	-$0.1
2019	$4,671	$38,155	1.3%	-0.1%	$0.1	-$0.1
2020	$4,669	$37,940	1.3%	-0.1%	$0.1	-$0.1
2021	$4,674	$37,732	1.3%	-0.1%	$0.1	-$0.1
2022	$4,672	$37,519	1.3%	-0.2%	$0.1	-$0.1
2023	$4,669	$37,440	1.2%	-0.2%	$0.1	-$0.1
2024	$4,673	$37,239	1.2%	-0.2%	$0.1	-$0.1
2025	$4,669	$37,032	1.2%	-0.2%	$0.1	-$0.1
2026	$4,672	$36,837	1.2%	-0.2%	$0.1	-$0.1
2027	$4,668	$36,638	1.2%	-0.2%	$0.1	$0.0
2028	$4,671	$36,450	1.2%	-0.3%	$0.1	$0.0
2029	$4,673	$36,403	1.2%	-0.3%	$0.1	$0.0
2030	$4,675	$36,244	1.2%	-0.3%	$0.1	$0.0
2031	$4,669	$36,091	1.2%	-0.3%	$0.1	$0.0
2032	$4,670	$35,958	1.2%	-0.3%	$0.1	$0.0
2033	$4,671	$35,951	1.2%	-0.3%	$0.1	$0.0
2034	$4,671	$35,827	1.2%	-0.3%	$0.1	$0.0
2035	$4,671	$35,708	1.2%	-0.3%	$0.1	-$0.1
2036	$4,670	$35,709	1.2%	-0.3%	$0.1	-$0.1
2037	$4,670	$35,604	1.2%	-0.3%	$0.1	-$0.1
2038	$4,668	$35,621	1.2%	-0.3%	$0.1	-$0.1
2039	$4,673	$35,539	1.2%	-0.3%	$0.1	-$0.1
2040	$4,672	$35,459	1.2%	-0.3%	$0.1	-$0.1
NPV at 3%					$1.5	-$1.1
NPV at 7%					$0.8	-$0.6

[a] Figures are in 2005 dollars.

[b] Net present values for 2006 are calculated using a social discount rate of 3% and 7% over the 2007 to 2040 time period.

Table 7B-5. Impact on C2 Tow/Tug/Push Vessel Market: 800–2,000 hp (Average Price per Vessel = $2,325,000)[a,b]

Year	Variable Engineering Cost/Unit	Absolute Change in Price ($)	Change in Price (%)	Change in Quantity (%)	Total Engineering Costs (million $)	Change in Equipment Manufacturers' Surplus (million $)
2007	$0	$0	0.0%	0.0%	$0.0	Loss less than $0.1
2008	$0	$0	0.0%	0.0%	$0.0	Loss less than $0.1
2009	$0	$0	0.0%	0.0%	$0.0	Loss less than $0.1
2010	$0	$0	0.0%	0.0%	$0.0	Loss less than $0.1
2011	$0	$0	0.0%	0.0%	$0.0	Loss less than $0.1
2012	$0	$0	0.0%	0.0%	$0.0	Loss less than $0.1
2013	$0	$0	0.0%	0.0%	$0.0	Loss less than $0.1
2014	$0	-$45	0.0%	0.0%	$0.0	Loss less than $0.1
2015	$0	-$89	0.0%	0.0%	$0.5	-$0.5
2016	$3,960	$138,748	6.0%	-0.1%	$0.3	-$0.3
2017	$3,967	$138,497	6.0%	-0.1%	$0.2	-$0.2
2018	$3,963	$106,330	4.6%	-0.1%	$0.1	-$0.1
2019	$3,969	$106,067	4.6%	-0.1%	$0.1	-$0.1
2020	$3,965	$105,799	4.6%	-0.1%	$0.1	-$0.1
2021	$3,960	$105,539	4.6%	-0.1%	$0.1	-$0.1
2022	$3,965	$105,290	4.6%	-0.2%	$0.1	-$0.1
2023	$3,960	$105,038	4.6%	-0.2%	$0.1	-$0.1
2024	$3,964	$104,798	4.6%	-0.2%	$0.1	-$0.1
2025	$3,968	$104,564	4.5%	-0.2%	$0.1	-$0.1
2026	$3,962	$104,327	4.5%	-0.2%	$0.1	-$0.1
2027	$3,966	$105,410	4.6%	-0.2%	$0.0	Loss less than $0.1
2028	$3,969	$105,181	4.6%	-0.3%	$0.0	Loss less than $0.1
2029	$3,962	$104,955	4.6%	-0.3%	$0.0	Loss less than $0.1
2030	$3,964	$104,759	4.6%	-0.3%	$0.0	Loss less than $0.1
2031	$3,966	$104,574	4.5%	-0.3%	$0.0	Loss less than $0.1
2032	$3,968	$104,403	4.5%	-0.3%	$0.0	Loss less than $0.1
2033	$3,960	$104,230	4.5%	-0.3%	$0.0	Loss less than $0.1
2034	$3,961	$104,070	4.5%	-0.3%	$0.0	Loss less than $0.1
2035	$3,961	$103,917	4.5%	-0.3%	$0.0	Loss less than $0.1
2036	$3,962	$103,770	4.5%	-0.3%	$0.0	Loss less than $0.1
2037	$3,962	$103,635	4.5%	-0.3%	$0.0	Loss less than $0.1
2038	$3,962	$103,510	4.5%	-0.3%	$0.0	Loss less than $0.1
2039	$3,961	$103,396	4.5%	-0.3%	$0.0	Loss less than $0.1
2040	$3,960	$103,287	4.5%	-0.3%	$0.0	Loss less than $0.1
NPV at 3%					$1.7	-$1.4
NPV at 7%					$1.0	-$0.8

[a] Figures are in 2005 dollars.

[b] Net present values for 2006 are calculated using a social discount rate of 3% and 7% over the 2007 to 2040 time period.

Table 7B-6. Impact on C2 Tow/Tug/Push Vessel Market: >2,000 hp (Average Price per Vessel = $4,500,000)[a,b]

Year	Variable Engineering Cost/Unit	Absolute Change in Price ($)	Change in Price (%)	Change in Quantity (%)	Total Engineering Costs (million $)	Change in Equipment Manufacturers' Surplus (million $)
2007	$0	$0	0.0%	0.0%	$0.0	Loss less than $0.1
2008	$0	$0	0.0%	0.0%	$0.0	Loss less than $0.1
2009	$0	$0	0.0%	0.0%	$0.0	Loss less than $0.1
2010	$0	$0	0.0%	0.0%	$0.0	Loss less than $0.1
2011	$0	$0	0.0%	0.0%	$0.0	Loss less than $0.1
2012	$0	$0	0.0%	0.0%	$0.0	Loss less than $0.1
2013	$0	$0	0.0%	0.0%	$0.0	Loss less than $0.1
2014	$0	-$90	0.0%	0.0%	$0.0	Loss less than $0.1
2015	$0	-$178	0.0%	0.0%	$1.9	-$1.9
2016	$7,154	$218,206	4.8%	-0.1%	$1.4	-$1.1
2017	$7,154	$217,926	4.8%	-0.1%	$1.0	-$0.8
2018	$7,156	$167,280	3.7%	-0.1%	$0.6	-$0.4
2019	$7,154	$166,921	3.7%	-0.1%	$0.6	-$0.4
2020	$7,155	$166,572	3.7%	-0.1%	$0.6	-$0.4
2021	$7,155	$166,229	3.7%	-0.1%	$0.7	-$0.5
2022	$7,154	$165,895	3.7%	-0.2%	$0.7	-$0.5
2023	$7,156	$165,570	3.7%	-0.2%	$0.7	-$0.5
2024	$7,154	$165,251	3.7%	-0.2%	$0.7	-$0.5
2025	$7,154	$164,943	3.7%	-0.2%	$0.7	-$0.5
2026	$7,154	$164,644	3.7%	-0.2%	$0.7	-$0.5
2027	$7,155	$164,356	3.7%	-0.2%	$0.3	-$0.2
2028	$7,154	$164,079	3.6%	-0.3%	$0.3	-$0.2
2029	$7,154	$163,832	3.6%	-0.3%	$0.3	-$0.2
2030	$7,154	$163,613	3.6%	-0.3%	$0.3	-$0.2
2031	$7,155	$163,422	3.6%	-0.3%	$0.3	-$0.2
2032	$7,154	$163,254	3.6%	-0.3%	$0.3	-$0.2
2033	$7,154	$163,099	3.6%	-0.3%	$0.3	-$0.2
2034	$7,154	$162,956	3.6%	-0.3%	$0.3	-$0.2
2035	$7,155	$162,826	3.6%	-0.3%	$0.3	-$0.2
2036	$7,154	$162,704	3.6%	-0.3%	$0.3	-$0.2
2037	$7,154	$162,604	3.6%	-0.3%	$0.3	-$0.2
2038	$7,154	$162,522	3.6%	-0.3%	$0.3	-$0.3
2039	$7,155	$162,462	3.6%	-0.3%	$0.3	-$0.3
2040	$7,154	$162,413	3.6%	-0.3%	$0.3	-$0.3
NPV at 3%					$8.6	-$6.7
NPV at 7%					$4.6	-$3.6

[a] Figures are in 2005 dollars.

[b] Net present values for 2006 are calculated using a social discount rate of 3% and 7% over the 2007 to 2040 time period.

Table 7B-7. Impact on C1 Ferries Vessel Market: 800–2,000 hp (Average Price per Vessel = $1,550,000)[a,b]

Year	Variable Engineering Cost/Unit	Absolute Change in Price ($)	Change in Price (%)	Change in Quantity (%)	Total Engineering Costs (million $)	Change in Equipment Manufacturers' Surplus (million $)
2007	$0	$0	0.0%	0.0%	$0.0	Loss less than $0.1
2008	$0	$0	0.0%	0.0%	$0.0	Loss less than $0.1
2009	$0	$0	0.0%	0.0%	$0.0	Loss less than $0.1
2010	$0	$0	0.0%	0.0%	$0.0	Loss less than $0.1
2011	$0	$0	0.0%	0.0%	$0.0	Loss less than $0.1
2012	$0	$0	0.0%	0.0%	$0.0	Loss less than $0.1
2013	$0	$0	0.0%	0.0%	$0.0	Loss less than $0.1
2014	$0	-$27	0.0%	0.0%	$0.0	Loss less than $0.1
2015	$0	-$55	0.0%	0.0%	$0.1	-$0.1
2016	$2,391	$29,437	1.9%	-0.1%	$0.1	-$0.1
2017	$2,388	$29,348	1.9%	-0.1%	$0.1	Loss less than $0.1
2018	$2,384	$22,899	1.5%	-0.1%	$0.0	Loss less than $0.1
2019	$2,380	$22,786	1.5%	-0.1%	$0.0	Loss less than $0.1
2020	$2,376	$22,675	1.5%	-0.1%	$0.0	Loss less than $0.1
2021	$2,390	$22,583	1.5%	-0.1%	$0.0	Loss less than $0.1
2022	$2,385	$22,476	1.5%	-0.2%	$0.0	Loss less than $0.1
2023	$2,381	$22,372	1.4%	-0.2%	$0.0	Loss less than $0.1
2024	$2,393	$22,287	1.4%	-0.2%	$0.0	Loss less than $0.1
2025	$2,388	$22,188	1.4%	-0.2%	$0.0	Loss less than $0.1
2026	$2,384	$22,092	1.4%	-0.2%	$0.0	Loss less than $0.1
2027	$2,379	$21,998	1.4%	-0.2%	$0.0	Loss less than $0.1
2028	$2,390	$21,925	1.4%	-0.3%	$0.0	Loss less than $0.1
2029	$2,384	$21,843	1.4%	-0.3%	$0.0	Loss less than $0.1
2030	$2,379	$21,771	1.4%	-0.3%	$0.0	Loss less than $0.1
2031	$2,389	$21,723	1.4%	-0.3%	$0.0	Loss less than $0.1
2032	$2,383	$21,665	1.4%	-0.3%	$0.0	Loss less than $0.1
2033	$2,378	$21,612	1.4%	-0.3%	$0.0	Loss less than $0.1
2034	$2,387	$21,578	1.4%	-0.3%	$0.0	Loss less than $0.1
2035	$2,381	$21,531	1.4%	-0.3%	$0.0	Loss less than $0.1
2036	$2,390	$21,503	1.4%	-0.3%	$0.0	Loss less than $0.1
2037	$2,383	$21,466	1.4%	-0.3%	$0.0	Loss less than $0.1
2038	$2,392	$21,450	1.4%	-0.3%	$0.0	Loss less than $0.1
2039	$2,385	$21,423	1.4%	-0.3%	$0.0	Loss less than $0.1
2040	$2,378	$21,403	1.4%	-0.3%	$0.0	Loss less than $0.1
NPV at 3%					$0.5	-$0.4
NPV at 7%					$0.3	-$0.2

[a] Figures are in 2005 dollars.

[b] Net present values for 2006 are calculated using a social discount rate of 3% and 7% over the 2007 to 2040 time period.

Table 7B-8. Impact on C1 Ferries Vessel Market: >2,000 hp (Average Price per Vessel = $3,000,000)[a,b]

Year	Variable Engineering Cost/Unit	Absolute Change in Price ($)	Change in Price (%)	Change in Quantity (%)	Total Engineering Costs (million $)	Change in Equipment Manufacturers' Surplus (million $)
2007	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2008	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2009	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2010	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2011	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2012	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2013	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2014	$0	-$53	0.0%	0.0%	<$0.1	Loss less than $0.1
2015	$0	-$106	0.0%	0.0%	<$0.1	Loss less than $0.1
2016	$4,657	$49,362	1.6%	-0.1%	<$0.1	Loss less than $0.1
2017	$4,666	$49,206	1.6%	-0.1%	<$0.1	Loss less than $0.1
2018	$4,674	$38,376	1.3%	-0.1%	<$0.1	Loss less than $0.1
2019	$4,682	$38,167	1.3%	-0.1%	<$0.1	Loss less than $0.1
2020	$4,690	$37,961	1.3%	-0.1%	<$0.1	Loss less than $0.1
2021	$4,648	$37,706	1.3%	-0.1%	<$0.1	Loss less than $0.1
2022	$4,655	$37,503	1.3%	-0.2%	<$0.1	Loss less than $0.1
2023	$4,662	$37,433	1.2%	-0.2%	<$0.1	Loss less than $0.1
2024	$4,668	$37,234	1.2%	-0.2%	<$0.1	Loss less than $0.1
2025	$4,673	$37,037	1.2%	-0.2%	<$0.1	Loss less than $0.1
2026	$4,679	$36,843	1.2%	-0.2%	<$0.1	Loss less than $0.1
2027	$4,683	$36,653	1.2%	-0.2%	<$0.1	Loss less than $0.1
2028	$4,687	$36,467	1.2%	-0.3%	<$0.1	Loss less than $0.1
2029	$4,691	$36,421	1.2%	-0.3%	<$0.1	Loss less than $0.1
2030	$4,649	$36,219	1.2%	-0.3%	<$0.1	Loss less than $0.1
2031	$4,653	$36,075	1.2%	-0.3%	<$0.1	Loss less than $0.1
2032	$4,655	$35,944	1.2%	-0.3%	<$0.1	Loss less than $0.1
2033	$4,658	$35,938	1.2%	-0.3%	<$0.1	Loss less than $0.1
2034	$4,660	$35,816	1.2%	-0.3%	<$0.1	Loss less than $0.1
2035	$4,661	$35,699	1.2%	-0.3%	<$0.1	Loss less than $0.1
2036	$4,663	$35,701	1.2%	-0.3%	<$0.1	Loss less than $0.1
2037	$4,663	$35,597	1.2%	-0.3%	<$0.1	Loss less than $0.1
2038	$4,664	$35,617	1.2%	-0.3%	<$0.1	Loss less than $0.1
2039	$4,664	$35,530	1.2%	-0.3%	<$0.1	Loss less than $0.1
2040	$4,664	$35,451	1.2%	-0.3%	<$0.1	Loss less than $0.1
NPV at 3%					$0.2	-$0.2
NPV at 7%					$0.1	-$0.1

[a] Figures are in 2005 dollars.

[b] Net present values for 2006 are calculated using a social discount rate of 3% and 7% over the 2007 to 2040 time period.

Table 7B-9. Impact on C2 Ferries Vessel Market: 800–2,000 hp (Average Price per Vessel = $2,325,000)[a,b]

Year	Variable Engineering Cost/Unit	Absolute Change in Price ($)	Change in Price (%)	Change in Quantity (%)	Total Engineering Costs (million $)	Change in Equipment Manufacturers' Surplus (million $)
2007	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2008	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2009	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2010	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2011	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2012	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2013	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2014	$0	-$45	0.0%	0.0%	<$0.1	Loss less than $0.1
2015	$0	-$89	0.0%	0.0%	<$0.1	Loss less than $0.1
2016	$3,946	$138,733	6.0%	-0.1%	<$0.1	Loss less than $0.1
2017	$3,910	$138,440	6.0%	-0.1%	<$0.1	Loss less than $0.1
2018	$3,986	$106,353	4.6%	-0.1%	<$0.1	Loss less than $0.1
2019	$3,951	$106,048	4.6%	-0.1%	<$0.1	Loss less than $0.1
2020	$3,915	$105,750	4.6%	-0.1%	<$0.1	Loss less than $0.1
2021	$3,988	$105,567	4.6%	-0.1%	<$0.1	Loss less than $0.1
2022	$3,953	$105,277	4.6%	-0.2%	<$0.1	Loss less than $0.1
2023	$3,917	$104,995	4.6%	-0.2%	<$0.1	Loss less than $0.1
2024	$3,987	$104,821	4.6%	-0.2%	<$0.1	Loss less than $0.1
2025	$3,952	$104,547	4.5%	-0.2%	<$0.1	Loss less than $0.1
2026	$3,917	$104,281	4.5%	-0.2%	<$0.1	Loss less than $0.1
2027	$3,984	$105,428	4.6%	-0.2%	<$0.1	Loss less than $0.1
2028	$3,948	$105,161	4.6%	-0.3%	<$0.1	Loss less than $0.1
2029	$4,013	$105,007	4.6%	-0.3%	<$0.1	Loss less than $0.1
2030	$3,978	$104,773	4.6%	-0.3%	<$0.1	Loss less than $0.1
2031	$3,942	$104,550	4.5%	-0.3%	<$0.1	Loss less than $0.1
2032	$4,005	$104,440	4.5%	-0.3%	<$0.1	Loss less than $0.1
2033	$3,969	$104,239	4.5%	-0.3%	<$0.1	Loss less than $0.1
2034	$3,934	$104,043	4.5%	-0.3%	<$0.1	Loss less than $0.1
2035	$3,994	$103,949	4.5%	-0.3%	<$0.1	Loss less than $0.1
2036	$3,958	$103,766	4.5%	-0.3%	<$0.1	Loss less than $0.1
2037	$3,923	$103,596	4.5%	-0.3%	<$0.1	Loss less than $0.1
2038	$3,980	$103,529	4.5%	-0.3%	<$0.1	Loss less than $0.1
2039	$3,945	$103,380	4.5%	-0.3%	<$0.1	Loss less than $0.1
2040	$4,000	$103,327	4.5%	-0.3%	<$0.1	Loss less than $0.1
NPV at 3%					$0.2	-$0.1
NPV at 7%					$0.1	-$0.1

[a] Figures are in 2005 dollars.

[b] Net present values for 2006 are calculated using a social discount rate of 3% and 7% over the 2007 to 2040 time period.

Table 7B-10. Impact on C2 Ferries Vessel Market: >2,000 hp (Average Price per Vessel = $4,500,000)[a,b]

Year	Variable Engineering Cost/Unit	Absolute Change in Price ($)	Change in Price (%)	Change in Quantity (%)	Total Engineering Costs (million $)	Change in Equipment Manufacturers' Surplus (million $)
2007	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2008	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2009	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2010	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2011	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2012	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2013	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2014	$0	-$90	0.0%	0.0%	<$0.1	Loss less than $0.1
2015	$0	-$178	0.0%	0.0%	$0.2	-$0.2
2016	$7,158	$218,210	4.8%	-0.1%	$0.1	-$0.1
2017	$7,150	$217,923	4.8%	-0.1%	$0.1	-$0.1
2018	$7,142	$167,266	3.7%	-0.1%	$0.1	Loss less than $0.1
2019	$7,161	$166,927	3.7%	-0.1%	$0.1	Loss less than $0.1
2020	$7,151	$166,568	3.7%	-0.1%	$0.1	Loss less than $0.1
2021	$7,141	$166,216	3.7%	-0.1%	$0.1	Loss less than $0.1
2022	$7,158	$165,898	3.7%	-0.2%	$0.1	Loss less than $0.1
2023	$7,147	$165,561	3.7%	-0.2%	$0.1	Loss less than $0.1
2024	$7,162	$165,258	3.7%	-0.2%	$0.1	Loss less than $0.1
2025	$7,150	$164,939	3.7%	-0.2%	$0.1	Loss less than $0.1
2026	$7,163	$164,653	3.7%	-0.2%	$0.1	Loss less than $0.1
2027	$7,150	$164,352	3.7%	-0.2%	<$0.1	Loss less than $0.1
2028	$7,163	$164,088	3.6%	-0.3%	<$0.1	Loss less than $0.1
2029	$7,149	$163,827	3.6%	-0.3%	<$0.1	Loss less than $0.1
2030	$7,160	$163,619	3.6%	-0.3%	<$0.1	Loss less than $0.1
2031	$7,145	$163,412	3.6%	-0.3%	<$0.1	Loss less than $0.1
2032	$7,155	$163,255	3.6%	-0.3%	<$0.1	Loss less than $0.1
2033	$7,163	$163,108	3.6%	-0.3%	<$0.1	Loss less than $0.1
2034	$7,147	$162,950	3.6%	-0.3%	<$0.1	Loss less than $0.1
2035	$7,155	$162,825	3.6%	-0.3%	<$0.1	Loss less than $0.1
2036	$7,162	$162,712	3.6%	-0.3%	<$0.1	Loss less than $0.1
2037	$7,145	$162,594	3.6%	-0.3%	<$0.1	Loss less than $0.1
2038	$7,150	$162,519	3.6%	-0.3%	<$0.1	Loss less than $0.1
2039	$7,155	$162,462	3.6%	-0.3%	<$0.1	Loss less than $0.1
2040	$7,160	$162,419	3.6%	-0.3%	<$0.1	Loss less than $0.1
NPV at 3%					$0.8	-$0.6
NPV at 7%					$0.4	-$0.3

[a] Figures are in 2005 dollars.

[b] Net present values for 2006 are calculated using a social discount rate of 3% and 7% over the 2007 to 2040 time period.

Table 7B-11. Impact on C1 Supply/Crew Vessel Market: 800–2,000 hp (Average Price per Vessel = $3,100,000)[a,b]

Year	Variable Engineering Cost/Unit	Absolute Change in Price ($)	Change in Price (%)	Change in Quantity (%)	Total Engineering Costs (million $)	Change in Equipment Manufacturers' Surplus (million $)
2007	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2008	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2009	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2010	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2011	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2012	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2013	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2014	$0	-$55	0.0%	0.0%	<$0.1	Loss less than $0.1
2015	$0	-$108	0.0%	0.0%	$0.1	-$0.1
2016	$2,385	$29,105	0.9%	-0.1%	$0.1	-$0.1
2017	$2,381	$28,931	0.9%	-0.1%	$0.1	Loss less than $0.1
2018	$2,377	$22,414	0.7%	-0.1%	<$0.1	Loss less than $0.1
2019	$2,389	$22,209	0.7%	-0.1%	<$0.1	Loss less than $0.1
2020	$2,384	$21,991	0.7%	-0.1%	<$0.1	Loss less than $0.1
2021	$2,380	$21,778	0.7%	-0.1%	<$0.1	Loss less than $0.1
2022	$2,391	$21,587	0.7%	-0.2%	<$0.1	Loss less than $0.1
2023	$2,386	$21,384	0.7%	-0.2%	<$0.1	Loss less than $0.1
2024	$2,381	$21,186	0.7%	-0.2%	<$0.1	Loss less than $0.1
2025	$2,392	$21,009	0.7%	-0.2%	<$0.1	Loss less than $0.1
2026	$2,386	$20,822	0.7%	-0.2%	<$0.1	Loss less than $0.1
2027	$2,380	$20,640	0.7%	-0.2%	<$0.1	Loss less than $0.1
2028	$2,390	$20,482	0.7%	-0.3%	<$0.1	Loss less than $0.1
2029	$2,384	$20,326	0.7%	-0.3%	<$0.1	Loss less than $0.1
2030	$2,378	$20,187	0.7%	-0.3%	<$0.1	Loss less than $0.1
2031	$2,387	$20,079	0.6%	-0.3%	<$0.1	Loss less than $0.1
2032	$2,381	$19,971	0.6%	-0.3%	<$0.1	Loss less than $0.1
2033	$2,389	$19,886	0.6%	-0.3%	<$0.1	Loss less than $0.1
2034	$2,383	$19,792	0.6%	-0.3%	<$0.1	Loss less than $0.1
2035	$2,391	$19,720	0.6%	-0.3%	<$0.1	Loss less than $0.1
2036	$2,384	$19,640	0.6%	-0.3%	<$0.1	Loss less than $0.1
2037	$2,391	$19,586	0.6%	-0.3%	<$0.1	Loss less than $0.1
2038	$2,384	$19,529	0.6%	-0.3%	<$0.1	Loss less than $0.1
2039	$2,391	$19,498	0.6%	-0.3%	<$0.1	Loss less than $0.1
2040	$2,384	$19,463	0.6%	-0.3%	<$0.1	Loss less than $0.1
NPV at 3%					$0.5	-$0.5
NPV at 7%					$0.3	-$0.3

[a] Figures are in 2005 dollars.

[b] Net present values for 2006 are calculated using a social discount rate of 3% and 7% over the 2007 to 2040 time period.

Table 7B-12. Impact on C1 Supply/Crew Vessel Market: >2,000 hp (Average Price per Vessel = $6,000,000)[a,b]

Year	Variable Engineering Cost/Unit	Absolute Change in Price ($)	Change in Price (%)	Change in Quantity (%)	Total Engineering Costs (million $)	Change in Equipment Manufacturers' Surplus (million $)
2007	$0	$0	0.0%	0.0%	$0.0	$0.0
2008	$0	$0	0.0%	0.0%	$0.0	$0.0
2009	$0	$0	0.0%	0.0%	$0.0	$0.0
2010	$0	$0	0.0%	0.0%	$0.0	$0.0
2011	$0	$0	0.0%	0.0%	$0.0	$0.0
2012	$0	$0	0.0%	0.0%	$0.0	$0.0
2013	$0	$0	0.0%	0.0%	$0.0	$0.0
2014	$0	–$402	0.0%	0.0%	$0.0	$0.0
2015	$0	–$799	0.0%	0.0%	$0.8	–$0.8
2016	$4,671	$45,225	0.8%	–0.3%	$0.6	–$0.6
2017	$4,672	$43,974	0.7%	–0.3%	$0.4	–$0.5
2018	$4,673	$32,249	0.5%	–0.4%	$0.3	–$0.4
2019	$4,670	$30,635	0.5%	–0.4%	$0.3	–$0.4
2020	$4,673	$29,061	0.5%	–0.5%	$0.3	–$0.5
2021	$4,672	$27,513	0.5%	–0.6%	$0.3	–$0.6
2022	$4,671	$26,001	0.4%	–0.6%	$0.3	–$0.6
2023	$4,673	$24,663	0.4%	–0.7%	$0.3	–$0.7
2024	$4,671	$23,221	0.4%	–0.8%	$0.3	–$0.7
2025	$4,672	$21,819	0.4%	–0.8%	$0.3	–$0.8
2026	$4,673	$20,457	0.3%	–0.9%	$0.3	–$0.8
2027	$4,673	$19,136	0.3%	–0.9%	$0.2	–$0.7
2028	$4,672	$17,870	0.3%	–1.0%	$0.2	–$0.8
2029	$4,672	$16,860	0.3%	–1.0%	$0.2	–$0.8
2030	$4,671	$15,846	0.3%	–1.1%	$0.2	–$0.9
2031	$4,672	$14,953	0.2%	–1.1%	$0.2	–$0.9
2032	$4,673	$14,166	0.2%	–1.1%	$0.2	–$0.9
2033	$4,671	$13,556	0.2%	–1.2%	$0.2	–$1.0
2034	$4,671	$12,875	0.2%	–1.2%	$0.2	–$1.0
2035	$4,671	$12,242	0.2%	–1.2%	$0.2	–$1.0
2036	$4,673	$11,778	0.2%	–1.2%	$0.2	–$1.1
2037	$4,672	$11,279	0.2%	–1.3%	$0.2	–$1.1
2038	$4,670	$10,982	0.2%	–1.3%	$0.2	–$1.1
2039	$4,671	$10,651	0.2%	–1.3%	$0.2	–$1.1
2040	$4,672	$10,391	0.2%	–1.3%	$0.2	–$1.2
NPV at 3%					$3.9	–$10.5
NPV at 7%					$2.1	–$4.6

[a] Figures are in 2005 dollars.

[b] Net present values for 2006 are calculated using a social discount rate of 3% and 7% over the 2007 to 2040 time period.

Table 7B-13. Impact on C2 Supply/Crew Vessel Market: 800–2,000 hp (Average Price per Vessel = $2,325,000)[a,b]

Year	Variable Engineering Cost/Unit	Absolute Change in Price ($)	Change in Price (%)	Change in Quantity (%)	Total Engineering Costs (million $)	Change in Equipment Manufacturers' Surplus (million $)
2007	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2008	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2009	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2010	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2011	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2012	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2013	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2014	$0	-$45	0.0%	0.0%	<$0.1	Loss less than $0.1
2015	$0	-$89	0.0%	0.0%	$0.3	-$0.3
2016	$3,967	$138,755	6.0%	-0.1%	$0.2	-$0.2
2017	$3,969	$138,498	6.0%	-0.1%	$0.1	-$0.1
2018	$3,970	$106,337	4.6%	-0.1%	$0.1	-$0.1
2019	$3,971	$106,068	4.6%	-0.1%	$0.1	-$0.1
2020	$3,972	$105,806	4.6%	-0.1%	$0.1	-$0.1
2021	$3,972	$105,551	4.6%	-0.1%	$0.1	-$0.1
2022	$3,972	$105,297	4.6%	-0.2%	$0.1	-$0.1
2023	$3,972	$105,050	4.6%	-0.2%	$0.1	-$0.1
2024	$3,971	$104,804	4.6%	-0.2%	$0.1	-$0.1
2025	$3,970	$104,566	4.5%	-0.2%	$0.1	-$0.1
2026	$3,969	$104,334	4.5%	-0.2%	$0.1	-$0.1
2027	$3,968	$105,412	4.6%	-0.2%	<$0.1	Loss less than $0.1
2028	$3,966	$105,178	4.6%	-0.3%	<$0.1	Loss less than $0.1
2029	$3,964	$104,957	4.6%	-0.3%	<$0.1	Loss less than $0.1
2030	$3,961	$104,757	4.6%	-0.3%	<$0.1	Loss less than $0.1
2031	$3,959	$104,567	4.5%	-0.3%	<$0.1	Loss less than $0.1
2032	$3,972	$104,407	4.5%	-0.3%	<$0.1	Loss less than $0.1
2033	$3,969	$104,239	4.5%	-0.3%	<$0.1	Loss less than $0.1
2034	$3,965	$104,075	4.5%	-0.3%	<$0.1	Loss less than $0.1
2035	$3,962	$103,917	4.5%	-0.3%	<$0.1	Loss less than $0.1
2036	$3,958	$103,766	4.5%	-0.3%	<$0.1	Loss less than $0.1
2037	$3,969	$103,642	4.5%	-0.3%	<$0.1	Loss less than $0.1
2038	$3,964	$103,513	4.5%	-0.3%	<$0.1	Loss less than $0.1
2039	$3,959	$103,394	4.5%	-0.3%	<$0.1	Loss less than $0.1
2040	$3,969	$103,296	4.5%	-0.3%	<$0.1	Loss less than $0.1
NPV at 3%					$1.0	-$0.8
NPV at 7%					$0.5	-$0.5

[a] Figures are in 2005 dollars.

[b] Net present values for 2006 are calculated using a social discount rate of 3% and 7% over the 2007 to 2040 time period.

Table 7B-14. Impact on C2 Supply/Crew Vessel Market: >2,000 hp (Average Price per Vessel = $4,500,000)[a,b]

Year	Variable Engineering Cost/Unit	Absolute Change in Price ($)	Change in Price (%)	Change in Quantity (%)	Total Engineering Costs (million $)	Change in Equipment Manufacturers' Surplus (million $)
2007	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2008	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2009	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2010	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2011	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2012	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2013	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2014	$0	-$90	0.0%	0.0%	<$0.1	Loss less than $0.1
2015	$0	-$178	0.0%	0.0%	$1.1	-$1.1
2016	$7,153	$218,205	4.8%	-0.1%	$0.8	-$0.7
2017	$7,154	$217,926	4.8%	-0.1%	$0.6	-$0.4
2018	$7,154	$167,278	3.7%	-0.1%	$0.4	-$0.2
2019	$7,154	$166,921	3.7%	-0.1%	$0.4	-$0.2
2020	$7,154	$166,571	3.7%	-0.1%	$0.4	-$0.3
2021	$7,152	$166,227	3.7%	-0.1%	$0.4	-$0.3
2022	$7,155	$165,896	3.7%	-0.2%	$0.4	-$0.3
2023	$7,153	$165,567	3.7%	-0.2%	$0.4	-$0.3
2024	$7,154	$165,251	3.7%	-0.2%	$0.4	-$0.3
2025	$7,155	$164,944	3.7%	-0.2%	$0.4	-$0.3
2026	$7,156	$164,646	3.7%	-0.2%	$0.4	-$0.3
2027	$7,155	$164,357	3.7%	-0.2%	$0.2	-$0.1
2028	$7,155	$164,080	3.6%	-0.3%	$0.2	-$0.1
2029	$7,153	$163,831	3.6%	-0.3%	$0.2	-$0.1
2030	$7,155	$163,614	3.6%	-0.3%	$0.2	-$0.1
2031	$7,153	$163,420	3.6%	-0.3%	$0.2	-$0.1
2032	$7,154	$163,254	3.6%	-0.3%	$0.2	-$0.1
2033	$7,154	$163,099	3.6%	-0.3%	$0.2	-$0.1
2034	$7,154	$162,957	3.6%	-0.3%	$0.2	-$0.1
2035	$7,154	$162,824	3.6%	-0.3%	$0.2	-$0.1
2036	$7,156	$162,706	3.6%	-0.3%	$0.2	-$0.1
2037	$7,155	$162,604	3.6%	-0.3%	$0.2	-$0.1
2038	$7,156	$162,524	3.6%	-0.3%	$0.2	-$0.1
2039	$7,153	$162,459	3.6%	-0.3%	$0.2	-$0.1
2040	$7,153	$162,412	3.6%	-0.3%	$0.2	-$0.1
NPV at 3%					$4.9	-$3.8
NPV at 7%					$2.6	-$2.1

[a] Figures are in 2005 dollars.

[b] Net present values for 2006 are calculated using a social discount rate of 3% and 7% over the 2007 to 2040 time period.

Table 7B-15. Impact on C1 Cargo Vessel Market: 800–2,000 hp (Average Price per Vessel = $3,100,000)[a,b]

Year	Variable Engineering Cost/Unit	Absolute Change in Price ($)	Change in Price (%)	Change in Quantity (%)	Total Engineering Costs (million $)	Change in Equipment Manufacturers' Surplus (million $)
2007	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2008	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2009	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2010	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2011	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2012	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2013	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2014	$0	-$55	0.0%	0.0%	<$0.1	Loss less than $0.1
2015	$0	-$108	0.0%	0.0%	<$0.1	Loss less than $0.1
2016	$2,400	$29,119	0.9%	-0.1%	<$0.1	Loss less than $0.1
2017	$2,378	$28,928	0.9%	-0.1%	<$0.1	Loss less than $0.1
2018	$2,412	$22,449	0.7%	-0.1%	<$0.1	Loss less than $0.1
2019	$2,390	$22,210	0.7%	-0.1%	<$0.1	Loss less than $0.1
2020	$2,369	$21,976	0.7%	-0.1%	<$0.1	Loss less than $0.1
2021	$2,401	$21,800	0.7%	-0.1%	<$0.1	Loss less than $0.1
2022	$2,380	$21,576	0.7%	-0.2%	<$0.1	Loss less than $0.1
2023	$2,411	$21,409	0.7%	-0.2%	<$0.1	Loss less than $0.1
2024	$2,390	$21,194	0.7%	-0.2%	<$0.1	Loss less than $0.1
2025	$2,368	$20,986	0.7%	-0.2%	<$0.1	Loss less than $0.1
2026	$2,398	$20,834	0.7%	-0.2%	<$0.1	Loss less than $0.1
2027	$2,377	$20,637	0.7%	-0.2%	<$0.1	Loss less than $0.1
2028	$2,406	$20,498	0.7%	-0.3%	<$0.1	Loss less than $0.1
2029	$2,384	$20,326	0.7%	-0.3%	<$0.1	Loss less than $0.1
2030	$2,363	$20,172	0.7%	-0.3%	<$0.1	Loss less than $0.1
2031	$2,391	$20,083	0.6%	-0.3%	<$0.1	Loss less than $0.1
2032	$2,369	$19,959	0.6%	-0.3%	<$0.1	Loss less than $0.1
2033	$2,396	$19,892	0.6%	-0.3%	<$0.1	Loss less than $0.1
2034	$2,375	$19,784	0.6%	-0.3%	<$0.1	Loss less than $0.1
2035	$2,401	$19,730	0.6%	-0.3%	<$0.1	Loss less than $0.1
2036	$2,379	$19,635	0.6%	-0.3%	<$0.1	Loss less than $0.1
2037	$2,404	$19,599	0.6%	-0.3%	<$0.1	Loss less than $0.1
2038	$2,383	$19,528	0.6%	-0.3%	<$0.1	Loss less than $0.1
2039	$2,407	$19,514	0.6%	-0.3%	<$0.1	Loss less than $0.1
2040	$2,386	$19,465	0.6%	-0.3%	<$0.1	Loss less than $0.1
NPV at 3%					$0.2	-$0.2
NPV at 7%					$0.1	-$0.1

[a] Figures are in 2005 dollars.

[b] Net present values for 2006 are calculated using a social discount rate of 3% and 7% over the 2007 to 2040 time period.

Table 7B-16. Impact on C1 Cargo Vessel Market: >2,000 hp (Average Price per Vessel = $6,000,000)[a,b]

Year	Variable Engineering Cost/Unit	Absolute Change in Price ($)	Change in Price (%)	Change in Quantity (%)	Total Engineering Costs (million $)	Change in Equipment Manufacturers' Surplus (million $)
2007	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2008	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2009	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2010	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2011	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2012	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2013	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2014	$0	-$106	0.0%	0.0%	<$0.1	Loss less than $0.1
2015	$0	-$210	0.0%	0.0%	<$0.1	Loss less than $0.1
2016	$4,606	$48,681	0.8%	-0.1%	<$0.1	Loss less than $0.1
2017	$4,723	$48,469	0.8%	-0.1%	<$0.1	Loss less than $0.1
2018	$4,681	$37,458	0.6%	-0.1%	<$0.1	Loss less than $0.1
2019	$4,639	$36,989	0.6%	-0.1%	<$0.1	Loss less than $0.1
2020	$4,598	$36,530	0.6%	-0.1%	<$0.1	Loss less than $0.1
2021	$4,708	$36,227	0.6%	-0.1%	<$0.1	Loss less than $0.1
2022	$4,666	$35,780	0.6%	-0.2%	<$0.1	Loss less than $0.1
2023	$4,625	$35,473	0.6%	-0.2%	<$0.1	Loss less than $0.1
2024	$4,731	$35,189	0.6%	-0.2%	<$0.1	Loss less than $0.1
2025	$4,689	$34,764	0.6%	-0.2%	<$0.1	Loss less than $0.1
2026	$4,647	$34,349	0.6%	-0.2%	<$0.1	Loss less than $0.1
2027	$4,606	$33,944	0.6%	-0.2%	<$0.1	Loss less than $0.1
2028	$4,707	$33,694	0.6%	-0.3%	<$0.1	Loss less than $0.1
2029	$4,665	$33,458	0.6%	-0.3%	<$0.1	Loss less than $0.1
2030	$4,624	$33,128	0.6%	-0.3%	<$0.1	Loss less than $0.1
2031	$4,721	$32,967	0.5%	-0.3%	<$0.1	Loss less than $0.1
2032	$4,679	$32,693	0.5%	-0.3%	<$0.1	Loss less than $0.1
2033	$4,638	$32,553	0.5%	-0.3%	<$0.1	Loss less than $0.1
2034	$4,731	$32,439	0.5%	-0.3%	<$0.1	Loss less than $0.1
2035	$4,689	$32,201	0.5%	-0.3%	<$0.1	Loss less than $0.1
2036	$4,647	$32,090	0.5%	-0.3%	<$0.1	Loss less than $0.1
2037	$4,606	$31,885	0.5%	-0.3%	<$0.1	Loss less than $0.1
2038	$4,695	$31,946	0.5%	-0.3%	<$0.1	Loss less than $0.1
2039	$4,653	$31,781	0.5%	-0.3%	<$0.1	Loss less than $0.1
2040	$4,612	$31,634	0.5%	-0.3%	<$0.1	Loss less than $0.1
NPV at 3%					$0.1	-$0.1
NPV at 7%					<$0.1	Loss less than $0.1

[a] Figures are in 2005 dollars.

[b] Net present values for 2006 are calculated using a social discount rate of 3% and 7% over the 2007 to 2040 time period.

Table 7B-17. Impact on C2 Cargo Vessel Market: 800–2,000 hp (Average Price per Vessel = $4,650,000)[a,b]

Year	Variable Engineering Cost/Unit	Absolute Change in Price ($)	Change in Price (%)	Change in Quantity (%)	Total Engineering Costs (million $)	Change in Equipment Manufacturers' Surplus (million $)
2007	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2008	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2009	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2010	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2011	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2012	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2013	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2014	$0	-$85	0.0%	0.0%	<$0.1	Loss less than $0.1
2015	$0	-$169	0.0%	0.0%	$0.1	-$0.1
2016	$3,972	$138,276	3.0%	-0.1%	<$0.1	Loss less than $0.1
2017	$3,937	$137,857	3.0%	-0.1%	<$0.1	Loss less than $0.1
2018	$3,972	$105,630	2.3%	-0.1%	<$0.1	Loss less than $0.1
2019	$3,937	$105,165	2.3%	-0.1%	<$0.1	Loss less than $0.1
2020	$3,971	$104,780	2.3%	-0.1%	<$0.1	Loss less than $0.1
2021	$3,936	$104,335	2.3%	-0.1%	<$0.1	Loss less than $0.1
2022	$3,969	$103,965	2.3%	-0.2%	<$0.1	Loss less than $0.1
2023	$3,934	$103,537	2.3%	-0.2%	<$0.1	Loss less than $0.1
2024	$3,966	$103,183	2.2%	-0.2%	<$0.1	Loss less than $0.1
2025	$3,997	$102,838	2.2%	-0.2%	<$0.1	Loss less than $0.1
2026	$3,962	$102,438	2.2%	-0.2%	<$0.1	Loss less than $0.1
2027	$3,992	$103,418	2.2%	-0.2%	<$0.1	Loss less than $0.1
2028	$3,956	$103,027	2.2%	-0.3%	<$0.1	Loss less than $0.1
2029	$3,985	$102,727	2.2%	-0.3%	<$0.1	Loss less than $0.1
2030	$3,950	$102,395	2.2%	-0.3%	<$0.1	Loss less than $0.1
2031	$3,978	$102,150	2.2%	-0.3%	<$0.1	Loss less than $0.1
2032	$3,942	$101,866	2.2%	-0.3%	<$0.1	Loss less than $0.1
2033	$3,969	$101,659	2.2%	-0.3%	<$0.1	Loss less than $0.1
2034	$3,995	$101,460	2.2%	-0.3%	<$0.1	Loss less than $0.1
2035	$3,959	$101,212	2.2%	-0.3%	<$0.1	Loss less than $0.1
2036	$3,984	$101,036	2.2%	-0.3%	<$0.1	Loss less than $0.1
2037	$3,949	$100,820	2.2%	-0.3%	<$0.1	Loss less than $0.1
2038	$3,973	$100,684	2.2%	-0.3%	<$0.1	Loss less than $0.1
2039	$3,937	$100,506	2.2%	-0.3%	<$0.1	Loss less than $0.1
2040	$3,961	$100,400	2.2%	-0.3%	<$0.1	Loss less than $0.1
NPV at 3%					$0.3	-$0.2
NPV at 7%					$0.1	-$0.1

[a] Figures are in 2005 dollars.

[b] Net present values for 2006 are calculated using a social discount rate of 3% and 7% over the 2007 to 2040 time period.

Table 7B-18. Impact on C2 Cargo Vessel Market: >2,000 hp (Average Price per Vessel = $9,000,000)[a,b]

Year	Variable Engineering Cost/Unit	Absolute Change in Price ($)	Change in Price (%)	Change in Quantity (%)	Total Engineering Costs (million $)	Change in Equipment Manufacturers' Surplus (million $)
2007	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2008	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2009	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2010	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2011	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2012	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2013	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2014	$0	-$168	0.0%	0.0%	<$0.1	Loss less than $0.1
2015	$0	-$334	0.0%	0.0%	$0.3	-$0.3
2016	$7,150	$217,255	2.4%	-0.1%	$0.2	-$0.2
2017	$7,157	$216,739	2.4%	-0.1%	$0.1	-$0.1
2018	$7,147	$165,883	1.8%	-0.1%	$0.1	-$0.1
2019	$7,153	$165,219	1.8%	-0.1%	$0.1	-$0.1
2020	$7,159	$164,568	1.8%	-0.1%	$0.1	-$0.1
2021	$7,147	$163,914	1.8%	-0.1%	$0.1	-$0.1
2022	$7,152	$163,292	1.8%	-0.2%	$0.1	-$0.1
2023	$7,156	$162,684	1.8%	-0.2%	$0.1	-$0.1
2024	$7,159	$162,093	1.8%	-0.2%	$0.1	-$0.1
2025	$7,162	$161,518	1.8%	-0.2%	$0.1	-$0.1
2026	$7,148	$160,943	1.8%	-0.2%	$0.1	-$0.1
2027	$7,149	$160,403	1.8%	-0.2%	<$0.1	Loss less than $0.1
2028	$7,150	$159,886	1.8%	-0.3%	<$0.1	-$0.1
2029	$7,151	$159,422	1.8%	-0.3%	<$0.1	-$0.1
2030	$7,151	$159,012	1.8%	-0.3%	<$0.1	-$0.1
2031	$7,150	$158,652	1.8%	-0.3%	<$0.1	-$0.1
2032	$7,149	$158,336	1.8%	-0.3%	<$0.1	-$0.1
2033	$7,147	$158,045	1.8%	-0.3%	<$0.1	-$0.1
2034	$7,160	$157,790	1.8%	-0.3%	<$0.1	-$0.1
2035	$7,157	$157,539	1.8%	-0.3%	<$0.1	-$0.1
2036	$7,154	$157,310	1.7%	-0.3%	<$0.1	-$0.1
2037	$7,150	$157,118	1.7%	-0.3%	<$0.1	-$0.1
2038	$7,160	$156,975	1.7%	-0.3%	<$0.1	-$0.1
2039	$7,155	$156,853	1.7%	-0.3%	<$0.1	-$0.1
2040	$7,149	$156,760	1.7%	-0.3%	<$0.1	-$0.1
NPV at 3%					$1.3	-$1.3
NPV at 7%					$0.7	-$0.7

[a] Figures are in 2005 dollars.

[b] Net present values for 2006 are calculated using a social discount rate of 3% and 7% over the 2007 to 2040 time period.

Table 7B-19. Impact on C1 Other Commercial Vessel Market: 800–2,000 hp (Average Price per Vessel = $1,085,000)[a,b]

Year	Variable Engineering Cost/Unit	Absolute Change in Price ($)	Change in Price (%)	Change in Quantity (%)	Total Engineering Costs (million $)	Change in Equipment Manufacturers' Surplus (million $)
2007	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2008	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2009	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2010	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2011	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2012	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2013	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2014	$0	-$19	0.0%	0.0%	<$0.1	Loss less than $0.1
2015	$0	-$38	0.0%	0.0%	$0.1	-$0.1
2016	$2,381	$29,525	2.7%	-0.1%	$0.1	-$0.1
2017	$2,383	$29,466	2.7%	-0.1%	<$0.1	Loss less than $0.1
2018	$2,384	$23,043	2.1%	-0.1%	<$0.1	Loss less than $0.1
2019	$2,385	$22,966	2.1%	-0.1%	<$0.1	Loss less than $0.1
2020	$2,386	$22,892	2.1%	-0.1%	<$0.1	Loss less than $0.1
2021	$2,386	$22,818	2.1%	-0.1%	<$0.1	Loss less than $0.1
2022	$2,387	$22,747	2.1%	-0.2%	<$0.1	Loss less than $0.1
2023	$2,387	$22,677	2.1%	-0.2%	<$0.1	Loss less than $0.1
2024	$2,387	$22,608	2.1%	-0.2%	<$0.1	Loss less than $0.1
2025	$2,387	$22,541	2.1%	-0.2%	<$0.1	Loss less than $0.1
2026	$2,386	$22,476	2.1%	-0.2%	<$0.1	Loss less than $0.1
2027	$2,386	$22,413	2.1%	-0.2%	<$0.1	Loss less than $0.1
2028	$2,385	$22,353	2.1%	-0.3%	<$0.1	Loss less than $0.1
2029	$2,384	$22,299	2.1%	-0.3%	<$0.1	Loss less than $0.1
2030	$2,383	$22,251	2.1%	-0.3%	<$0.1	Loss less than $0.1
2031	$2,382	$22,208	2.0%	-0.3%	<$0.1	Loss less than $0.1
2032	$2,381	$22,170	2.0%	-0.3%	<$0.1	Loss less than $0.1
2033	$2,379	$22,135	2.0%	-0.3%	<$0.1	Loss less than $0.1
2034	$2,377	$22,103	2.0%	-0.3%	<$0.1	Loss less than $0.1
2035	$2,375	$22,072	2.0%	-0.3%	<$0.1	Loss less than $0.1
2036	$2,392	$22,063	2.0%	-0.3%	<$0.1	Loss less than $0.1
2037	$2,390	$22,039	2.0%	-0.3%	<$0.1	Loss less than $0.1
2038	$2,388	$22,019	2.0%	-0.3%	<$0.1	Loss less than $0.1
2039	$2,385	$22,003	2.0%	-0.3%	<$0.1	Loss less than $0.1
2040	$2,382	$21,990	2.0%	-0.3%	<$0.1	Loss less than $0.1
NPV at 3%					$0.4	-$0.3
NPV at 7%					$0.2	-$0.2

[a] Figures are in 2005 dollars.

[b] Net present values for 2006 are calculated using a social discount rate of 3% and 7% over the 2007 to 2040 time period.

Table 7B-20. Impact on C1 Other Commercial Vessel Market: >2,000 hp (Average Price per Vessel = $2,100,000)[a,b]

Year	Variable Engineering Cost/Unit	Absolute Change in Price ($)	Change in Price (%)	Change in Quantity (%)	Total Engineering Costs (million $)	Change in Equipment Manufacturers' Surplus (million $)
2007	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2008	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2009	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2010	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2011	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2012	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2013	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2014	$0	-$38	0.0%	0.0%	<$0.1	Loss less than $0.1
2015	$0	-$74	0.0%	0.0%	<$0.1	Loss less than $0.1
2016	$4,692	$49,587	2.4%	-0.1%	<$0.1	Loss less than $0.1
2017	$4,650	$49,428	2.4%	-0.1%	<$0.1	Loss less than $0.1
2018	$4,673	$38,652	1.8%	-0.1%	<$0.1	Loss less than $0.1
2019	$4,694	$38,519	1.8%	-0.1%	<$0.1	Loss less than $0.1
2020	$4,653	$38,325	1.8%	-0.1%	<$0.1	Loss less than $0.1
2021	$4,673	$38,192	1.8%	-0.1%	<$0.1	Loss less than $0.1
2022	$4,693	$38,061	1.8%	-0.2%	<$0.1	Loss less than $0.1
2023	$4,652	$38,000	1.8%	-0.2%	<$0.1	Loss less than $0.1
2024	$4,671	$37,870	1.8%	-0.2%	<$0.1	Loss less than $0.1
2025	$4,689	$37,739	1.8%	-0.2%	<$0.1	Loss less than $0.1
2026	$4,647	$37,551	1.8%	-0.2%	<$0.1	Loss less than $0.1
2027	$4,665	$37,424	1.8%	-0.2%	<$0.1	Loss less than $0.1
2028	$4,682	$37,299	1.8%	-0.3%	<$0.1	Loss less than $0.1
2029	$4,698	$37,310	1.8%	-0.3%	<$0.1	Loss less than $0.1
2030	$4,656	$37,145	1.8%	-0.3%	<$0.1	Loss less than $0.1
2031	$4,672	$37,047	1.8%	-0.3%	<$0.1	Loss less than $0.1
2032	$4,686	$36,957	1.8%	-0.3%	<$0.1	Loss less than $0.1
2033	$4,645	$36,934	1.8%	-0.3%	<$0.1	Loss less than $0.1
2034	$4,659	$36,850	1.8%	-0.3%	<$0.1	Loss less than $0.1
2035	$4,672	$36,767	1.8%	-0.3%	<$0.1	Loss less than $0.1
2036	$4,685	$36,803	1.8%	-0.3%	<$0.1	Loss less than $0.1
2037	$4,697	$36,727	1.7%	-0.3%	<$0.1	Loss less than $0.1
2038	$4,655	$36,719	1.7%	-0.3%	<$0.1	Loss less than $0.1
2039	$4,667	$36,654	1.7%	-0.3%	<$0.1	Loss less than $0.1
2040	$4,678	$36,595	1.7%	-0.3%	<$0.1	Loss less than $0.1
NPV at 3%					$0.2	-$0.1
NPV at 7%					$0.1	-$0.1

[a] Figures are in 2005 dollars.

[b] Net present values for 2006 are calculated using a social discount rate of 3% and 7% over the 2007 to 2040 time period.

Table 7B-21. Impact on C2 Other Commercial Vessel Market: 800–2,000 hp (Average Price per Vessel = $1,627,500)[a,b]

Year	Variable Engineering Cost/Unit	Absolute Change in Price ($)	Change in Price (%)	Change in Quantity (%)	Total Engineering Costs (million $)	Change in Equipment Manufacturers' Surplus (million $)
2007	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2008	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2009	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2010	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2011	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2012	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2013	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2014	$0	-$33	0.0%	0.0%	<$0.1	Loss less than $0.1
2015	$0	-$65	0.0%	0.0%	<$0.1	Loss less than $0.1
2016	$3,950	$138,883	8.6%	-0.1%	<$0.1	Loss less than $0.1
2017	$3,915	$138,627	8.6%	-0.1%	<$0.1	Loss less than $0.1
2018	$3,880	$106,460	6.6%	-0.1%	<$0.1	Loss less than $0.1
2019	$3,846	$106,204	6.6%	-0.1%	<$0.1	Loss less than $0.1
2020	$3,811	$105,954	6.6%	-0.1%	<$0.1	Loss less than $0.1
2021	$3,777	$105,710	6.6%	-0.1%	<$0.1	Loss less than $0.1
2022	$4,118	$105,841	6.6%	-0.2%	<$0.1	Loss less than $0.1
2023	$4,081	$105,601	6.6%	-0.2%	<$0.1	Loss less than $0.1
2024	$4,045	$105,363	6.5%	-0.2%	<$0.1	Loss less than $0.1
2025	$4,009	$105,131	6.5%	-0.2%	<$0.1	Loss less than $0.1
2026	$3,973	$104,904	6.5%	-0.2%	<$0.1	Loss less than $0.1
2027	$3,938	$105,987	6.6%	-0.2%	<$0.1	Loss less than $0.1
2028	$3,902	$105,757	6.6%	-0.3%	<$0.1	Loss less than $0.1
2029	$3,868	$105,537	6.6%	-0.3%	<$0.1	Loss less than $0.1
2030	$3,833	$105,334	6.5%	-0.3%	<$0.1	Loss less than $0.1
2031	$3,799	$105,138	6.5%	-0.3%	<$0.1	Loss less than $0.1
2032	$4,107	$105,296	6.5%	-0.3%	<$0.1	Loss less than $0.1
2033	$4,071	$105,115	6.5%	-0.3%	<$0.1	Loss less than $0.1
2034	$4,034	$104,937	6.5%	-0.3%	<$0.1	Loss less than $0.1
2035	$3,998	$104,764	6.5%	-0.3%	<$0.1	Loss less than $0.1
2036	$3,963	$104,598	6.5%	-0.3%	<$0.1	Loss less than $0.1
2037	$3,927	$104,441	6.5%	-0.3%	<$0.1	Loss less than $0.1
2038	$3,892	$104,293	6.5%	-0.3%	<$0.1	Loss less than $0.1
2039	$3,858	$104,153	6.5%	-0.3%	<$0.1	Loss less than $0.1
2040	$3,823	$104,016	6.5%	-0.3%	<$0.1	Loss less than $0.1
NPV at 3%					<$0.1	Loss less than $0.1
NPV at 7%					<$0.1	Loss less than $0.1

[a] Figures are in 2005 dollars.

[b] Net present values for 2006 are calculated using a social discount rate of 3% and 7% over the 2007 to 2040 time period.

Table 7B-22. Impact on C2 Other Commercial Vessel Market: >2,000 hp (Average Price per Vessel = $3,150,000)[a,b]

Year	Variable Engineering Cost/Unit	Absolute Change in Price ($)	Change in Price (%)	Change in Quantity (%)	Total Engineering Costs (million $)	Change in Equipment Manufacturers' Surplus (million $)
2007	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2008	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2009	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2010	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2011	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2012	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2013	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1
2014	$0	-$66	0.0%	0.0%	<$0.1	Loss less than $0.1
2015	$0	-$131	0.0%	0.0%	$0.1	-$0.1
2016	$7,111	$218,447	6.9%	-0.1%	<$0.1	Loss less than $0.1
2017	$7,145	$218,275	6.9%	-0.1%	<$0.1	Loss less than $0.1
2018	$7,178	$167,718	5.3%	-0.1%	<$0.1	Loss less than $0.1
2019	$7,114	$167,391	5.3%	-0.1%	<$0.1	Loss less than $0.1
2020	$7,146	$167,165	5.3%	-0.1%	<$0.1	Loss less than $0.1
2021	$7,177	$166,944	5.3%	-0.1%	<$0.1	Loss less than $0.1
2022	$7,113	$166,633	5.3%	-0.2%	<$0.1	Loss less than $0.1
2023	$7,142	$166,422	5.3%	-0.2%	<$0.1	Loss less than $0.1
2024	$7,170	$166,216	5.3%	-0.2%	<$0.1	Loss less than $0.1
2025	$7,197	$166,016	5.3%	-0.2%	<$0.1	Loss less than $0.1
2026	$7,133	$165,732	5.3%	-0.2%	<$0.1	Loss less than $0.1
2027	$7,159	$165,545	5.3%	-0.2%	<$0.1	Loss less than $0.1
2028	$7,184	$165,366	5.2%	-0.3%	<$0.1	Loss less than $0.1
2029	$7,120	$165,120	5.2%	-0.3%	<$0.1	Loss less than $0.1
2030	$7,144	$164,982	5.2%	-0.3%	<$0.1	Loss less than $0.1
2031	$7,166	$164,863	5.2%	-0.3%	<$0.1	Loss less than $0.1
2032	$7,188	$164,761	5.2%	-0.3%	<$0.1	Loss less than $0.1
2033	$7,124	$164,583	5.2%	-0.3%	<$0.1	Loss less than $0.1
2034	$7,144	$164,498	5.2%	-0.3%	<$0.1	Loss less than $0.1
2035	$7,164	$164,420	5.2%	-0.3%	<$0.1	Loss less than $0.1
2036	$7,182	$164,350	5.2%	-0.3%	<$0.1	Loss less than $0.1
2037	$7,118	$164,213	5.2%	-0.3%	<$0.1	Loss less than $0.1
2038	$7,136	$164,170	5.2%	-0.3%	<$0.1	Loss less than $0.1
2039	$7,153	$164,141	5.2%	-0.3%	<$0.1	Loss less than $0.1
2040	$7,169	$164,122	5.2%	-0.3%	<$0.1	Loss less than $0.1
NPV at 3%					$0.2	-$0.2
NPV at 7%					$0.1	-$0.1

[a] Figures are in 2005 dollars.

[b] Net present values for 2006 are calculated using a social discount rate of 3% and 7% over the 2007 to 2040 time period.

Table 7B-23. Impact on C1 Fishing Vessel Market: 800–2,000 hp (Average Price per Vessel = $1,085,000)[a,b]

Year	Variable Engineering Cost/Unit	Absolute Change in Price ($)	Change in Price (%)	Change in Quantity (%)	Total Engineering Costs (million $)	Change in Equipment Manufacturers' Surplus (million $)	Change in Consumer Surplus (million $)	Change in Total Surplus (million $)
2007	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1	Loss less than $0.1	Loss less than $0.1
2008	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1	Loss less than $0.1	Loss less than $0.1
2009	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1	Loss less than $0.1	Loss less than $0.1
2010	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1	Loss less than $0.1	Loss less than $0.1
2011	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1	Loss less than $0.1	Loss less than $0.1
2012	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1	Loss less than $0.1	Loss less than $0.1
2013	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1	Loss less than $0.1	Loss less than $0.1
2014	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1	Loss less than $0.1	Loss less than $0.1
2015	$0	$0	0.0%	0.0%	$8.0	-$8.0	Loss less than $0.1	-$7.96
2016	$2,385	$15,870	1.5%	-2.0%	$4.9	-$8.6	-$5.05	-$13.60
2017	$2,385	$15,869	1.5%	-2.0%	$3.0	-$6.7	-$5.09	-$11.77
2018	$2,385	$12,468	1.1%	-1.6%	$2.1	-$4.8	-$4.04	-$8.86
2019	$2,385	$12,467	1.1%	-1.6%	$2.1	-$4.8	-$4.08	-$8.92
2020	$2,385	$12,467	1.1%	-1.6%	$2.1	-$4.9	-$4.12	-$8.99
2021	$2,385	$12,466	1.1%	-1.6%	$2.1	-$4.9	-$4.15	-$9.06
2022	$2,385	$12,465	1.1%	-1.6%	$2.1	-$4.9	-$4.19	-$9.13
2023	$2,385	$12,464	1.1%	-1.6%	$2.1	-$5.0	-$4.23	-$9.20
2024	$2,385	$12,463	1.1%	-1.6%	$2.1	-$5.0	-$4.27	-$9.27
2025	$2,385	$12,462	1.1%	-1.6%	$2.1	-$5.0	-$4.30	-$9.34
2026	$2,385	$12,462	1.1%	-1.6%	$2.1	-$5.1	-$4.34	-$9.42
2027	$2,385	$12,461	1.1%	-1.6%	$0.8	-$3.8	-$4.38	-$8.21
2028	$2,385	$12,460	1.1%	-1.6%	$0.9	-$3.9	-$4.42	-$8.29
2029	$2,385	$12,460	1.1%	-1.6%	$0.9	-$3.9	-$4.46	-$8.36
2030	$2,385	$12,459	1.1%	-1.6%	$0.9	-$3.9	-$4.50	-$8.44
2031	$2,385	$12,459	1.1%	-1.6%	$0.9	-$4.0	-$4.54	-$8.51
2032	$2,385	$12,458	1.1%	-1.6%	$0.9	-$4.0	-$4.58	-$8.59
2033	$2,385	$12,458	1.1%	-1.6%	$0.9	-$4.0	-$4.62	-$8.67
2034	$2,385	$12,457	1.1%	-1.6%	$0.9	-$4.1	-$4.66	-$8.74
2035	$2,385	$12,457	1.1%	-1.6%	$0.9	-$4.1	-$4.71	-$8.82
2036	$2,385	$12,457	1.1%	-1.6%	$0.9	-$4.2	-$4.75	-$8.90
2037	$2,385	$12,457	1.1%	-1.6%	$0.9	-$4.2	-$4.79	-$8.98
2038	$2,385	$12,456	1.1%	-1.6%	$0.9	-$4.2	-$4.83	-$9.06
2039	$2,385	$12,456	1.1%	-1.6%	$0.9	-$4.3	-$4.88	-$9.14
2040	$2,385	$12,456	1.1%	-1.6%	$0.9	-$4.3	-$4.92	-$9.23
NPV at 3%					$28.4	-$68.3	-$58.2	-$126.5
NPV at 7%					$15.6	-$33.8	-$26.5	-$60.3

[a] Figures are in 2005 dollars.

[b] Net present values for 2006 are calculated using a social discount rate of 3% and 7% over the 2007 to 2040 time period.

Table 7B-24. Impact on C1 Fishing Vessel Market: >2,000 hp (Average Price per Vessel = $2,100,000)[a,b]

Year	Variable Engineering Cost/Unit	Absolute Change in Price ($)	Change in Price (%)	Change in Quantity (%)	Total Engineering Costs (million $)	Change in Equipment Manufacturers' Surplus (million $)	Change in Consumer Surplus (million $)	Change in Total Surplus (million $)
2007	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1	Loss less than $0.1	Loss less than $0.1
2008	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1	Loss less than $0.1	Loss less than $0.1
2009	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1	Loss less than $0.1	Loss less than $0.1
2010	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1	Loss less than $0.1	Loss less than $0.1
2011	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1	Loss less than $0.1	Loss less than $0.1
2012	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1	Loss less than $0.1	Loss less than $0.1
2013	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1	Loss less than $0.1	Loss less than $0.1
2014	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1	Loss less than $0.1	Loss less than $0.1
2015	$0	-$1	0.0%	0.0%	$2.8	-$2.8	Loss less than $0.1	-$2.80
2016	$4,672	$26,671	1.3%	-1.8%	$2.0	-$4.1	-$2.98	-$7.05
2017	$4,671	$26,670	1.3%	-1.8%	$1.3	-$3.4	-$3.01	-$6.43
2018	$4,672	$20,959	1.0%	-1.4%	$1.0	-$2.5	-$2.39	-$4.93
2019	$4,671	$20,955	1.0%	-1.4%	$1.0	-$2.6	-$2.41	-$4.97
2020	$4,671	$20,950	1.0%	-1.4%	$1.0	-$2.6	-$2.43	-$5.01
2021	$4,671	$20,942	1.0%	-1.4%	$1.0	-$2.6	-$2.45	-$5.05
2022	$4,672	$20,935	1.0%	-1.4%	$1.0	-$2.6	-$2.48	-$5.09
2023	$4,672	$20,996	1.0%	-1.4%	$1.0	-$2.6	-$2.51	-$5.14
2024	$4,671	$20,985	1.0%	-1.4%	$1.0	-$2.7	-$2.53	-$5.18
2025	$4,671	$20,972	1.0%	-1.4%	$1.0	-$2.7	-$2.55	-$5.22
2026	$4,672	$20,960	1.0%	-1.4%	$1.0	-$2.7	-$2.57	-$5.26
2027	$4,672	$20,946	1.0%	-1.4%	$0.6	-$2.3	-$2.59	-$4.86
2028	$4,671	$20,930	1.0%	-1.4%	$0.6	-$2.3	-$2.61	-$4.90
2029	$4,672	$20,981	1.0%	-1.4%	$0.6	-$2.3	-$2.64	-$4.95
2030	$4,671	$20,963	1.0%	-1.4%	$0.6	-$2.3	-$2.66	-$4.99
2031	$4,672	$20,945	1.0%	-1.4%	$0.6	-$2.3	-$2.68	-$5.03
2032	$4,671	$20,925	1.0%	-1.4%	$0.6	-$2.4	-$2.71	-$5.07
2033	$4,671	$20,969	1.0%	-1.4%	$0.6	-$2.4	-$2.74	-$5.13
2034	$4,671	$20,947	1.0%	-1.4%	$0.6	-$2.4	-$2.76	-$5.17
2035	$4,672	$20,925	1.0%	-1.4%	$0.6	-$2.4	-$2.78	-$5.21
2036	$4,671	$20,963	1.0%	-1.4%	$0.6	-$2.5	-$2.81	-$5.27
2037	$4,671	$20,939	1.0%	-1.4%	$0.6	-$2.5	-$2.83	-$5.31
2038	$4,671	$20,974	1.0%	-1.4%	$0.6	-$2.5	-$2.86	-$5.37
2039	$4,671	$20,947	1.0%	-1.4%	$0.6	-$2.5	-$2.88	-$5.41
2040	$4,671	$20,920	1.0%	-1.4%	$0.7	-$2.5	-$2.91	-$5.45
NPV at 3%					$13.6	-$36.2	-$34.4	-$70.6
NPV at 7%					$7.1	-$17.4	-$15.6	-$33.1

[a] Figures are in 2005 dollars.

[b] Net present values for 2006 are calculated using a social discount rate of 3% and 7% over the 2007 to 2040 time period.

Table 7B-25. Impact on C2 Fishing Vessel Market: 800–2,000 hp (Average Price per Vessel = $1,627,500)[a,b]

Year	Variable Engineering Cost/Unit	Absolute Change in Price ($)	Change in Price (%)	Change in Quantity (%)	Total Engineering Costs (million $)	Change in Equipment Manufacturers' Surplus (million $)	Change in Consumer Surplus (million $)	Change in Total Surplus (million $)
2007	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1	Loss less than $0.1	Loss less than $0.1
2008	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1	Loss less than $0.1	Loss less than $0.1
2009	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1	Loss less than $0.1	Loss less than $0.1
2010	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1	Loss less than $0.1	Loss less than $0.1
2011	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1	Loss less than $0.1	Loss less than $0.1
2012	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1	Loss less than $0.1	Loss less than $0.1
2013	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1	Loss less than $0.1	Loss less than $0.1
2014	$0	-$2	0.0%	0.0%	<$0.1	Loss less than $0.1	Loss less than $0.1	Loss less than $0.1
2015	$0	-$5	0.0%	0.0%	$0.1	-$0.1	Loss less than $0.1	-$0.15
2016	$3,976	$74,266	4.6%	-6.5%	$0.1	-$0.3	-$0.21	-$0.48
2017	$3,974	$74,193	4.6%	-6.5%	$0.1	-$0.2	-$0.21	-$0.46
2018	$3,972	$57,092	3.5%	-5.0%	$0.0	-$0.2	-$0.17	-$0.34
2019	$3,970	$57,033	3.5%	-5.0%	$0.0	-$0.2	-$0.17	-$0.34
2020	$3,967	$56,975	3.5%	-5.0%	$0.0	-$0.2	-$0.17	-$0.35
2021	$3,964	$56,919	3.5%	-4.9%	$0.0	-$0.2	-$0.17	-$0.35
2022	$3,961	$56,861	3.5%	-4.9%	$0.0	-$0.2	-$0.17	-$0.35
2023	$3,958	$56,806	3.5%	-4.9%	$0.0	-$0.2	-$0.17	-$0.35
2024	$3,954	$56,749	3.5%	-4.9%	$0.0	-$0.2	-$0.17	-$0.36
2025	$3,950	$56,694	3.5%	-4.9%	$0.0	-$0.2	-$0.18	-$0.36
2026	$3,977	$56,656	3.5%	-4.9%	$0.0	-$0.2	-$0.18	-$0.36
2027	$3,973	$57,298	3.6%	-5.0%	$0.0	-$0.2	-$0.18	-$0.34
2028	$3,968	$57,238	3.6%	-5.0%	$0.0	-$0.2	-$0.18	-$0.34
2029	$3,962	$57,178	3.6%	-5.0%	$0.0	-$0.2	-$0.18	-$0.35
2030	$3,957	$57,121	3.5%	-5.0%	$0.0	-$0.2	-$0.19	-$0.35
2031	$3,952	$57,064	3.5%	-5.0%	$0.0	-$0.2	-$0.19	-$0.35
2032	$3,975	$57,025	3.5%	-5.0%	$0.0	-$0.2	-$0.19	-$0.35
2033	$3,969	$56,970	3.5%	-5.0%	$0.0	-$0.2	-$0.19	-$0.36
2034	$3,962	$56,915	3.5%	-4.9%	$0.0	-$0.2	-$0.19	-$0.36
2035	$3,956	$56,861	3.5%	-4.9%	$0.0	-$0.2	-$0.19	-$0.36
2036	$3,977	$56,823	3.5%	-4.9%	$0.0	-$0.2	-$0.20	-$0.37
2037	$3,970	$56,771	3.5%	-4.9%	$0.0	-$0.2	-$0.20	-$0.37
2038	$3,962	$56,720	3.5%	-4.9%	$0.0	-$0.2	-$0.20	-$0.37
2039	$3,955	$56,670	3.5%	-4.9%	$0.0	-$0.2	-$0.20	-$0.37
2040	$3,974	$56,634	3.5%	-4.9%	$0.0	-$0.2	-$0.20	-$0.38
NPV at 3%					$0.5	-$2.5	-$2.4	-$4.9
NPV at 7%					$0.3	-$1.2	-$1.1	-$2.3

[a] Figures are in 2005 dollars.

[b] Net present values for 2006 are calculated using a social discount rate of 3% and 7% over the 2007 to 2040 time period.

Table 7B-26. Impact on C2 Fishing Vessel Market: >2,000 hp (Average Price per Vessel = $3,150,000)[a,b]

Year	Variable Engineering Cost/Unit	Absolute Change in Price ($)	Change in Price (%)	Change in Quantity (%)	Total Engineering Costs (million $)	Change in Equipment Manufacturers' Surplus (million $)	Change in Consumer Surplus (million $)	Change in Total Surplus (million $)
2007	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1	Loss less than $0.1	Loss less than $0.1
2008	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1	Loss less than $0.1	Loss less than $0.1
2009	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1	Loss less than $0.1	Loss less than $0.1
2010	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1	Loss less than $0.1	Loss less than $0.1
2011	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1	Loss less than $0.1	Loss less than $0.1
2012	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1	Loss less than $0.1	Loss less than $0.1
2013	$0	$0	0.0%	0.0%	<$0.1	Loss less than $0.1	Loss less than $0.1	Loss less than $0.1
2014	$0	-$6	0.0%	0.0%	<$0.1	Loss less than $0.1	Loss less than $0.1	Loss less than $0.1
2015	$0	-$12	0.0%	0.0%	$0.6	-$0.6	Loss less than $0.1	-$0.58
2016	$7,154	$116,881	3.7%	-5.2%	$0.4	-$1.5	-$1.34	-$2.86
2017	$7,157	$116,864	3.7%	-5.2%	$0.3	-$1.4	-$1.35	-$2.77
2018	$7,152	$89,954	2.9%	-4.0%	$0.2	-$1.0	-$1.06	-$2.10
2019	$7,154	$89,932	2.9%	-4.0%	$0.2	-$1.0	-$1.07	-$2.11
2020	$7,156	$89,910	2.9%	-4.0%	$0.2	-$1.1	-$1.07	-$2.13
2021	$7,157	$89,888	2.9%	-4.0%	$0.2	-$1.1	-$1.08	-$2.15
2022	$7,158	$89,866	2.9%	-4.0%	$0.2	-$1.1	-$1.09	-$2.17
2023	$7,158	$89,844	2.9%	-4.0%	$0.2	-$1.1	-$1.10	-$2.19
2024	$7,157	$89,822	2.9%	-4.0%	$0.2	-$1.1	-$1.11	-$2.20
2025	$7,156	$89,802	2.9%	-4.0%	$0.2	-$1.1	-$1.12	-$2.22
2026	$7,154	$89,781	2.9%	-4.0%	$0.2	-$1.1	-$1.13	-$2.24
2027	$7,152	$89,760	2.8%	-4.0%	$0.1	-$1.0	-$1.14	-$2.14
2028	$7,157	$89,745	2.8%	-4.0%	$0.1	-$1.0	-$1.15	-$2.16
2029	$7,154	$89,727	2.8%	-4.0%	$0.1	-$1.0	-$1.16	-$2.18
2030	$7,157	$89,714	2.8%	-4.0%	$0.1	-$1.0	-$1.17	-$2.20
2031	$7,153	$89,699	2.8%	-4.0%	$0.1	-$1.0	-$1.18	-$2.22
2032	$7,155	$89,689	2.8%	-4.0%	$0.1	-$1.0	-$1.19	-$2.24
2033	$7,157	$89,680	2.8%	-4.0%	$0.1	-$1.1	-$1.20	-$2.26
2034	$7,151	$89,667	2.8%	-4.0%	$0.1	-$1.1	-$1.22	-$2.28
2035	$7,152	$89,659	2.8%	-4.0%	$0.1	-$1.1	-$1.23	-$2.30
2036	$7,152	$89,651	2.8%	-4.0%	$0.1	-$1.1	-$1.24	-$2.32
2037	$7,152	$89,644	2.8%	-4.0%	$0.1	-$1.1	-$1.25	-$2.34
2038	$7,158	$89,642	2.8%	-4.0%	$0.1	-$1.1	-$1.26	-$2.36
2039	$7,156	$89,637	2.8%	-4.0%	$0.1	-$1.1	-$1.27	-$2.38
2040	$7,154	$89,633	2.8%	-4.0%	$0.1	-$1.1	-$1.28	-$2.40
NPV at 3%					$2.7	-$14.8	-$15.2	-$30.0
NPV at 7%					$1.4	-$7.0	-$6.9	-$13.9

[a] Figures are in 2005 dollars.

[b] Net present values for 2006 are calculated using a social discount rate of 3% and 7% over the 2007 to 2040 time period.

Appendix 7C: Impacts on Transportation Service Markets

This appendix provides the time series of impacts from 2007 through 2040 for two transportation service markets (railroad and marine). Table 7C-1 through Table 7C-2 provide the time series of impacts and include the following:

- relative change in market price (%)
- relative change in market quantity (%)
- total engineering costs (variable and fixed) associated with each engine market
- changes in service user surplus
- changes in service provider surplus
- changes in total surplus

All costs and surplus changes are presented in 2005 dollars and real service prices are assumed to be constant during the period of analysis. Net present values for 2006 are calculated using a social discount rate of 3% and 7% over the 2007 and 2040 time period.

The NPV calculations presented in this Appendix are based on the period 2006-2040, reflecting the period when the analysis was completed. This has the consequence of discounting the current year costs, 2007, and all subsequent years are discounted by an additional year. The result is a smaller stream of social costs than by calculating the NPV over 2007-2040 (3% smaller for 3% NPV and 7% smaller for 7% NPV).

Table 7C-1. Table 7C-1. Impact on Railroad Transportation Services Market

Year	Change in Price (%)	Change in Quantity (%)	Total Engineering Costs (million $)	Change in Service Consumer Surplus (million $)	Change in Service Provider Surplus (million $)	Change in Total Surplus (million $)
2007	0.0%	0.0%	$0.0	$0.0	$0.0	$0.0
2008	0.1%	0.0%	$58.0	-$31.5	-$26.2	-$57.7
2009	0.0%	0.0%	$34.5	-$18.8	-$15.6	-$34.4
2010	0.1%	0.0%	$55.3	-$30.0	-$25.0	-$55.1
2011	0.1%	-0.1%	$104.8	-$57.0	-$47.5	-$104.4
2012	0.1%	0.0%	$84.0	-$45.6	-$38.0	-$83.6
2013	0.1%	0.0%	$74.4	-$40.4	-$33.7	-$74.1
2014	0.1%	0.0%	$52.6	-$28.6	-$23.8	-$52.4
2015	0.1%	0.0%	$44.0	-$45.9	-$38.2	-$84.1
2016	0.1%	-0.1%	$74.5	-$63.5	-$52.9	-$116.3
2017	0.2%	-0.1%	$72.0	-$75.2	-$62.6	-$137.8
2018	0.2%	-0.1%	$86.5	-$83.8	-$69.8	-$153.6
2019	0.2%	-0.1%	$93.3	-$84.2	-$70.2	-$154.4
2020	0.2%	-0.1%	$81.4	-$78.9	-$65.8	-$144.7
2021	0.2%	-0.1%	$95.7	-$87.9	-$73.2	-$161.1
2022	0.2%	-0.1%	$131.0	-$108.0	-$90.0	-$198.1
2023	0.3%	-0.1%	$189.9	-$140.9	-$117.4	-$258.3
2024	0.3%	-0.1%	$192.1	-$142.6	-$118.8	-$261.4
2025	0.3%	-0.1%	$210.4	-$153.4	-$127.8	-$281.2
2026	0.3%	-0.1%	$210.9	-$154.2	-$128.5	-$282.7
2027	0.3%	-0.2%	$226.1	-$163.1	-$135.9	-$299.0
2028	0.3%	-0.2%	$255.7	-$179.6	-$149.7	-$329.4
2029	0.3%	-0.2%	$271.2	-$188.4	-$157.0	-$345.5
2030	0.4%	-0.2%	$284.5	-$195.9	-$163.2	-$359.1
2031	0.4%	-0.2%	$298.5	-$203.9	-$169.9	-$373.9
2032	0.4%	-0.2%	$308.3	-$209.7	-$174.8	-$384.5
2033	0.4%	-0.2%	$378.4	-$248.0	-$206.6	-$454.6
2034	0.5%	-0.2%	$401.3	-$260.7	-$217.2	-$477.9
2035	0.5%	-0.2%	$422.5	-$272.3	-$227.0	-$499.3
2036	0.5%	-0.2%	$429.0	-$274.6	-$228.9	-$503.5
2037	0.5%	-0.2%	$445.1	-$282.5	-$235.4	-$517.9
2038	0.5%	-0.2%	$460.8	-$290.0	-$241.7	-$531.7
2039	0.5%	-0.2%	$476.4	-$297.4	-$247.8	-$545.2
2040	0.5%	-0.3%	$491.3	-$304.2	-$253.5	-$557.8
NPV at 3%			$3,457.2	-$2,386.5	-$1,988.8	-$4,375.3
NPV at 7%			$1,514.5	-$1,053.7	-$878.1	-$1,931.9

[a] Figures are in 2005 dollars.

[b] Net present values for 2006 are calculated using a social discount rate of 3% and 7% over the 2007 to 2040 time period.

Table 7C-2. Impact on Marine Transportation Services Market

Year	Change in Price (%)	Change in Quantity (%)	Total Engineering Costs (million $)	Change in Service Consumer Surplus (million $)	Change in Service Provider Surplus (million $)	Change in Total Surplus (million $)
2007	0.0%	0.0%	$0.0	$0.0	$0.0	$0.0
2008	0.0%	0.0%	$0.0	$0.0	$0.0	$0.0
2009	0.0%	0.0%	$0.0	$0.0	$0.0	$0.0
2010	0.0%	0.0%	$0.0	$0.0	$0.0	$0.0
2011	0.0%	0.0%	$0.0	$0.0	$0.0	$0.0
2012	0.0%	0.0%	$0.0	$0.0	$0.0	$0.0
2013	0.0%	0.0%	$0.0	$0.0	$0.0	$0.0
2014	0.0%	0.0%	$2.8	-$1.5	-$1.3	-$2.8
2015	0.0%	0.0%	$5.6	-$3.1	-$2.5	-$5.6
2016	0.1%	-0.1%	$14.8	-$18.7	-$15.6	-$34.3
2017	0.1%	-0.1%	$23.9	-$23.8	-$19.8	-$43.6
2018	0.2%	-0.1%	$36.0	-$27.9	-$23.3	-$51.2
2019	0.2%	-0.1%	$48.0	-$34.6	-$28.8	-$63.4
2020	0.2%	-0.1%	$60.0	-$41.2	-$34.3	-$75.4
2021	0.3%	-0.1%	$72.0	-$47.7	-$39.8	-$87.5
2022	0.3%	-0.2%	$83.9	-$54.3	-$45.2	-$99.5
2023	0.3%	-0.2%	$95.7	-$60.7	-$50.6	-$111.4
2024	0.4%	-0.2%	$107.5	-$67.2	-$56.0	-$123.2
2025	0.4%	-0.2%	$119.1	-$73.6	-$61.3	-$134.9
2026	0.4%	-0.2%	$130.6	-$79.9	-$66.6	-$146.4
2027	0.5%	-0.2%	$141.9	-$86.1	-$71.8	-$157.9
2028	0.5%	-0.3%	$153.0	-$92.2	-$76.8	-$169.0
2029	0.5%	-0.3%	$163.3	-$97.8	-$81.5	-$179.4
2030	0.6%	-0.3%	$172.6	-$103.0	-$85.8	-$188.8
2031	0.6%	-0.3%	$181.2	-$107.7	-$89.8	-$197.5
2032	0.6%	-0.3%	$189.0	-$112.0	-$93.4	-$205.4
2033	0.6%	-0.3%	$196.4	-$116.1	-$96.8	-$212.9
2034	0.6%	-0.3%	$203.6	-$120.1	-$100.1	-$220.2
2035	0.6%	-0.3%	$210.4	-$123.9	-$103.2	-$227.1
2036	0.6%	-0.3%	$216.9	-$127.5	-$106.2	-$233.7
2037	0.7%	-0.3%	$222.7	-$130.7	-$108.9	-$239.7
2038	0.7%	-0.3%	$227.9	-$133.6	-$111.3	-$244.9
2039	0.7%	-0.3%	$232.4	-$136.1	-$113.5	-$249.6
2040	0.7%	-0.3%	$236.3	-$138.4	-$115.3	-$253.7
NPV at 3%			$1,648.3	-$1,015.4	-$846.2	-$1,861.6
NPV at 7%			$646.4	-$405.9	-$338.2	-$744.1

[a] Figures are in 2005 dollars.

[b] Net present values for 2006 are calculated using a social discount rate of 3% and 7% over the 2007 to 2040 time period.

Appendix 7D: Time Series of Social Costs

This appendix provides a time series of the rule's estimated social costs from 2007 through 2040. Costs are presented in 2005 dollars. In addition, this appendix includes the net present values by stakeholder for 2006 using social discount rates of 3% and 7% over the 2007 and 2040 time period. As a result, it illustrates how the choice of discount rate determines the present value of the total social costs of the program.

The NPV calculations presented in this Appendix are based on the period 2006-2040, reflecting the period when the analysis was completed. This has the consequence of discounting the current year costs, 2007, and all subsequent years are discounted by an additional year. The result is a smaller stream of social costs than by calculating the NPV over 2007-2040 (3% smaller for 3% NPV and 7% smaller for 7% NPV).

Table 7D-1. Time Series of Social Costs: 2007 to 2040 (Million $)[a,b]

Stakeholder Groups	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Locomotives												
Locomotive producers	–$3.2	–$3.4	–$3.3	–$7.5	–$11.1	–$12.6	–$12.6	–$17.2	–$8.6	–$13.4	–$0.6	–$0.7
Rail transportation service providers	$0.0	–$26.2	–$15.6	–$25.0	–$47.5	–$38.0	–$33.7	–$23.8	–$38.2	–$52.9	–$62.6	–$69.8
Users of rail transportation service	$0.0	–$31.5	–$18.8	–$30.0	–$57.0	–$45.6	–$40.4	–$28.6	–$45.9	–$63.5	–$75.2	–$83.8
Total locomotive sector	–$3.2	–$61.1	–$37.7	–$62.5	–$115.6	–$96.3	–$86.7	–$69.5	–$92.8	–$129.7	–$138.4	–$154.3
Marine												
Marine engine producers	–$25.0	–$25.0	–$25.0	–$25.0	–$86.0	–$41.2	–$41.2	–$41.2	–$56.6	–$0.9	–$0.9	–$0.8
C1 >800 hp	–$1.7	–$1.7	–$1.8	–$1.8	–$22.8	–$20.4	–$20.4	–$20.4	–$26.7	–$0.7	–$0.7	–$0.6
C2 >800 hp	–$4.2	–$4.2	–$4.2	–$4.2	–$27.8	–$20.7	–$20.7	–$20.7	–$29.9	–$0.2	–$0.2	–$0.2
Other marine	–$19.1	–$19.1	–$19.1	–$19.1	–$35.4	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Marine vessel producers	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	–$17.5	–$18.0	–$14.1	–$9.9
C1 >800 hp	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	–$12.5	–$13.6	–$10.6	–$7.7
C2 >800 hp	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	–$5.0	–$4.4	–$3.5	–$2.2
Other marine	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Recreational and fishing vessel consumers	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	–$9.6	–$9.7	–$7.7
Marine transportation service providers	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	–$1.3	–$2.5	–$15.6	–$19.8	–$23.3
Users of marine transportation service	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	–$1.5	–$3.1	–$18.7	–$23.8	–$27.9
Total marine sector	–$25.0	–$25.0	–$25.0	–$25.0	–$86.0	–$41.2	–$41.2	–$44.0	–$79.8	–$62.9	–$68.3	–$69.5
Total program	–$28.2	–$86.1	–$62.7	–$87.5	–$201.5	–$137.5	–$127.9	–$113.5	–$172.5	–$192.6	–$206.7	–$223.9

(continued)

Table 7D-1. Time Series of Social Costs: 2007 to 2040 (Million $)[a,b] (continued)

Stakeholder Groups	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Locomotives												
Locomotive producers	–$0.7	–$0.7	–$0.8	–$1.0	–$1.3	–$1.3	–$1.4	–$1.4	–$1.5	–$1.7	–$1.8	–$1.8
Rail transportation service providers	–$70.2	–$65.8	–$73.2	–$90.0	–$117.4	–$118.8	–$127.8	–$128.5	–$135.9	–$149.7	–$157.0	–$163.2
Users of rail transportation service	–$84.2	–$78.9	–$87.9	–$108.0	–$140.9	–$142.6	–$153.4	–$154.2	–$163.1	–$179.6	–$188.4	–$195.9
Total locomotive sector	–$155.1	–$145.3	–$161.9	–$199.0	–$259.6	–$262.7	–$282.6	–$284.1	–$300.6	–$331.0	–$347.2	–$360.9
Marine												
Marine engine producers	–$0.8	–$0.8	–$0.8	–$0.8	–$0.8	–$0.8	–$0.8	–$0.9	–$0.9	–$0.9	–$0.9	–$0.9
C1 >800 hp	–$0.6	–$0.6	–$0.6	–$0.6	–$0.6	–$0.6	–$0.6	–$0.6	–$0.6	–$0.6	–$0.6	–$0.7
C2 >800 hp	–$0.2	–$0.2	–$0.2	–$0.2	–$0.2	–$0.2	–$0.2	–$0.2	–$0.2	–$0.2	–$0.2	–$0.2
Other marine	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Marine vessel producers	–$10.0	–$10.1	–$10.2	–$10.3	–$10.4	–$10.6	–$10.7	–$10.8	–$7.9	–$8.0	–$8.1	–$8.2
C1 >800 hp	–$7.7	–$7.8	–$7.9	–$7.9	–$8.0	–$8.1	–$8.1	–$8.2	–$6.2	–$6.3	–$6.4	–$6.4
C2 >800 hp	–$2.2	–$2.3	–$2.3	–$2.3	–$2.4	–$2.4	–$2.4	–$2.5	–$1.5	–$1.6	–$1.6	–$1.6
Other marine	$0.0	–$0.1	–$0.1	–$0.1	–$0.1	–$0.1	–$0.1	–$0.1	–$0.1	–$0.1	–$0.1	–$0.1
Recreational and fishing vessel consumers	–$7.7	–$7.8	–$7.9	–$7.9	–$8.0	–$8.1	–$8.1	–$8.2	–$8.3	–$8.4	–$8.4	–$8.5
Marine transportation service providers	–$28.8	–$34.3	–$39.8	–$45.2	–$50.6	–$56.0	–$61.3	–$66.6	–$71.8	–$76.8	–$81.5	–$85.8
Users of marine transportation service	–$34.6	–$41.2	–$47.7	–$54.3	–$60.7	–$67.2	–$73.6	–$79.9	–$86.1	–$92.2	–$97.8	–$103.0
Total marine sector	–$81.9	–$94.1	–$106.4	–$118.5	–$130.6	–$142.6	–$154.5	–$166.3	–$174.9	–$186.3	–$196.8	–$206.5
Total program	–$236.9	–$239.5	–$268.2	–$317.6	–$390.2	–$405.4	–$437.2	–$450.4	–$475.5	–$517.3	–$544.0	–$567.3

(continued)

Table 7D-1. Time Series of Social Costs: 2007 to 2040 (Million $)[a,b] (continued)

Stakeholder Groups	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	NPV (3%)	NPV (7%)
Locomotives												
Locomotive producers	–$1.9	–$1.9	–$2.3	–$2.4	–$2.5	–$2.4	–$2.4	–$2.4	–$2.3	–$2.3	–$92.8	–$63.5
Rail transportation service providers	–$169.9	–$174.8	–$206.6	–$217.2	–$227.0	–$228.9	–$235.4	–$241.7	–$247.8	–$253.5	–$1,988.8	–$878.1
Users of rail transportation service	–$203.9	–$209.7	–$248.0	–$260.7	–$272.3	–$274.6	–$282.5	–$290.0	–$297.4	–$304.2	–$2,386.5	–$1,053.7
Total locomotive sector	–$375.8	–$386.4	–$456.9	–$480.3	–$501.8	–$505.9	–$520.3	–$534.1	–$547.6	–$560.1	–$4,468.1	–$1,995.4
Marine												
Marine engine producers	–$0.9	–$0.9	–$1.0	–$1.0	–$1.0	–$1.0	–$1.0	–$1.0	–$1.0	–$1.0	–$313.3	–$242.3
C1 >800 hp	–$0.7	–$0.7	–$0.7	–$0.7	–$0.7	–$0.7	–$0.7	–$0.7	–$0.7	–$0.7	–$102.1	–$73.9
C2 >800 hp	–$0.2	–$0.2	–$0.2	–$0.3	–$0.3	–$0.3	–$0.3	–$0.3	–$0.3	–$0.3	–$112.4	–$84.4
Other marine	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	–$98.7	–$84.0
Marine vessel producers	–$8.3	–$8.4	–$8.5	–$8.6	–$8.7	–$8.8	–$8.9	–$9.0	–$9.1	–$9.1	–$143.8	–$71.3
C1 >800 hp	–$6.5	–$6.6	–$6.6	–$6.7	–$6.8	–$6.8	–$6.9	–$7.0	–$7.0	–$7.1	–$110.1	–$54.3
C2 >800 hp	–$1.7	–$1.7	–$1.7	–$1.7	–$1.8	–$1.8	–$1.8	–$1.8	–$1.9	–$1.9	–$32.4	–$16.5
Other marine	–$0.1	–$0.1	–$0.1	–$0.2	–$0.2	–$0.2	–$0.2	–$0.2	–$0.2	–$0.2	–$1.3	–$0.5
Recreational and fishing vessel consumers	–$8.6	–$8.7	–$8.7	–$8.8	–$8.9	–$9.0	–$9.1	–$9.1	–$9.2	–$9.3	–$110.0	–$50.1
Marine transportation service providers	–$89.8	–$93.4	–$96.8	–$100.1	–$103.2	–$106.2	–$108.9	–$111.3	–$113.5	–$115.3	–$846.2	–$338.2
Users of marine transportation service	–$107.7	–$112.0	–$116.1	–$120.1	–$123.9	–$127.5	–$130.7	–$133.6	–$136.1	–$138.4	–$1,015.4	–$405.9
Total marine sector	–$215.3	–$223.4	–$231.1	–$238.5	–$245.6	–$252.5	–$258.6	–$264.1	–$268.9	–$273.1	–$2,428.7	–$1,107.7
Total program	–$591.1	–$609.8	–$688.0	–$718.8	–$747.4	–$758.3	–$778.8	–$798.1	–$816.4	–$833.2	–$6,896.8	–$3,103.1

[a] Figures are in 2005 dollars.

[b] Net present values for 2006 are calculated using a social discount rate of 3% and 7% over the 2007 to 2040 time period.

Appendix 7E: Model Equations

To develop the economic impact model, we use a set of nonlinear supply and demand equations for the affected markets and transform them into a set of linear supply and demand equations. These resulting equations describe stakeholder production and consumption responses to policy-induced cost and price changes in each market. They are also used to specify the conditions for a new with-policy equilibrium. We describe these equations in more detail below.

7E.1 Economic Model Equations

7E.1.1 Supply Equations

First, we consider the formal definition of the elasticity of supply with respect to changes in own price:

$$\varepsilon_s = \frac{dQ_s / Q_s}{dp / p}. \qquad \text{(7E.1)}$$

Next, we can use "hat" notation to transform Eq. (7E.1) to proportional changes and rearrange terms:

$$\hat{Q}_s = \varepsilon_s \hat{p} \qquad \text{(7E.1a)}$$

where

$\hat{Q}_s$ = percentage change in the quantity of market supply,

ε_S = market elasticity of supply, and

$\hat{p}$ = percentage change in market price.

As Fullerton and Metcalfe (2002) note, this approach takes the elasticity definition and turns it into a linear *behavioral* equation for each market.

To introduce the direct impact of the regulatory program, we assume the direct per-unit compliance cost (c) leads to a proportional shift in the marginal cost of production. Under the assumption of perfect competition (price equals marginal cost), we can approximate this shift at the initial equilibrium point as follows:

$$\hat{MC} = \frac{c}{MC_o} = \frac{c}{p_o}. \qquad \text{(7E.1b)}$$

The with-regulation supply response to price and cost changes can now be written as:

$$\hat{Q}_S = \varepsilon_S \, (\hat{p} - \hat{M}C) \qquad (7E.1c)$$

For equipment producers, the supply response also simultaneously accounts for changes in equilibrium input prices (engines). To do this, we modify Eq. (7E.1b) as follows:

$$\hat{M}C = \frac{c + \alpha(\Delta p_{eng})}{MC_o} = \frac{c + \alpha(\Delta p_{eng})}{p_o} \qquad (7E.1d)$$

where Δp_{engine} is the equilibrium change in the engine price and α is the ratio of engines used per unit of equipment. For example, if one piece of equipment uses only one engine, then α = 1. This equation can accommodate other input-output ratios by multiplying Δp_{eng} by the appropriate input-to-output ratio (α).

For transportation service providers, the supply response also simultaneously accounts for changes in equilibrium input prices (equipment). To do this, we use an equation similar to Eq. (7E.1.d):

$$\hat{M}C = \frac{c + \alpha(\Delta p_{equip})}{MC_o} = \frac{c + \alpha(\Delta p_{equip})}{p_o} \qquad (7E.1e)$$

where Δp_{equip} is the equilibrium change in the equipment price and α is the ratio of equipment used per unit of transportation services.

7E.1.2 Demand Equations

Similar to supply, we can characterize services and selected equipment[18] demand responses to price changes as:

$$\hat{Q}_d = \eta_d \, \hat{p} \qquad (7E.2)$$

where

$\hat{Q}_d$ = percentage change in the quantity of market demand,

η^d = market elasticity of demand, and

$\hat{p}$ = percentage change in market price.

[18] The equipment markets are recreational vessels and fishing vessels. The remaining vessel and locomotive demand curves are derived from the supply decisions of the appropriate downstream transportation service markets.

In contrast the demand for engines and selected equipment markets is a derived demand and is related to equipment or service supply decisions. In order to maintain a constant input-to-output ratio, the derived demand for inputs is specified as:

$$\hat{Q}_{input} = \hat{Q}_{output} . \quad (7E.3)$$

7E.1.3 Market Equilibrium Conditions

In response to the exogenous increase production costs, stakeholder responses are completely characterized by represented in Eq. (7E.1.c)(service, equipment and engine supply), Eq. (7E.2) (service and selected equipment demand), Eq. (7E.3) (derived demand for selected equipment and engine). Next, we specify the relationship that must hold for markets to "clear", that is, supply in each market equals demand. Given the equations specified above, the new equilibrium satisfies the condition that for each market, the proportional change in supply equals the proportional change in demand:

$$\hat{Q}_s = \hat{Q}_d . \quad (7E.4)$$

7E.2 Computing With-Regulation Equilibrium Conditions within the Spreadsheet

The French economist Léon Walras proposed one early model of market price adjustment by using the following thought experiment. Suppose there is a hypothetical agent that facilitates market adjustment by playing the role of an "auctioneer." He announces prices, collects information about supply and demand responses (without transactions actually taking place), and continues this process until market equilibrium is achieved.

For example, consider the with-regulation supply and demand conditions at the without-regulation equilibrium price (P) (see Figure 7E-1). The auctioneer determines that the quantity demanded (A) exceeds the quantity supplied (B) at this price and calls out a new (higher) price (P′) based on the amount of excess demand. Consumers and producers make new consumption and production choices at this new price (i.e., they move along their respective demand and supply functions), and the auctioneer checks again to see if excess demand or supply exists. This process continues until P = P* (point C in Figure 7E-1) is reached (i.e., excess demand is zero in the market). A similar analysis takes place when excess supply exists. The auctioneer calls out lower prices when the price is higher than the equilibrium price.

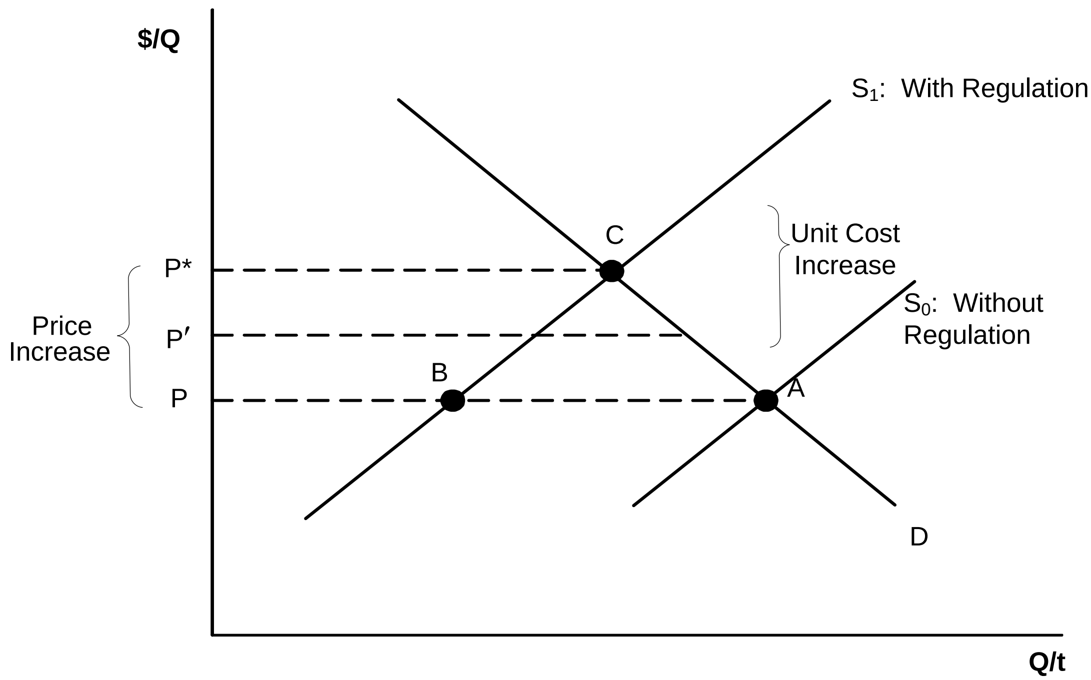


Figure 7E-1. Computing With-Regulation Equilibrium

The economic model uses a similar type of algorithm for determining with-regulation equilibria, and the process can be summarized by six recursive steps:

1. Impose the control costs on affected supply segments, thereby affecting their supply decisions.

2. Recalculate the market supply in each market. Excess demand currently exists.

3. Determine the new prices via a price revision rule. We use a rule similar to the factor price revision rule described by Kimbell and Harrison (1986). P_i is the market price at iteration i, q_d is the quantity demanded, and q_s is the quantity supplied. The parameter z influences the magnitude of the price revision and the speed of convergence. The revision rule increases the price when excess demand exists, lowers the price when excess supply exists, and leaves the price unchanged when market demand equals market supply. The price adjustment is expressed as follows:

$$P_{i+1} = P_1 \bullet \left(\frac{q_d}{q_s} \right)^z \qquad (7E.5)$$

4. Recalculate market supply with new prices.

5. Compute market demand in each market.

6. Compare supply and demand in each market. If equilibrium conditions are not satisfied, go to Step 3, resulting in a new set of market prices. Repeat until equilibrium conditions are satisfied (i.e., the ratio of supply and demand is arbitrarily close to one). When the ratio is appropriately close to one, the market-clearing condition of supply equals demand is satisfied.

7E.3 Social Costs: Consumer and Producer Economic Welfare Calculations

The change in consumer surplus in the affected markets can be estimated using the following linear approximation method:

$$\Delta CS = -[Q_1 \times \Delta p] + [0.5 \times \Delta Q \times \Delta p]. \qquad (7E.6)$$

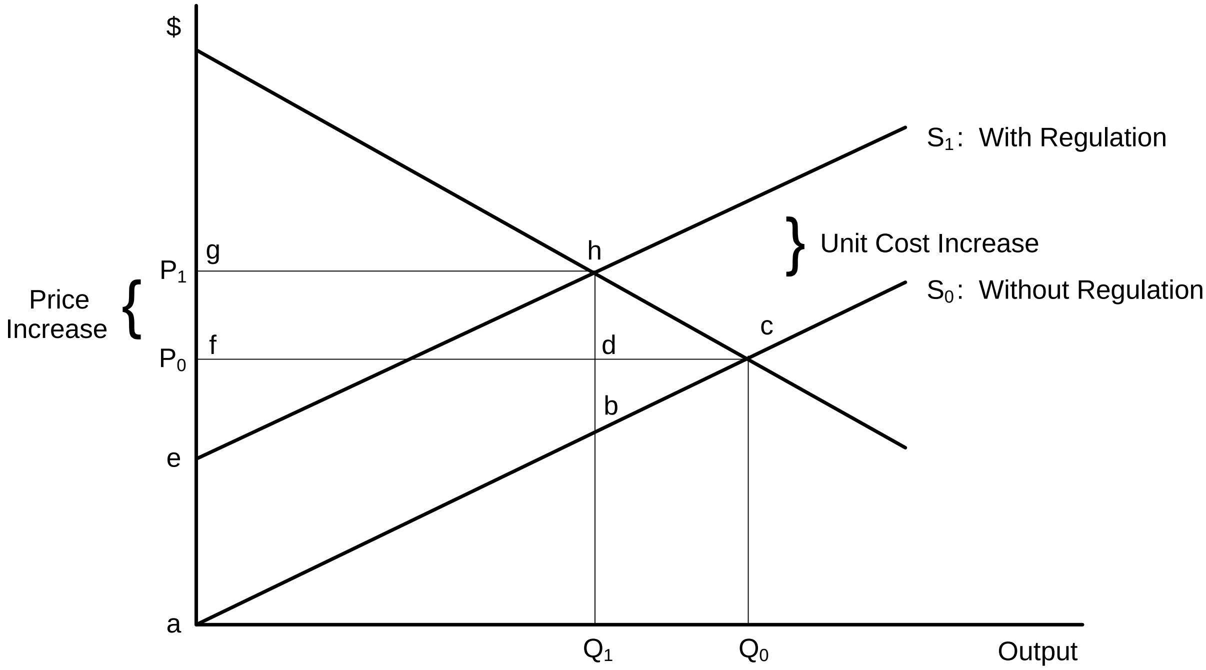
As shown, higher market prices and reduced consumption lead to welfare losses for consumers. A geometric representation of this calculation is illustrated in Figure 7E-2.

For affected supply, the change in producer surplus can be estimated with the following equation:

$$\Delta PS = [Q_1 \times \Delta p] - [Q_1 \times \Delta MC] - [0.5 \times \Delta Q \times (\Delta p - \Delta MC)]. \qquad (7E.7)$$

Increased regulatory costs and output declines have a negative effect on producer surplus, because the net price change (Δp – ΔMC) is negative. However, these losses are mitigated, to some degree, as a result of higher market prices. A geometric representation of this calculation is also illustrated in Figure 7E-2.

Throughout this report, changes in surplus reflect the *social costs* of the proposed rule. These calculations exclude any environmental benefits associated with the proposed rule.



Δ consumer surplus = –[fghd + dhc]

Δ producer surplus = [fghd – aehb] – bdc

Δ total surplus = –[aehb + dhc + bdc]

Figure 7E-2. Economic Welfare Calculations: Changes in Consumer, Producer, and Total Surplus

Appendix 7F: Elasticity Parameters for Economic Impact Modeling

Elasticities were obtained from peer-reviewed literature or were obtained from other sources that estimated these parameters using empirical methods (i.e. econometrically). Table 7F-1 and Table 7F-2 summarize the price elasticities of supply and demand used in this anlaysis. The methodologies for estimating the supply and demand elasticities are described in the documents identified in the data source column. The unknown parameters for the analysis were the locomotive and commercial marine vessel supply elasticities and this appendix describes the methods and data used to identify an acceptable value for the economic impact analysis.

It should be noted that the methods we used to estimate the price elasticites described below have certain limitations. The production function approach that was used to estimate several of the supply elasticities was used due to limitations in available data. Specifically, firm level or plant level data was unavailable for the companies that operate in the affected sectors. As a result, several of the supply elasticities were estimated using a production function approach with industry level aggregate data. However, the use of aggregate industry level data may not be appropriate or an accurate way to estimate the price elasticity of supply compared to firm-level or plant-level data. This is because, at the aggregate industry level, the size of the data sample is limited to the time series of the available years and because aggregate industry data may not reveal each individual firm or plant production function (heterogeneity). There may be significant differences among the firms that may be hidden in the aggregate data but that may affect the estimated elasticity. In addition, the use of time series aggregate industry data may introduce time trend effects that are difficult to isolate and control.

To address these concerns, EPA intends to investigate estimates for the price elasticity of supply for the affected industries for which published estimates are not available, using alternative methods and data inputs. This research program will use the cross-sectional data model at either the firm-level or plant level from the U.S. Census Bureau to estimate these elasticities. We plan to use the results of this research provided the results are robust and that they are available in time for the analysis for the final rule.

Table 7F-1. Summary of Market Demand Elasticities Used in EIM

MARKET	ESTIMATE	SOURCE	METHOD	DATA SOURCE
Rail				
Rail Transp. Svcs	-0.5	Literature Estimate	Literature Review	Boyer, K.D. 1997. *Principles of Transportation Economics*. Reading, MA: Addison-Wesley.
Locomotives	Derived			

MARKET	ESTIMATE	SOURCE	METHOD	DATA SOURCE
Marine				
Marine Transp. Svcs	-0.5	Literature Estimate	Assumed value	Uses the same elasticity as the locomotive transportation services sector.
Vessels—Commercial	Derived			
Vessels—Fishing	-1.4	Econometric Estimate	Assumed value	Uses the same elasticity as the recreation vessels sector.
Vessels—Recreational	-1.4	Econometric Estimate	Previous EPA Economic Analysis	U.S. Environmental Protection Agency (EPA). 2002. *Final Regulatory Support Document: Control of Emissions from Unregulated Nonroad Engines*. EPA420-R-02-022. Available at <http://www.epa.gov/otaq/regs/nonroad/2002/r02022.pdf>.
Engines	Derived			

Table 7F-2. Summary of Supply Elasticities Used in EIM

MARKET	ESTIMATE	SOURCE	METHOD	DATA SOURCE
Rail				
Rail Transp. Svcs	0.6	Literature Estimate	Previous EPA Economic Analysis	U.S. Environmental Protection Agency (EPA). 2004. *Final Regulatory Impact Analysis: Control of Emissions from Nonroad Diesel Engines*. EPA420-R-04-007. Available at <http://www.epa.gov/nonroad-diesel/2004fr/420r04007.pdf>.
Locomotives	2.7	EPA Estimate	Calibration Method	U.S. Bureau of the Census. 2004. "Railroad Rolling Stock Manufacturing: 2002." *2002 Economic Census Manufacturing Industry Series*. EC02-31I-336510 (RV). Washington, DC: U.S. Bureau of the Census. Table 1. U.S. Bureau of the Census. 2005. "Statistics for Industry Groups and Industries: 2004." *Annual Survey of Manufacturers.* M04(AS)-1. Washington, DC: U.S. Bureau of the Census. Table 2.
Marine				
Marine Transp. Svcs	0.6	Literature Estimate	Assumed value	Uses the same elasticity as the rail transportation services sector.

Vessels—Commercial	2.3	EPA Estimate	Calibration Method	U.S. Bureau of the Census. 2004. "Ship Building and Repairing: 2002." *2002 Economic Census Manufacturing Industry Series*. EC02-31I-336611 (RV). Washington, DC: U.S. Bureau of the Census. Table 1. U.S. Bureau of the Census. 2005. "Statistics for Industry Groups and Industries: 2004." *Annual Survey of Manufacturers.* M04(AS)-1. Washington, DC: U.S. Bureau of the Census. Table 2.
Vessels—Fishing	1.6	Econometric Estimate	Assumed value	Uses the same elasticity as the recreation vessels sector.
Vessels—Recreational	1.6	Econometric Estimate	Previous EPA Economic Analysis	U.S. Environmental Protection Agency (EPA). 2002. *Final Regulatory Support Document: Control of Emissions from Unregulated Nonroad Engines*. EPA420-R-02-022. Available at <http://www.epa.gov/otaq/regs/nonroad/2002/r02022.pdf>.
Engines	3.8	Econometric Estimate	Previous EPA Economic Analysis	U.S. Environmental Protection Agency (EPA). 2004. *Final Regulatory Impact Analysis: Control of Emissions from Nonroad Diesel Engines*. EPA420-R-04-007. Available at <http://www.epa.gov/nonroad-diesel/2004fr/420r04007.pdf>.

The technique we used to quantify the locomotive and commercial marine vessel industry supply elasticity involves specifying an economic model of supply, treating some of the parameters of the model as fixed using secondary data, and solving for unknown parameters that replicate a benchmark data set.[19] The specific procedure uses an analytical expression for a short-to-intermediate run supply elasticity derived by Rutherford and recent benchmark data sets from Economic Census data between 1997 and 2004. [22] The industry-level benchmark data set offers advantages over previously used data sets (e.g., National Bureau of Economic Research [NBER] Manufacturing Productivity Database) because it relies on the latest industrial classification system (North American Industry Classification System [NAICS]). Using the latest classification system allows us to select a more precise industry code that characterizes locomotive manufacturing. In addition, EPA can use the most up-to-date data set available for the analysis.

[19] A complete discussion of the meaning, merits and criticism, and best practices of these types of techniques can be found in Dawkins, Christina & T. N. Srinivasan, & John Whalley, (2001). "Calibration" in Handbook of Econometrics, Volume 5, ed. J. J. Heckman & E. E. Leamer, (Amsterdam: Elsevier).

As described by Rutherford, the procedure specifies that the functional form of the production function is the constant elasticity of substitution (CES). It also assumes there is a fixed capital input that makes it consistent with the intermediate-run time frame of the analysis. As Rutherford shows, the price elasticity of supply can be expressed as

$$\varepsilon = (1 - \theta) \times \sigma / \theta,$$

where θ represents the value share of capital and σ represents the elasticity of substitution between inputs. For this analysis, we assume an elasticity of substitution of one ($\sigma = 1$), which yields a Cobb-Douglas production technology that is a special case of the CES production function. The Cobb-Douglas production function is one of the most commonly used production functions in economics studies.

We collected the latest Economic Census data for NAICS 336510 (Railroad Rolling Stock Manufacturing) that provides an estimate of the value share of capital θ for locomotives. To compute this value share, we subtracted reported payroll costs from the reported industry value added and divided by the total value of shipments (see Table 7F-3). Using the elasticity formula, $\sigma = 1$, and annual value share data reported in Table 7F-3, we computed an average supply elasticity value of 2.7 for this industry. Accounting for variability of the value share parameter across 1997 to 2004, we computed a 95% confidence interval for the elasticity value that ranges from 1.9 to 3.4.

Similarly, we estimated the value share of capital θ for commercial marine vessels from latest Economic Census data for NAICS 336611 (Ship Building and Repairing Manufacturing). Using the elasticity formula, $\sigma = 1$, and annual value share data reported in Table 7F-4, we computed an average supply elasticity value of 2.3 for this industry. By the value share parameter across 1997 to 2004, we computed a 95% confidence interval for the elasticity value that ranges from 1.3 to 3.2.

The parameter estimates suggest both locomotive and commercial marine vessel supplies are elastic and firms can change production levels in response to changes in market prices. Two factors support an elastic supply estimate for this sector. First, industries that are less capital intensive typically have more flexibility to adjust variable inputs (e.g. labor and/or materials) and can change production levels in response to variations in market prices. The Census data for locomotive and ship building manufacturing are consistent with this observation and suggest the capital share of production costs in the locomotive or ship building industry is small relative to other inputs. The value share of capital is ranging from 20% to 30% for locomotives and from 25% to 38% for ship building and repairing. Second, industries with excess production capacity also have more flexibility to change output levels in response to price changes. Data from the Census also suggest the locomotive manufacturing industry's capacity utilization rates have been low, implying excess capacity exists. Data for the fourth quarters of 2000 to 2004 show utilization rates ranging from 45% to 69%. For ship building and repairing industry, the production capacity utilization ratio for the fourth quarters of 2000 to 2004 is ranging around 50% to 80% according to U.S. Bureau of the Census data.

Table 7F-3. Benchmark Supply Elasticities for NAICS 336510 (Railroad Rolling Stock Manufacturing): 1997–2004 ($1,000)

Year	Value of Shipments	Value Added	Payroll Costs	Value Share of Capital (θ)[a]	Supply Elasticity $\varepsilon = (1 - \theta) \times \sigma / \theta$ σ=1 (Cobb-Douglas)
2004	$7,566,129	$3,216,704	$1,123,054	28%	2.6
2003	$7,404,763	$2,909,834	$1,156,084	24%	3.2
2002	$7,793,382	$3,741,703	$1,195,073	33%	2.1
2001	$8,578,053	$3,824,449	$1,449,784	28%	2.6
2000	$9,722,424	$4,360,089	$1,480,181	30%	2.4
1999	$10,352,310	$4,460,735	$1,532,969	28%	2.5
1998	$9,256,810	$3,848,408	$1,440,110	26%	2.8
1997	$8,263,395	$3,345,283	$1,319,135	25%	3.1
Parameter Statistics					
Average					2.7
Standard deviation					0.4
Upper bound (95% confidence interval)					3.4
Lower bound (95% confidence interval)					1.9

[a]The value share of capital is computed by subtracting payroll costs from reported value added and dividing by the total value of shipments.

Sources: U.S. Bureau of the Census. 2004. “Railroad Rolling Stock Manufacturing: 2002.” *2002 Economic Census Manufacturing Industry Series*. EC02-31I-336510 (RV). Washington, DC: U.S. Bureau of the Census. Table 1.

U.S. Bureau of the Census. 2005. “Statistics for Industry Groups and Industries: 2004.” *Annual Survey of Manufacturers*. M04(AS)-1. Washington, DC: U.S. Bureau of the Census. Table 2.

Table 7F-4. Benchmark Supply Elasticities for NAICS 336611 (Ship Building & Repairing): 1997–2004 ($1,000)

Year	Value of Shipments	Value Added	Payroll Costs	Value Share of Capital (θ)[a]	Supply Elasticity $\varepsilon = (1 - \theta) \times \sigma / \theta$ σ=1 (Cobb-Douglas)
2004	$13,705,958	$8,573,286	$3,772,590	35%	1.9
2003	$13,485,503	$8,679,730	$3,692,026	37%	1.7
2002	$12,814,574	$8,449,010	$3,628,382	38%	1.7
2001	$11,792,832	$6,968,749	$3,439,474	30%	2.3
2000	$11,380,112	$6,324,192	$3,435,806	25%	2.9
1999	$11,070,960	$6,328,784	$3,336,632	27%	2.7
1998	$11,143,246	$6,728,975	$3,347,525	30%	2.3
1997	$10,542,961	$6,202,797	$3,353,414	27%	2.7
	Parameter Statistics				
	Average				2.3
	Standard Deviation				0.5
	Upper Bound (95% Confidence Interval)				3.2
	Lower Bound (95% Confidence Interval)				1.3

[a]The value share of capital is computed by subtracting payroll costs from reported value added and dividing by the total value of shipments.

Sources: U.S. Bureau of the Census. 2004b. “Ship Building and Repairing: 2002.” *2002 Economic Census Manufacturing Industry Series*. EC02-31I-336611 (RV). Washington, DC: U.S. Bureau of the Census. Table 1.

U.S. Bureau of the Census. 2005. “Statistics for Industry Groups and Industries: 2004.” *Annual Survey of Manufacturers*. M04(AS)-1. Washington, DC: U.S. Bureau of the Census. Table 2.

Appendix 13G: Initial Market Equilibrium - Price Forecasts

The EIM analysis begins with current market conditions: equilibrium supply and demand. To estimate the economic impact of a regulation, standard practice uses projected market equilibrium (time series of prices and quantities) as the baseline and evaluates market changes from this projected baseline. Consequently, it is necessary to forecast equilibrium prices and quantities for future years.

Equilibrium price forecasts typically use one of two approaches (EPA 1999, p 5-25). The first assumes a constant (real) price of goods and services over time. The second models a specific time series where prices may change over time due to

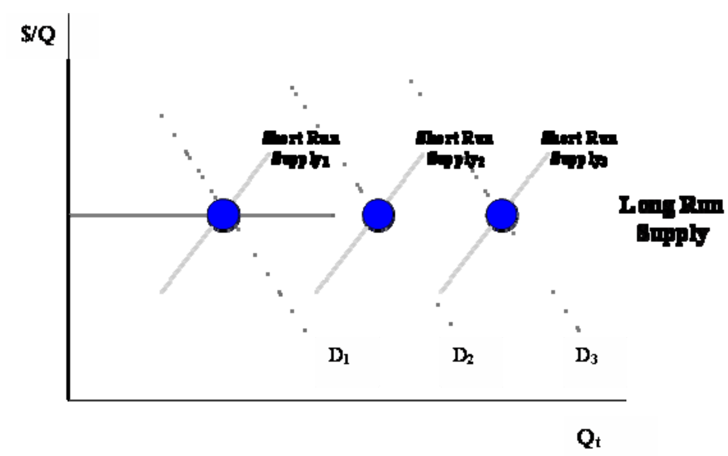


Figure 13.3-1. Prices and Quantities in Long Run Market Equilibrium

exogenous factors.

In the absence of shocks to the economy or the supply of raw materials, economic theory suggests that the equilibrium market price for goods and services should remain constant over time. As shown in Figure 7G-1, demand grows over time, in the long run, capacity will also grow as existing firms expand or new firms enter the market and eliminate any excess profits. This produces a flat long run supply curve. Note that in the short to medium run time frame the supply curve has a positive slope due to limitations in how quickly firms can react.

If capacity is constrained (preventing the outward shift of the baseline supply curve) or if the price of production inputs increase (shifting the baseline supply curve upward over time), then prices may trend upward reflecting that either the growth in demand is exceeding supply or the commodity is becoming more expensive to produce.

It is very difficult to develop forecasts events (such as those mentioned above) that influence long run prices. As a result, the approach used in this analysis is to use a constant 2005 observed price.

Appendix 7H: Sensitivity Analysis

The economic impact analysis presented in this Chapter is based on an economic impact model developed specifically for this analysis. The EIM reflects specific assumptions about behavioral responses (modeled by supply and demand elasticities) and how the engineering compliance costs are included in the market supply function shift. This appendix examines the sensitivity of the results to the values used for these key parameters. Alternative values for these parameters are selected and the results are compared to the results of the primary analysis described in Section 7.1. Three model components are examined:

- Scenario 1: alternative market supply and demand elasticity parameters
- Scenario 2: alternative ways to treat the market supply shifts
- Scenario 3: alternative ways to treat marine operating costs

The results of these sensitivity analyses are presented below. Although estimates of total economic welfare changes are similar for many of the scenarios, the different assumptions highlight the role the assumptions play in determining the distribution of welfare changes among stakeholders.

The NPV calculations presented in this Appendix are based on the period 2006-2040, reflecting the period when the analysis was completed. This has the consequence of discounting the current year costs, 2007, and all subsequent years are discounted by an additional year. The result is a smaller stream of social costs than by calculating the NPV over 2007-2040 (3% smaller for 3% NPV and 7% smaller for 7% NPV).

7H.1 Model Elasticity Parameters

Key model parameters include supply and demand elasticity estimates used by the model to characterize behavioral responses of producers and consumers in each market.

Consumer demand and producer supply responsiveness to changes in the commodity prices are referred to by economists as “elasticity.” The measure is typically expressed as the percentage change in quantity (demanded or supplied) brought about by a percent change in own price. A detailed discussion regarding the estimation and selection of the elasticities used in the EIM are discussed in Appendix 10F. This component of the sensitivity analysis examines the impact of changes in selected elasticity values, holding other parameters constant. The goal is to determine whether alternative elasticity values significantly alter conclusions in this report.

There are at least two ways to examine the sensitivity of the EIA results to assumptions about the price elasticity of supply or demand. The first is to choose upper and lower bounds for these variables based on the ranges of values reported in the literature or based on sensitivity analysis constructed around estimated values. This method was not available for this study because, as described in Appendix F, many of these parameters were obtained from secondary sources and information was not readily available to compute confidence intervals for them. Therefore, an alternative approach was used in which the supply or demand elasticity parameters were increased/decreased by 25 percent while holding the other elasticities constant. Table 7H-1 reports the upper- and lower-bound demand and supply elasticity estimates used in this analysis.

Parameter	Elasticity Source	Lower Bound	Base Case	Upper Bound
DEMAND ELASTICITIES				
Rail and marine transportation services	Literature estimate	-0.4	-0.5	-0.6
Locomotive	Derived		N/A	
Commercial vessels	Derived		N/A	
Recreational and fishing vessels	Econometric Estimate	-1.1	-1.4	-1.8
Marine engines	Derived		N/A	
SUPPLY ELASTICITIES				
Rail and marine transportation services	Literature estimate	0.45	0.6	0.8
Locomotives	Calibration Estimate	2.0	2.7	3.4
Commercial marine vessels	Calibration Estimate	2.0	2.3	3.4
Recreational and fishing vessels	Econometric Estimate	1.2	1.6	2.0
Marine engines	Econometric Estimate	2.9	3.8	4.8

The results of this analysis for 2020 are presented in Tables 7F-2 and 7F-3. Varying the model's elasticity parameters does not significantly change the estimated impacts on total economic welfare. However, varying the model parameters has an impact on how the regulatory program costs are distributed across stakeholders. The elasticity parameters play an important role in determining the economic incidence of the regulatory program.

In scenarios in which the supply side of the service markets is more responsive to price changes (more elastic) users of services would bear more of the burden of the regulatory program. Thus, when the elasticity of supply is more elastic (producers are more sensitive to a change in price) and demand is held constant, the expected surplus loss to users of transportation services increases from 17 percent to 21 percent for marine and from 33 percent to 36 percent for rail, respectively (see Table 7H-2). Similarly, when the elasticity of demand is less elastic (consumers are less sensitive to a change in price) and the supply elasticity is held constant, the expected surplus loss to users of transportation services increases from 17 percent to 19 percent for marine and from 33 percent to 37 percent for rail, respectively (see Table 7H-3).

In contrast, when the supply side of the service market is less responsive to price changes (the elasticity of supply is less elastic) or the demand side of the service is more sensitive to price changes (the elasticity of demand is more elastic), service providers would bear more of the burden of the regulatory program. Here, when the elasticity of supply is decreased but the elasticity of demand is held constant, the expected surplus loss to providers of transportation services increases from 14 percent to 18 percent for marine and from 28 percent to 32 percent for rail, respectively (see Table 7H-2). When the elasticity of demand is more elastic (consumers are more sensitive to a change in price) and the supply elasticity is held constant, the expected surplus loss to providers of transportation services increases from 14 percent to 16 percent for marine and from 28 percent to 31 percent for rail, respectively (see Table 7H-3).

With regard to locomotive, marine vessel, and marine diesel engine suppliers, their share of the surplus loss increases when the price elasticity of supply is less elastic (they are less sensitive to prices changes) or when the price elasticity of demand is more elastic (consumers are more sensitive to price changes).

With regard to market effects, price increases and quantity decreases are somewhat higher when the price elasticity of supply is more elastic or the price elasticity of demand is less elastic, and somewhat lower when the price elasticity of supply is less elastic or the price elasticity of demand is more elastic.

Table 7H-2. Sensitivity Analysis for Supply Elasticity Parameters: 2020[a]

Market–Level Impacts	Variable Engineering Cost Per Unit	Primary Case				Supply Upper				Supply Lower			
		Change in Price		Change in Quantity		Change in Price		Change in Quantity		Change in Price		Change in Quantity	
		Absolute	Percent	Absolute	Percent	Absolute	Percent	Absolute	Percent	Absolute	Percent	Absolute	Percent
Locomotives													
Locomotives	$48,610	$48,092	2.54%	0	–0.08%	$48,177	2.54%	0	–0.08%	$48,041	2.53%	0	–0.06%
Transportation services	NA	NA	0.16%	NA	–0.08%	NA	0.16%	NA	–0.08%	NA	0.13%	NA	–0.06%
Marine													
Engines													
C1 >800 hp	$13,882	$13,269	8.42%	–6	–1.35%	$13,620	8.63%	–3	–0.71%	$13,542	8.63%	–2	–0.56%
C2 >800 hp	$49,379	$48,818	18.7%	–1	–0.72%	$48,683	18.70%	–1	–1.10%	$48,475	18.63%	–1	–0.86%
Other marine	$0	$0	0.00%	0	0.00%	–$5	–0.02%	–3	–0.11%	–$6	–0.03%	–2	–0.09%
Equipment													
C1 >800 hp	$2,979	$16,331	1.14%	–7	–1.35%	$22,965	1.14%	–4	–0.71%	$21,279	1.05%	–3	–0.56%
C2 >800 hp	$6,516	$143,933	3.64%	–1	–0.71%	$141,157	3.69%	–1	–1.10%	$136,129	3.53%	–1	–0.85%
Other marine	$0	–$2	0.00%	–1	0.00%	–$42	–0.02%	–18	–0.05%	–$54	–0.02%	–14	–0.04%
Transportation services	NA	NA	0.24%	NA	–0.12%	NA	1.10%	NA	–0.55%	NA	0.86%	NA	–0.43%

Welfare Impacts (Million $)	Primary Case Surplus Change	Primary Case Share	Supply Upper Surplus Change	Supply Upper Share	Supply Lower Surplus Change	Supply Lower Share
Locomotives						
Locomotive producers	–$0.7	0.3%	–$0.6	0.2%	–$0.7	0.3%
Rail transportation service providers	–$65.8	27.5%	–$57.9	24.3%	–$76.1	31.9%
Users of rail transportation service	–$78.9	32.9%	–$86.9	36.4%	–$68.5	28.7%
Total locomotive sector	–$145.3	60.7%	–$145.3	61.0%	–$145.4	61.0%
Marine						
Marine engine producers	–$0.8	0.3%	–$0.7	0.3%	–$0.9	0.4%
C1 >800 hp	–$0.6	0.2%	–$0.3	0.1%	–$0.3	0.1%
C2 >800 hp	–$0.2	0.1%	–$0.2	0.1%	–$0.3	0.1%
Other marine	$0.0	0.0%	–$0.2	0.1%	–$0.3	0.1%
Marine vessel producers	–$10.1	4.2%	–$8.5	3.6%	–$10.1	4.2%
C1 >800 hp	–$7.8	3.3%	–$4.7	2.0%	–$5.5	2.3%
C2 >800 hp	–$2.3	0.9%	–$2.5	1.1%	–$3.0	1.2%
Other marine	–$0.1	0.0%	–$1.3	0.5%	–$1.6	0.7%
Rec/fishing vessel consumers	–$7.8	3.3%	–$2.4	1.0%	–$1.9	0.8%
Marine transportation service providers	–$34.3	14.3%	–$32.6	13.7%	–$42.2	17.7%
Users of marine transportation service	–$41.2	17.2%	–$48.8	20.5%	–$38.0	15.9%
Total marine sector	–$94.1	39.3%	–$93.0	39.0%	–$93.1	39.0%
Total program	–$239.5	100.0%	–$238.3	100.0%	–$238.4	100.0%

[a] Figures are in 2005 dollars.

Table 7H-3. Sensitivity Analysis for Demand Elasticity Parameters: 2020[a]

Market–Level Impacts	Variable Engineering Cost Per Unit	Primary Case				Demand Upper Bound				Demand Lower Bound			
		Change in Price		Change in Quantity		Change in Price		Change in Quantity		Change in Price		Change in Quantity	
		Absolute	Percent	Absolute	Percent	Absolute	Percent	Absolute	Percent	Absolute	Percent	Absolute	Percent
Locomotives													
Locomotives	$48,610	$48,092	2.54%	0	–0.08%	$48,058	2.53%	0	–0.08%	$48,193	2.54%	0	–0.06%
Transportation services	NA	NA	0.16%	NA	–0.08%	NA	0.13%	NA	–0.08%	NA	0.17%	NA	–0.06%
Marine													
Engines													
C1 >800 hp	$13,882	$13,269	8.42%	–6	–1.35%	$13,552	8.59%	–3	–0.72%	$13,629	8.64%	–2	–0.55%
C2 >800 hp	$49,379	$48,818	18.74%	–1	–0.72%	$48,501	18.64%	–1	–1.11%	$48,709	18.71%	–1	–0.85%
Other marine	$0	$0	0.03%	0	0.00%	–$6	–0.03%	–3	–0.11%	–$4	–0.02%	–2	–0.08%
Equipment													
C1 >800 hp	$2,979	$16,331	1.14%	–7	–1.35%	$21,492	1.06%	–4	–0.72%	$23,174	1.15%	–3	–0.55%
C2 >800 hp	$6,516	$143,933	3.64%	–1	–0.71%	$136,763	3.55%	–1	–1.11%	$141,778	3.71%	–1	–0.84%
Other marine	$0	–$2	0.02%	–1	0.00%	–$52	–0.02%	–18	–0.05%	–$40	–0.02%	–14	–0.04%
Transportation services	NA	NA	0.24%	NA	–0.12%	NA	0.89%	NA	–0.55%	NA	1.13%	NA	–0.42%

Welfare Impacts (Million $)	Primary Case Surplus Change	Share	Demand Upper Bound Surplus Change	Share	Demand Lower Bound Surplus Change	Share
Locomotives						
Locomotive producers	–$0.7	0.3%	–$0.8	0.3%	–$0.6	0.2%
Rail transportation service providers	–$65.8	27.5%	–$73.8	30.8%	–$55.7	23.2%
Users of rail transportation service	–$78.9	32.9%	–$70.8	29.6%	–$89.1	37.2%
Total locomotive sector	–$145.3	60.7%	–$145.3	60.7%	–$145.4	60.7%
Marine						
Marine engine producers	–$0.8	0.3%	–$0.9	0.4%	–$0.7	0.3%
C1 >800 hp	–$0.6	0.2%	–$0.7	0.3%	–$0.5	0.2%
C2 >800 hp	–$0.2	0.1%	–$0.2	0.1%	–$0.2	0.1%
Other marine	$0.0	0.0%	$0.0	0.0%	–$0.0	0.0%
Marine vessel producers	–$10.1	4.2%	–$10.9	4.6%	–$9.1	3.8%
C1 >800 hp	–$7.8	3.3%	–$8.5	3.5%	–$7.0	2.9%
C2 >800 hp	–$2.3	0.9%	–$2.4	1.0%	–$2.1	0.9%
Other marine	–$0.1	0.0%	–$0.1	0.0%	$0.0	0.0%
Rec/fishing vessel consumers	–$7.8	3.3%	–$6.9	2.9%	–$8.9	3.7%
Marine transportation service providers	–$34.3	14.3%	–$38.5	16.1%	–$29.1	12.1%
Users of marine transportation service	–$41.2	17.2%	–$36.9	15.4%	–$46.5	19.4%
Total marine sector	–$94.1	39.3%	–$94.1	39.3%	–$94.2	39.3%
Total program	–$239.5	100.0%	–$239.4	100.0%	–$239.5	100.0%

[a] Figures are in 2005 dollars.

7H.2 Fixed Cost Shift Scenario

As discussed in 7.2.3.4, in the primary economic analysis only the variable costs are used to shift the supply curve in the engine and equipment markets. This is because in a competitive market the industry supply curve is generally based on the market's marginal cost curve and fixed costs do not influence production decisions on the margin. In this scenario, the supply shift for engine and equipment producers includes both variable compliance costs and the fixed costs incurred in that year. This would allow the manufacturers to cover the fixed costs that occur in that year.

We present the results of this analysis for 2011 and 2015. In 2011, locomotive manufacturers would be incurring fixed costs associated with the Tier 3 and Tier 4 PM standards; marine engine manufacturers would be incurring costs in connection with both the Tier 3 and Tier 4 standards. Therefore, 2011 is a high-cost year for the program. In 2015, locomotive manufacturers would be incurring fixed costs for Tier 4 NO_x standards; marine engine manufacturers would be incurring costs for the Tier 4 standards. In addition the vessel redesign costs begin in 2015. Both 2011 and 2015 costs are also expected to be elevated due to certification costs.

The results of this analysis are presented in Tables 7H-4 and 7H-5.

In 2011, the changes in the results are considerable. In the market analysis, the expected price change for locomotives increases from -$425 to $11,700, although this is a small increase on a percentage basis (less than 1 percent). The prices of commercial marine engines and commercial marine vessels change significantly. The engine price increases increase from zero percent to 17 percent and 40 percent for commercial C1 and C2 engines, and from zero percent to 2.0 and 7.2 percent for commercial C1 and C2 vessels.

With regard to the social welfare analysis in 2011, the share of the surplus loss borne by locomotive and marine diesel engine producers decreases, while the share borne by rail and marine transportation service providers and users, as well as marine vessel suppliers, increases. This is because the fixed costs are passed from the producers to the end users. The share of the surplus loss decreases from 5.5 percent to 0.2 percent for locomotive producers and from 42.7 percent to 1.5 percent for marine engine producers, and increases from zero percent to 12.4 percent for marine vessel producers. The share increases from 23.6 percent and 28.3 percent to 26.1 percent and 31.3 percent for rail transportation service providers and users, and from zero percent to 6.5 percent and 7.8 percent for marine transportation service providers and users.

The impacts the 2015 results, for the Tier 4 program, are similar with large changes in the expected price increases and a shift from the engine and locomotive suppliers to the vessel suppliers and transportation service markets. In this case, however, there is a larger shift to the marine transportation service market, with the vessel suppliers bearing less of the costs. Specifically, the engine producer share is only about one percent in this case, with the marine transportation service providers and users bearing about 10.6 percent and 12.7 percent of the costs. This is still a significant increase, compared to the base case of 1.5 percent and 1.8 percent respectively (due to the operation costs from urea usage).

Even with these cost shifts, the overall production of locomotives and marine diesel engines and vessels is not expected to decrease significantly, and prices of rail and marine transportation services are not expected to increase significantly. There is no decrease in locomotive sales and commercial marine sales are expected to decrease by less than 200 units in 2011 and 2015 (less than 4 percent). Rail and marine transportation service prices are expected to increase by less than 1 percent. This is because rail and marine transportation services are production inputs for other goods and services, and an increase in their prices would be a relatively small increase to the total production costs of goods and services using these inputs.

Table 7H-4. Sensitivity Analysis for Supply Shifts: 2011[a]

	Variable Cost Only Supply Shift				Fixed and Variable Cost Supply Shift Scenario			
	Change in Price		Change in Quantity		Change in Price		Change in Quantity	
Market–Level Impacts	**Absolute**	**Percent**	**Absolute**	**Percent**	**Absolute**	**Percent**	**Absolute**	**Percent**
Locomotives								
Locomotives	$425	-0.02%	0	-0.06%	$11,706	0.79%	0	-0.07%
Transportation services	NA	-0.12%	NA	-0.06%	NA	0.13%	NA	-0.07%
Marine								
Engines								
C1 >800 hp	$0	-0.00%	0	-0.00%	$24.557	16.82%	–9	–2.37%
C2 >800 hp	$0	-0.00%	0	-0.00%	$92,754	39.9%	–1	–1.28%
Other marine	$0	-0.00%	0	-0.00%	$739	4.99%	–45	–0.94%
Equipment								
C1 >800 hp	$0	-0.00%	0	-0.00%	$27.112	2.03%	–11	–2.37%
C2 >800 hp	$0	-0.00%	0	-0.00%	$264,897	7.21%	–1	–1.24%
Other marine	$0	-0.00%	0	-0.00%	$603	0.52%	–203	–0.64%
Transportation services	NA	-0.00%	NA	-0.00%	NA	0.10%	NA	–0.05%
Welfare Impacts (Million $)	**Surplus Change**		**Share**		**Surplus Change**		**Share**	
Locomotives								
Locomotive producers		–$11.1	5.5%			–$0.4	0.2%	
Rail transportation service providers		–$47.5	23.6%			–$52.3	26.1%	
Users of rail transportation service		–$57.0	28.3%			–$62.8	31.3%	
Total locomotive sector		–$115.6	57.3%			–$115.6	57.6%	
Marine								
Marine engine producers		–$86.0	42.7%			–$2.9	1.5%	
C1 >800 hp		–$22.8	11.3%			–$0.9	0.4%	
C2 >800 hp		–$27.8	13.8%			–$0.3	0.1%	
Other marine		$35.4	17.6%			–$1.8	0.9%	
Marine vessel producers		–$0.00	0.0%			–$24.9	12.4%	
C1 >800 hp		–$0.00	0.0%			–$8.7	4.3%	
C2 >800 hp		–$0.00	0.0%			–$1.9	0.9%	
Other marine		–$0.00	0.0%			–$14.4	7.2%	
Rec/fishing vessel consumers		–$0.00	0.0%			–$28.4	14.1%	
Marine transportation svc providers		–$0.00	0.0%			–$13.0	6.5%	
Users of marine transportation service		–$0.00	0.0%			–$15.6	7.8%	
Total marine sector		–$86.0	42.7%			–$84.9	42.4%	
Total program		–$201.5	100.0%			–$200.5	100.0%	

[a] Figures are in 2005 dollars.

Table 7H-5. Sensitivity Analysis for Supply Shifts: 2015[a]

	Variable Cost Only Supply Shift				Fixed and Variable Cost Supply Shift Scenario			
	Change in Price		Change in Quantity		Change in Price		Change in Quantity	
Market–Level Impacts	**Absolute**	**Percent**	**Absolute**	**Percent**	**Absolute**	**Percent**	**Absolute**	**Percent**
Locomotives								
Locomotives	$36,023	1.90%	0	-0.05%	$43,405	2.39%	0	-0.05%
Transportation services	NA	0.09%	NA	-0.05%	NA	0.10%	NA	-0.05%
Marine								
Engines								
C1 >800 hp	–$1	0.00%	0	0.00%	$27,274	18.71%	–16	–3.94%
C2 >800 hp	–$6	0.00%	0	–0.01%	$96,310	41.44%	–1	–1.55%
Other marine	$0	0.00%	0	0.00%	$0	0.00%	0	0.00%
Equipment								
C1 >800 hp	–$11	0.00%	0	0.00%	$45,071	3.37%	–20	–3.92%
C2 >800 hp	–$147	0.00%	0	–0.01%	$321,217	8.71%	–2	–1.51%
Other marine	$0	0.00%	0	0.00%	-$1	0.00%	0	0.00%
Transportation services	NA	0.02%	NA	–0.01%	NA	0.13%	NA	–0.07%
Welfare Impacts (Million $)	**Surplus Change**		**Share**		**Surplus Change**		**Share**	
Locomotives								
Locomotive producers		–$8.6	5.0%			–$0.4	0.2%	
Rail transportation service providers		–$38.2	22.2%			–$42.0	24.5%	
Users of rail transportation service		–$45.9	26.6%			–$50.4	29.5%	
Total locomotive sector		–$92.8	53.8%			–$92.7	54.5%	
Marine								
Marine engine producers		–$56.6	32.8%			–$1.8	1.1%	
C1 >800 hp		–$26.7	15.5%			–$1.5	0.9%	
C2 >800 hp		–$29.9	17.3%			–$0.3	0.2%	
Other marine		$0.0	0.0%			$0.0	0.0%	
Marine vessel producers		–$17.5	10.2%			–$17.2	10.0%	
C1 >800 hp		–$12.5	7.2%			–$14.8	8.7%	
C2 >800 hp		–$5.0	2.9%			–$2.3	1.4%	
Other marine		$0.0	0.0%			$0.0	0.0%	
Rec/fishing vessel consumers		$0.0	0.0%			–$19.5	11.4%	
Marine transportation svc providers		–$2.5	1.5%			–$18.1	10.6%	
Users of marine transportation service		–$3.1	1.8%			–$21.7	12.7%	
Total marine sector		–$79.8	46.2%			–$78.3	45.8%	
Total program		–$172.5	100.0%			–$171.0	100.0%	

[a] Figures are in 2005 dollars.

7H.3 Marine Operating Cost Scenario

In the primary case, all operating costs are allocated to the marine transportation service providers. This assumption likely overstates the share of the operating costs for this sector because it includes operating costs that are associated with recreational vessels that have marine diesel engines above 2,700 hp (2,000 kW) and with fishing vessels that have marine diesel engines above 800 hp (600 kW).

In this scenario, we attempt to allocate these extra operating costs to fishing and recreational vessels. The difficulty with this scenario is devising a way to allocate the costs. Because urea usage is a function of fuel use, it is reasonable to allocate the costs as a function of fuel usage. However, there is no publicly available data that indicates these fuel usage rates. Therefore, we estimate the fraction of operating costs as a function of the share of the total population. This method likely overstates the operating costs in the other direction, over-allocating the costs to recreational and fishing vessels. This is because this allocation method assumes that all vessels consume fuel in the same proportion; this is unlikely to be the case for recreational and fishing vessels, since usage of these vessels tends to be seasonal and they tend to be used for fewer hours a year. However, this sensitivity analysis will provide an indication of how sensitive the results are to differences in the allocation of operating costs.

The results of this analysis are contained in Table 7H-6. The market analysis shows a small increase in the price increase and a small decrease in the quantity decrease for marine diesel engines and vessels. There is also a small decrease in the amount of marine transportation services provided and a smaller increase in the price. The main change, not surprisingly, is smaller decreases in share of surplus loss for marine engine and vessel producers and a larger share of the surplus loss for recreational and fishing vessel consumers, from 3.3 percent ($7.8 million) to 5.4 percent ($12.9 million). There is a corresponding decrease in the share of surplus loss for marine transportation service providers and users, from 14.3 percent to 13.7 percent, and from 17.2 percent to 16.5 percent, respectively.

Table F-4. Sensitivity Analysis for Marine Operating Costs: 2020[a]

	Primary Case				Operating Cost Sensitivity			
	Change in Price		Change in Quantity		Change in Price		Change in Quantity	
Market–Level Impacts	**Absolute**	**Percent**	**Absolute**	**Percent**	**Absolute**	**Percent**	**Absolute**	**Percent**
Locomotives								
Locomotives	$48,092	2.54%	0	–0.08%	$48,092	2.54%	0	-0.08%
Transportation services	NA	0.16%	NA	–0.08%	NA	0.16%	NA	-0.08%
Marine								
Engines								
C1 >800 hp	$13,269	8.42%	–6	–1.35%	$13,189	8.37%	-6	-1.54%
C2 >800 hp	$48,818	18.74%	–1	–0.72%	$48,792	18.73%	-1	-0.75%
Other marine	$0	0.03%	0	0.00%	$0	0.00%	0	0.00%
Equipment								
C1 >800 hp	$16,331	1.14%	–7	–1.35%	$18,537	1.31%	-8	-1.54%
C2 >800 hp	$143,933	3.64%	–1	–0.71%	$152,840	3.87%	-1	-0.75%
Other marine	–$2	0.02%	–1	0.00%	-$2	0.00%	-1	0.00%
Transportation services	NA	0.24%	NA	–0.12%	NA	0.23%	NA	-0.12%
Welfare Impacts (Million $)	**Surplus Change**		**Share**					
Locomotives							**Share**	
Locomotive producers		-$0.7	0.3%			-$0.7	0.3%	
Rail transportation service providers		-$65.8	27.5%			-$65.8	27.5%	
Users of rail transportation service		-$78.9	32.9%			-$78.9	32.9%	
Total locomotive sector		-$145.3	60.7%			-$145.3	60.7%	
Marine								
Marine engine producers		-$0.8	0.3%			-$0.9	0.4%	
C1 >800 hp		-$0.6	0.2%			-$0.7	0.3%	
C2 >800 hp		-$0.2	0.1%			-$0.2	0.1%	
Other marine		$0.0	0.0%			$0.0	0.0%	
Marine vessel producers		-$10.1	4.2%			-$7.9	3.3%	
C1 >800 hp		-$7.8	3.3%			-$6.6	2.7%	
C2 >800 hp		-$2.3	0.9%			-$1.3	0.6%	
Other marine		-$0.1	0.0%			-$0.1	0.0%	
Rec/fishing vessel consumers		-$7.8	3.3%			-$12.9	5.4%	
Marine transportation service providers		-$34.3	14.3%			-$32.9	13.7%	
Users of marine transportation service		-$41.2	17.2%			-$39.5	16.5%	
Total marine sector		-$94.1	39.3%			-$94.1	39.3%	
Total program		-$239.5	100.0%			-$239.4	100.0%	

[a] Figures are in 2005 dollars

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[1] U.S. EPA "EPA Guidelines for Preparing Economic Analyses." EPA 240-R-00-003. September 2000, p. 113. A copy of this document can be found at http://yosemite.epa.gov/ee/epa/eed.nsf/webpates/guidelines.html

[2] Association of American Railroads (AAR). Railroad Facts, 2006 Edition. November 2006. Policy and Economics Department, Association of American Railroads, 50 F Street NW, Washington DC 20001. www.aar.org.

[3] U.S. EPA. "OAQPS Economic Analysis Resource Document." Research Triangle Park, NC: EPA 1999. A copy of this document can be found at http://www.epa.gov/ttn/ecas/econdata/6807-305.pdf

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