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 1
Industry Characterization

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CHAPTER 1: INDUSTRY CHARACTERIZATION

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CHAPTER 1: Industry Characterization

In order to assess the impacts of emission regulations upon the affected industries, it is important to understand the nature of the industries impacted by the regulations. The industries affected by these regulations include marine diesel engine manufacturers and marinizers, the manufacturers of marine vessels which have marine diesel marine engines installed on them, the manufacturers of locomotives and locomotive engines, the owners and operators of locomotives (i.e., railroads), and remanufacturers of locomotives and locomotive engines. This chapter provides market information for each of these affected industries, and is provided for background purposes.

1.1 Marine

1.1.1 Introduction

The regulations for marine diesel engines will directly impact three industries. These industries are the manufacturers of marine diesel engines, diesel engine marinizers, and the manufacturers of vessels which have marine diesel engines installed on them. Each of these industries is discussed in more detail in the following sections. Much of this marine industry characterization was taken from a report done for us by RTI, International.[1]

1.1.1.1 Marine Diesel Market Overview

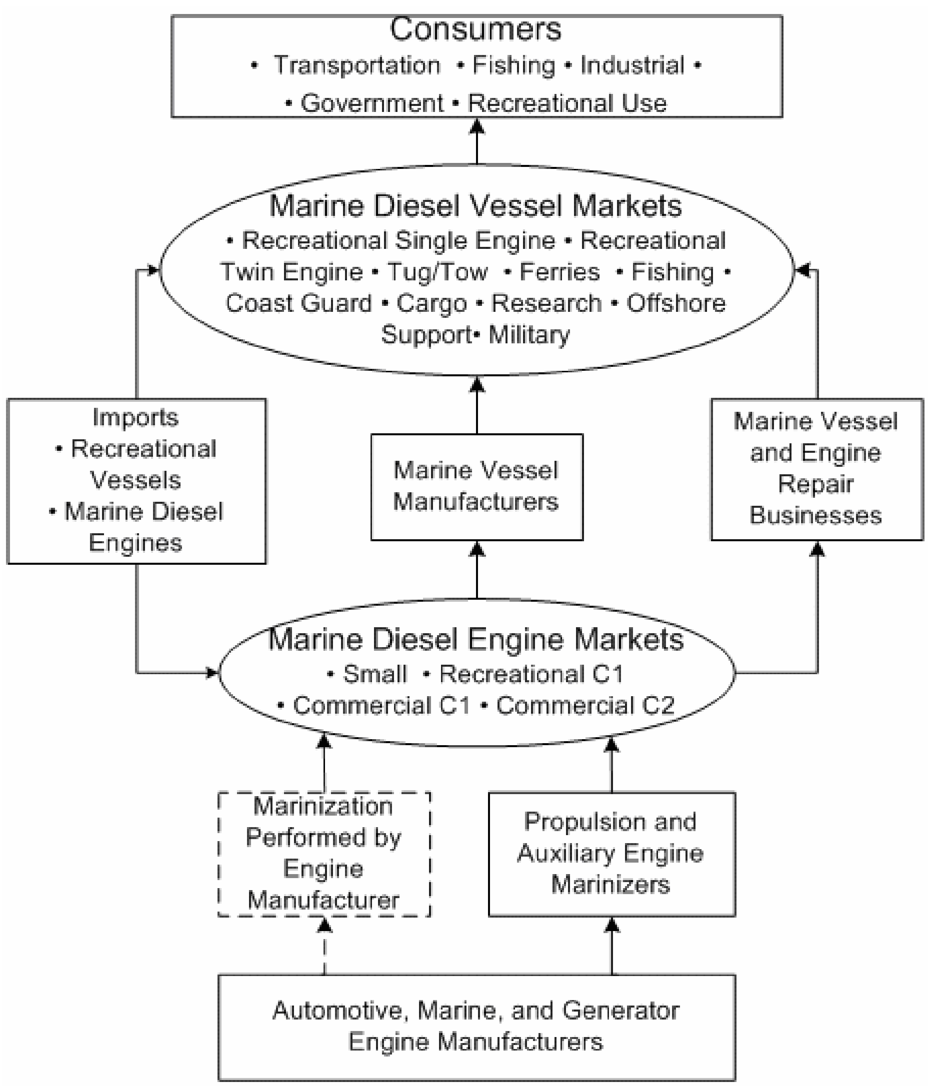
Marine diesel engines include both engines used for propulsion on marine vessels, and those used for marine vessel auxiliary power needs. Diesel marine engines are generally derived from engines originally designed and manufactured for land-based nonroad applications. These nonroad engines are then adapted for use in marine applications through the process of marinization, either by the original engine manufacturer, or by a post-manufacturer marinizer (PMM). The marinization process is discussed in further detail in section 1.1.2.2.2.

Propulsion engines can vary dramatically in size and power, from the smallest engines used in recreational sailboats, to very large engines used in ocean-going commercial vessels. Similarly, auxiliary engines cover a very broad range of sizes and rated power. Auxiliary engines can be used for a variety of purposes, including primary or emergency electrical power generation, and the powering of onboard equipment such as pumps, winches, cable and pipe laying machinery, and dredging equipment. A description of the various engine categories used for regulatory purposes is contained in section 1.1.2.1.

As with marine diesel engines, marine vessels include a very broad range of vessel sizes and types. These include small recreational vessels, as well as commercial vessels such as tow and tug boats, patrol boats, commercial fishing vessels, research vessels, passenger vessels tour boats and ferries), offshore support vessels which service offshore drilling platforms, and a variety of other specialized commercial vessels.

Figure 1-1 shows the links between the various market segments of the marine diesel engine industry and the marine vessel industry, as discussed further in the following sections.

Figure 1-1 Marine Diesel Market Segment Flow Chart



1.1.1.2 Current Emission Regulations

The first standards to take effect for commercial marine diesel engines are the Tier 1 emission standards, which were adopted in 2003, and became effective with the 2004 model year (68 FR 9746, February 28, 2003). These NO_x-only standards apply to commercial marine diesel engines with a per-cylinder displacement of greater than 2.5 liters per cylinder. As shown in Table 1-1 the standards vary depending on the rated speed of the engine.

Table 1-1 Tier 1 Standards for Commercial Marine Diesel Engines over 2.5 Liters per Cylinder

Rated engine speed (rpm)	NO_x (g/kW-hr)
<130	17
130-2000	45 X $rpm^{-0.2}$
>2000	9.8

We adopted Tier 2 emission standards for Category 1 (C1) marine diesel engines over 37 kW and for Category 2 (C2) marine diesel engines in 1999 (64 FR 73300, December 29, 1999). These standards are shown in Table 1-2.

Table 1-2 Tier 2 Emission Standards for C1 (over 37 kW) and C2 Commercial Marine Diesel Engines.

Category	Displacement (liters/cylinder)	Starting Date	NO_x+THC (g/kW-hr)	PM (g/kW-hr)	CO (g/kW-hr)
1	Power ≥37 kW, disp. <0.9	2005	7.5	0.40	5.0
	0.9 ≤ disp. < 1.2	2004	7.2	0.30	5.0
	1.2 ≤ disp. < 2.5	2004	7.2	0.20	5.0
	2.5 ≤ disp. < 5.0	2007	7.2	0.20	5.0
2	5.0 ≤ disp. < 15.0	2007	7.8	0.27	5.0
	15.0 ≤ disp. < 20.0, and power < 3300 kW	2007	8.7	0.50	5.0
	15.0 ≤ disp. < 20.0, and power ≥ 3300 kW	2007	9.8	0.50	5.0
	20.0 ≤ disp. < 25.0	2007	9.8	0.50	5.0
	25.0 ≤ disp. < 30.0	2007	11.0	0.50	5.0

We applied the Tier 2 emission standards for C1 engines shown in Table 1-2 to recreational marine diesel engines, but with applicable dates two years behind those for the corresponding commercial marine diesel engines (67 FR 68242, November 8, 2002).

There are currently no emission regulations specifically for marine diesel engines less than 37 kW. Rather, these engines are covered by the Tier 2 standards for nonroad compression ignition (CI) engines, as shown in Table 1-3 (63 FR 56968, October 23, 1998).

Table 1-3 Tier 2 Emission Standards for Marine Diesel Engines Below 37 kW

Engine Power	$NMHC+NO_x$ (g/kW-hr)	PM (g/kW-hr)	CO (g/kW-hr)
kW < 8	7.5	0.80	8.0
8 ≤ kW < 19	7.5	0.80	6.6
19 ≤kW < 37	7.5	0.60	5.5

1.1.1.3 Programs in California and Europe

The State of California has recently finalized a requirement that auxiliary engines on ocean-going vessels that operate in California waters use clean distillate fuel. Under California's proposal, NO_x, diesel PM and SO_x emissions from a regulated auxiliary diesel engine would be limited to the emission rates that would have resulted had the engine been fueled with distillate fuel. The regulated auxiliary engines are typically below 30 liters per cylinder displacement, although the California program would also apply to indirect drive diesel engines of any size. The requirements could be met by using either distillate fuel or an alternative emission control strategy as evidenced by an Alternative Compliance Plan. The proposed controls are effective January 1, 2007, for a 5,000 ppm equivalent fuel sulfur limit, and January 1, 2010, for a 1,000 ppm equivalent fuel sulfur limit. The requirements would apply to auxiliary diesel engines on ocean-going vessels while they are operating within any of regulated California waters, which include all California inland waters, all California estuarine waters, and all waters within a zone 24 nautical miles seaward of the coastline.

California's program is roughly patterned after the European Union's marine fuel Directive 2005/33. This directive, which limits the sulfur content of distillate fuels used in EU territory has four components. First, until August 10, 2006, the fuel sulfur content of distillate fuel cannot exceed 2,000 ppm. This applies to DMA, DMB, DMC, and DMX grades.[A] From August 11, 2006 to December 31, 2007, this

[A] ASTM specifications for marine fuels identify four kinds of marine distillate fuels: DMX, DMA, DMB, and DMC. DMX is a special light distillate intended mainly for use in emergency engines. DMA (also called MGO) is a general purpose marine distillate that must contain no traces of residual fuel. These fuels can be used in all marine diesel engines but are primarily used by Category 1 engines. DMB, also called marine diesel oil, is not typically used with Category 1 engines, but is used for Category 2 and 3 engines. DMB is allowed to have a trace of residual fuel, which can be high in sulfur. DMC is a grade of marine fuel that may contain some residual fuel and is often a residual fuel blend. Residual fuel is typically designated by the prefix RM (e.g., RMA, RMB, etc.). These fuels are also identified by their nominal viscosity (e.g., RMA10, RMG35, etc.). Most residual fuels require treatment by a purifier-clarifier centrifuge system, although RMA and RMB do not require this.

requirement is relaxed for DMB and DMC grades, which are then pegged to the 15,000 ppm SECA limit. That requirement applies to fuels placed on the market during that period. From January 1, 2008 to December 31, 2009, the fuel sulfur limit for DMA and DMX grades falls to 1,000 ppm. Finally, beginning January 1, 2010, a fuel sulfur limit of 1,000 ppm applies to all marine gas oils (DMA, DMB, DMC, and DMX) placed on the market, and to all types of marine fuels used by ships at berth in EU ports and by inland waterway vessels. These last limits apply to any fuel used onboard a vessel. Exemptions apply for ships that spend less than 2 hours at berth, ships that use shore-side electricity while at berth, and hybrid sea-river vessels while they are at sea.

In this proposal we are not considering similar programs for the fuels used by vessels while operating in U.S. territorial waters. We believe that the best approach for addressing emissions from auxiliary engines on foreign vessels that visit US ports is through the adoption of international standards that would reduce both NO_x and PM emissions from these engines. We will continue to participate in discussions for the next tier of international standards at the International Maritime Organization, as part of the U.S. negotiating team. We will also reconsider this issue as part of our future Category 3 marine diesel engine action.

1.1.2 Marine Diesel Engine Manufacturers

Diesel (compression-ignition) engines are designed to be quite robust in order to withstand the very high temperatures and pressures associated with compression-ignition. As a result, they tend to be very reliable and have very long service lives. Their energy efficiency and simple design result in low operating and maintenance costs. As a result, diesel engines tend to dominate commercial marine applications, where cost and reliability are key purchase decisions for the vessel operator. Diesel engines account for only a small portion of the recreational marine market, however, as their initial purchase price is high relative to gasoline (spark-ignition) engines. The benefits of lower operating costs are not nearly as important in the recreational market, where engines tend not to get much use as compared to commercial applications.

The terms "commercial" and "recreational" are defined in 40 CFR Part 94, *Control of Emissions for Marine Compression-Ignition Engines* (Code of Federal Regulations, 2006). The definitions in section 94.2 state that a commercial engine is an engine installed on a commercial vessel. Likewise, a recreational engine is an engine installed on a recreational vessel. Recreational vessel is defined as a vessel that is intended by its manufacturer to be operated primarily for pleasure purposes, although such a vessel could be chartered, rented or leased. Further, a recreational vessel should be less than 100 gross registered tons, should carry fewer than six passengers, and cannot be used solely for competition.

This industry characterization is concerned with the U.S. market for marine diesel engines, which encompasses all diesel marine engines installed on marine vessels to be flagged (registered) in the United States. This includes engines made in the U.S., engines imported for installation in vessels made in the U.S., and engines included in vessels made overseas and imported into the U.S. Unless otherwise noted, the production and engine characteristics data presented in the following sections were obtained from the Power Systems Research OELink database.[2]

1.1.2.1 Engine Categories and Characteristics

For the purposes of this industry characterization, we looked at four broad categories of diesel marine engines, based on the categories that currently exist for emission regulation purposes. These categories are shown in Table 1-4.

Table 1-4 Diesel Marine Engine Categories and Applications

Category	Power	Displacement per Cylinder	Applications
Small	≤37 kW	Any	Auxiliary, Recreational Propulsion
Recreational Category 1	>37 kW	< 5 liters	Recreational Propulsion
Commercial Category 1	>37 kW	< 5 liters	Auxiliary, Commercial Propulsion
Commercial Category 2	>37 kW	≥ 5 liters and < 30 liters	Auxiliary, Commercial Propulsion
Commercial Category 3	>37 kW	≥ 30 liters	Commercial Propulsion

Given the broad range of commercial and recreational marine vessels types, it is difficult to identify typical applications for each engine category. Nonetheless, the following paragraphs provide an overview of the general characteristics and typical applications of engines in each category.

Small: Engines in this category range from 4 to 43 horsepower (hp) and are characterized by low costs and high sales volumes. Most small engines are used for auxiliary purposes on marine vessels or for propulsion on recreational sailboats. In 2002 they accounted for approximately 26 percent of the marine diesel engines produced or imported in the U.S. market. They are typically marinized land-based nonroad diesel engines; we are not aware of any marine engines of this size made solely for marine application.

Category 1 (C1) Recreational: Engines in this category range from 52 to 3,155 hp and are characterized by high power density (power to weight ratio) and low annual hours of operation relative to commercial engines. Such engines are typically operated no more than 200 to 250 hours per year, and often less. These engines are used for propulsion in recreational vessels, which are designed for speed and planing operation. In 2002 they accounted for approximately 34 percent of the marine diesel engines produced or imported in the U.S. market.

Recreational vessels are designed primarily for speed, and this imposes certain constraints on the type of engine they can use. For a marine vessel to reach high speeds, it is necessary to reduce the surface contact between the vessel and the water, and consequently these vessels typically operate in a planing mode. However, the accompanying high engine speeds are sustained for only short periods of time compared to the total operation of the vessel (i.e., long enough for the vessel to get up on plane), and the duty cycle on which these engines are certified reflects these operations.

Planing imposes two important design requirements. First, the vessel needs to have a very high power, but lightweight, engine to achieve the speeds necessary to push the vessel onto the surface of the water. Therefore, recreational engine manufacturers have focused on achieving higher power output with lighter engines (this is also referred to as high power density). The tradeoff is less durability, and recreational engines are warranted for fewer hours of operation than commercial marine engines. The shorter warranty period is not a great concern, however, since recreational vessels, and therefore their engines, are typically used for fewer hours per year than commercial engines, and spend much less time operating at higher engine loads. Second, the vessel needs to be as light as possible, with vertical and horizontal centers of gravity carefully located to allow the hull of the vessel to be lifted onto the surface of the water. Therefore, recreational vessel manufacturers have focused on designing very lightweight hulls. They are typically made out of fiberglass, using precisely designed molds. The tradeoff is a reduced ability to accommodate any changes to the standard design. For these reasons, recreational vessels are typically designed around a specific engine or group of engines, and engines that are heavier or that are physically larger cannot be used without jeopardizing the vessel's planing abilities or, in many cases, designing a new fiberglass mold for a modified hull.

Category 1 (C1) Commercial: Engines in this category are very similar to engines in the C1 recreational category in displacement, but tend to have lower hp ratings than recreational marine diesel engines in order to provide increased durability required in commercial applications. In contrast to C1 recreational engines, C1 commercial engines are typically used 750 to 4,000 hours per year. They are typically used for propulsion in vessels with displacement hull designs. They are also used for a wide variety of auxiliary power needs on marine vessels. In 2002 they accounted for approximately 39 percent of the marine diesel engines produced or imported in the U.S. market.

In contrast to recreational marine vessels, commercial vessels are typically larger displacement hull vessels, and instead of operating on the surface of the water, for speed, they are pushed through the water. The speed at which a displacement vessel can operate is limited by its hull design and above that limit, there are quickly diminishing returns on power: little vessel speed increase is achieved by increasing power. Because vessel speed is limited by the hull design, there is little incentive to over power the vessel, and engines on these types of commercial vessels tend to be lower power when compared to recreational vessels of similar size. Commercial engines operate for long periods at about 80-90% of rated power and are designed primarily with durability and fuel consumption in mind.

Category 2 (C2): Engines in this category are typically derived from engines originally designed for use in locomotives or for land-based stationary power generation. Such engines typically operate 3,000 to 5,000 hours or more per year, and are designed to be durable and have a very long service life. Under our current program, all C2 marine diesel engines are handled the same way; there is no distinction between recreational or commercial engines in this category. In 2002 they accounted for approximately one percent of the marine diesel engines produced or imported in the U.S. market.

As we were developing this proposal, engine manufacturers brought to our attention another category of marine diesel engines that do not fit neatly in the above scheme. These are high power-density marine diesel engines used in some commercial vessels, including certain kinds of crew boats, research vessels, and fishing vessels. Unlike most commercial vessels, these vessels are built for higher speed, planing operation, which allows them to reach research fields, oil platforms, or fishing beds more quickly. These engines may have smaller service lives because of operation at these higher speeds. Our current program does not distinguish between these commercial engines and those used on displacement vessels with respect to useful life periods. Further, this industry characterization does not specifically address these engines as a unique group.

A final category of marine diesel engines, Category 3 (C3) engines, have displacements of 30 liters per cylinder or greater. Such engines are typically only used in large ocean-going vessels, and are not considered in this industry characterization. Table 1-5 shows a summary of the general characteristics of engines in each of the four categories considered in this industry characterization.

Table 1-5 Engine Characteristics for the Considered Engine Categories

	Small	Recreational Category 1	Commercial Category 1	Category 2
Cylinders	1–4	3–16	3–24	5–20
Horsepower	4.2–42.4	52–3,155	37.5–2,500	300–9,190[a]
Engine Speed (rpm)	1,800 – 3,000	1,800 – 3,000	1,800 – 3,000	750 – 1,500
Weight (lbs)	26–246	156–7,491	106–7,900	7,850–35,000
Cycle:				
2	0.0%	10.2%	9.5%	41.0%
4	100.0%	89.8%	90.5%	59.0%
Configuration:				
H-Block	8.1%	0.0%	0.0%	0.0%

Inline	91.9%	65.3%	73.3%	33.7%
V-Block	0.0%	34.7%	26.7%	66.3%
Cooling:				
Air	5.9%	0.0%	0.4%	0.0%
Oil	0.0%	0.0%	0.1%	0.0%
Water	94.1%	100.0%	99.5%	100.0%

a. While the PSR database shows one C2 engine family with a 300 hp rating, C2 engines are generally over 1000 hp at minimum.

Table 1-6 shows the total number of engines in each category which were sold in the United States in 2002.

Table 1-6 Marine Diesel Engine Sales by Engine Category in 2002

Application Category	Sales in 2002	Percent of Total
Small	10,761	26.4%
Recreational C1	13,952	34.2%
Commercial C1	15,826	38.8%
Commercial C2	277	0.7%
Total	40,816	

1.1.2.2 Supply Side

Marine diesel engines are typically derived from land-based nonroad engines. These engines are adapted for use in the marine environment through a process known as marinization. In this section we will discuss nonroad engine design, production and costs, followed by descriptions of the marinization process and the companies engaged in this activity. Finally we will discuss engine dressing and rebuilding practices for marine diesel engines.

1.1.2.2.1 Nonroad Diesel Engine Design and Production

Engine blocks are cast in a foundry, most often from gray iron. Depending on the size and complexity of the engine, the block may be formed by impression molding or two-piece sand-casting. Smaller, more complex parts, including cylinder heads, exhaust manifolds, and cylinder liners, are cast from ductile iron, typically using sand cores to allow formation of the complicated shapes. All castings must be cleaned and deburred prior to further processing. In addition, ductile iron parts will also usually be heat treated to relieve stress and harden the alloys. Table 1-7 lists the materials and primary production processes for various engine components.[3]

Table 1-7 Engine Component Materials and Production Processes

Component	Primary Materials	Primary Process
Block	Iron, aluminum	Casting
Cylinder head	Iron, aluminum	Casting, machining
Intake manifold	Plastic, aluminum	Casting, machining

Connecting rods	Powder metal, steel	Molding, forging, machining
Pistons	Aluminum	Forging, machining
Crankshaft	Iron, steel, powder metal	Molding, forging, machining
Valves	Steel, magnesium	Stamping, machining
Exhaust systems	Stainless steel, aluminum, iron	Extruding, stamping

The cast block, cylinder head, and cylinder liners, along with crankshafts, gears, connecting rods, and other engine parts, are next machined to exact specifications in a machining center. Holes are drilled, parts reshaped, excess metal removed, and the metal surfaces polished in the machining area. The operation of the finished engine depends critically on the precision of the machining work at this stage.

The third major step in engine manufacturing is assembly. This area is usually physically isolated from the dirty upstream operations so that contaminants are not introduced into the completed engines, thus affecting their operation or shortening the engine's life. In a typical plant, subassemblies are first put together on separate lines or in separate bays; then the subassemblies are brought together for final assembly. The completed engines are visually inspected and then evaluated on-line on a test bench or in a test cell to ensure their performance will meet expectations.

1.1.2.2.2 Engine Marinization

Land-based nonroad diesel engines generally need to be modified in some ways to make them suitable for installation on marine vessels. The process by which this is done is known as marinization. The marinization process results in changes to the emission characteristics of the nonroad engine. For this reason, a marinized nonroad engine must be certified to marine diesel engine emission standards even though the base nonroad engine is certified to the nonroad diesel engine emission standards. Sometimes, land-based nonroad diesel engines can be adapted for use in marine applications without changing the emission characteristics of the engine. This process is called engine dressing, and is discussed in section 1.1.2.2.5. Marinization typically involves three significant modifications: choosing and optimizing the fuel management system, configuring a marine cooling system, and making other peripheral changes. These changes are detailed in the following paragraphs.

Fuel and Air Management: High-performance engines are preferred for most recreational and some light duty commercial applications. These engines are built to maximize their power-to-weight ratio (provide more power with less added weight), which is typically done by increasing power from a given cylinder displacement. This is usually accomplished by installing a new fuel injection system, which injects more fuel directly into the cylinder to increase power. This can require changes to the camshaft, cylinder head, and the injection timing and pressure. Currently, the design limits for increased fuel to the cylinder are smoke and durability. Modifications made to the cooling system also help enhance performance. By cooling the charge, more air can be forced into the cylinder. As a result, more fuel can be injected and burned efficiently because of the increase in available oxygen. In addition, changes are often made to the pistons, cylinder head components, and the lubrication system. For example, aluminum piston skirts can be used to reduce the weight of the pistons. Cylinder head changes include changing valve timing to optimize engine breathing characteristics. Marinizers do not typically go as far as to physically modify the cylinder head.

Cooling System: To mitigate performance problems, engine manufacturers historically used cooling systems that cooled by circulating seawater through the engine that was pumped from outside the boat. Even though many currently operating marine diesel engines still use seawater to cool the engine, almost all newly built engines use a closed cooling system that recirculates coolant through the engine block. These engines still use raw seawater by using it to draw heat out of the engine coolant. These closed systems help prevent corrosion and allow the engine to operate at higher temperatures. As part of the cooling system, water-jacketed exhaust manifolds, pumps, and heat exchangers are added. Marine diesel engines may also have larger oil pans to help keep oil temperatures down.

Other Additions and Modifications: Marine engines are often installed in engine compartments without much air flow for cooling, which can result in a number of exposed hot surfaces (leading to safety concerns) or performance problems from overheating the engine. To address safety concerns and to comply with U.S. Coast Guard regulations, marine diesel engines are designed to keep engine and exhaust component (exhaust manifold, turbocharger and exhaust pipe) temperatures cool. Recreational and light duty commercial engines can accomplish this by running cool water through a jacket around the exhaust system components. Larger engines generally use a thick insulation around the exhaust pipes.

Marinization might also include replacing some engine parts with parts made of materials more durable in a marine environment. These changes include more use of chrome and brass to prevent corrosion. Because of the unique marine engine designs, marinizers also add their own front accessory drive assembly. Finally, marine engines must also be coupled with the lower drive unit to be applicable to a specific vessel.

1.1.2.2.3 Nonroad Diesel Engine Costs of Production

The U.S. Census Bureau does not differentiate cost of production figures for marine diesel engines (North American Industry Classification System [NAICS] 333618B106). However, because small, recreational C1, commercial C1, and commercial C2 engines are derived form nonroad diesel engines, costs of production for nonroad engines could be used to illustrate costs of production of marine diesel engines (NAICS 3336183). Costs of production figures are divided into major input categories of labor, materials, and capital expenditures. Of these categories, purchased materials account for the largest share of total costs. Based on data from the most recent Economic Census, costs of materials represent about 64 percent of the value of shipments, followed by labor at about 11 percent and capital expenditures at about 3 percent. (These numbers correspond with the broader "other engine manufacturing" category [NAICS 333618].)

Table 1-8 lists the primary materials used in engine components.[4] No breakdown of cost of materials used in production is available from the 2002 Economic Census for the specific category of marine diesel engines (NAICS 333618B106) nor for nonroad diesel engines (NAICS 3336183), but based on the broader "other engine manufacturing" category (NAICS 333618), cost of materials are dominated by cast and formed metal. Iron and steel accounted for 13 percent of material costs; aluminum accounted for 7 percent; injection fuel pumps for 5.6 percent; pistons, valves, and piston rings for 3.5 percent; and engine electrical equipment for 3.5 percent. All other materials and components, parts, containers, and supplies accounted for 52 percent; no single material accounted for more than 2 percent of material costs.

Table 1-8 Nonroad and "Other Engine" Costs of Production and Materials Consumed in 2002

NAICS	Value of Shipments ($\$10^6$)	Labor ($\$10^6$)[a]	Cost of Materials ($\$10^6$)[a]	Capital Expenditures ($\$10^6$)[a]
333618 Other engine equipment manufacturing	18,586	2,145	11,800	730
		11.5%	63.5%	3.9%
3336183 Diesel, semi-diesel, and dual-fuel engines (except automobile, highway truck, bus, tank)	2,003	215	1,287	59
		10.7%	64.3%	2.9%
Materials Consumed by 333618	Cost ($\$10^6$)	Share of Cost of Materials		
Iron and steel[b]	1,449	13.1%		
Aluminum[c]	770	6.9%		

a Percentages refer to the share of the total value of shipments.
b NAICS codes 33211101, 33151001, 33120007, 33120016, 33120033.
c NAICS codes 33152005, 33152003, 33631100.

1.1.2.2.4 Nonroad Diesel Engine Manufacturers and Marinizers

As was previously discussed, marine diesel engines are typically derived from similar size land-based diesel engines through the marinization process. Marinization is normally performed by two types of firms, and has an impact on the engine's emission characteristics.

First, there are large engine manufacturers such as Cummins, Caterpillar, and Deere that marinize their land-based nonroad engines. They are referred to as domestic engine manufacturers (DEMs), and they are usually involved in every step of the manufacturing process of a marine engine. Foreign engine manufacturers (FEMs) are similar to DEM, but they are owned by foreign parent companies (this also pertains to DDC and EMD, which are owned by foreign investment companies now). Production of marine engines begins on the nonroad production line; however, at some stage of the production process, an engine is moved to a different assembly line or area where production is completed using parts and processes specifically designed for marine applications.

Second, postmanufacture marinizers (PMMs), or simply marinizers, are smaller manufacturers that purchase complete or semi-complete land-based engines from engine manufacturers and complete the marinization process themselves using specially designed parts, potentially modifying fuel and cooling systems.

Table 1-9 lists DEM, FEM, and PMM companies. Only four U.S.-based engine manufacturers produce and marinize their marine diesel engines. Cummins is the only company involved in two types of production. In addition to marinizing their own, Cummins (through its subsidiary Onan) produces generators using Kubota engines and therefore is included in both the DEM and postmanufacture marinizers categories.

Table 1-9 Marine Engine Manufacturers

Domestic Engine Manufacturers	Foreign Engine Manufacturers	Postmanufacture Marinizers
Caterpillar	Deutz	Bombardier[a]
Cummins	EQT (parent to DDC)	Brunswick
Deere & Company	Greenbriar Equity, LLC (parent to EMD)	Cummins
General Electric	MAN	Daytona Marine[a]
	Rumo	Fairbanks Morse[a]
	Volvo	Klassen
	Yanmar	Kohler
		Marine Corp. of America[a]
		Marine Power
		NREC Power Systems
		Peninsular Diesel
		Reagan Equipment[a]
		Stewart & Stevenson
		Sword Marine Technology
		Valley Power Systems (parent to Alaska Diesel)
		Westerbeke

a. These companies' production is not included in the 2004 PSR database.

1.1.2.2.5 Marine Engine Dressing

Marine engine dressing refers to the modifications made to a land-based engine that enable it to be installed on a marine vessel. Unlike PMMs, however, the changes made by marine dressers do not affect the emission characteristics of the engine. These modifications can be made by engine manufacturers or marine dressing firms. Modifications typically include installing mounting supports and a generator (in the case of an auxiliary engine) or propeller gears (in the case of propulsion engines). Other modifications consist of adding adaptors, water-cooled exhaust manifolds, water tanks, electronic instrumentation, and alarm systems. There are many manufacturers of this type. However, because these companies do not do anything to the engines to change their emission characteristics, they are exempted from the regulations. Thus, their coverage will be omitted in this profile.

1.1.2.2.6 Marine Engine Rebuilding

Engines are often rebuilt to extend their service life. Engine rebuilding refers to overhauling an engine or otherwise performing extensive renovation on the engine (or on a portion of the engine or engine system). This involves disassembling the engine, inspecting and/or replacing many of the parts, and reassembling the engine in a way that extends its service life. Marine engines are typically rebuilt several times of the course of their service lives.

Many of these marine engine rebuilds are performed by machine shops. The Engine Rebuilders Association lists over 2,500 machine shops in its member database. In 2003, Engine Builder magazine surveyed these machine shops for their 2003 Machine Shop Market Profile. According to their results, 53 percent of these firms were involved in marine engine rebuilding in 2002. The rebuilding of gas and diesel marine engines accounted for 5.1 percent of the total 1.13 million engines rebuilt in 2002.[5] Finally, a large number of engine rebuilds are performed by ship and boat builders at their facilities.

1.1.2.3 Demand Side

Marine diesel engines can be distinguished according to whether they are used on commercial or recreational applications. As discussed above, the basic difference derives from the nature of the requirements on the engine in each application: more power density in recreational applications and more durability in commercial applications. In this section, we look at the characteristics of the four key segments of this industry; Recreational marine C1 and small (at or below 37 kW), Commercial C1, and C2 diesel engine markets.

Table 1-10 Marine Diesel Engine Production by Application and Use Type (2002) presents the total number of engines produced in and imported to the United States broken down by application category. According to the data in the PSR database, the largest single category is marine engines produced for propulsion purposes in recreational applications (17,954). A slightly smaller number was produced for all auxiliary functions (16,377) and the rest for propulsion purposes in commercial applications (6,524). Based on the engine category, the majority of the engines produced or imported were classified as commercial C1, followed by recreational C1 and small. Category 2 is the smallest category with 277 engines produced in 2002.

Table 1-10 Marine Diesel Engine Production by Application and Use Type (2002)

Use Type	Small (≤37 kW)	C1 Recreational	C1 Commercial	C2
Commercial propulsion	NA	NA	6,389	135
Marine auxiliary	6,798	NA	9,437	142
Pleasure propulsion	3,963	13,952	NA	NA
Total	10,761	13,952	15,826	277

1.1.2.3.1 Recreational Applications

Recreational boats (especially the larger ones powered by diesel engines) are generally considered discretionary goods; demand for them is typically price elastic

There are several reasons why consumers might choose diesel engines over gasoline engines for recreational applications. First, diesel engines are more durable and reliable. Second, diesel engines have better fuel consumption.

Based on the National Marine Manufacturers Association (NMMA) sales data, there were approximately 5,760 diesel-powered (out of a total 10,200 diesel and gas-powered inboard cruiser boats) recreational boats sold in 2002. NMMA also estimated that among 10,200 boats, 92.2 percent had a twin engine.[6] Under these ratios, we estimated 11,070 recreational marine diesel engines were sold for propulsion purposes in the United States in 2002. This number differs from 13,952 engines imported or produced in the United States in 2002, as reported in the PSR database. Some of the engines produced are used as the replacement engines; however, the PSR OELink database is probably not entirely accurate. Because the NMMA estimate is derived from surveying a large portion of the industry stakeholders, their consumption estimate seems more reliable.

Not included in that estimate are small marine diesel engines. PSR data indicate that 10,761 small marine diesel engines were produced in 2002, with approximately 64 percent of those being used for auxiliary purposes and the remainder used as maneuvering engines on recreational applications and as cruising engines on sailboats.

1.1.2.3.2 Commercial C1 Applications

Engines in this category are inputs into various commercial applications, such as seasonal and commercial fishing vessels, emergency rescue vessels, ferries, and coastal freighters.

Commercial vessels are inputs into a wide range of production processes that generate products and services. As a result, the demand for C1 engines is linked directly to the demand for boats, and indirectly through the supply chain to the demand for final products and services produced with commercial ships and boats.

No data are readily available on the volumes of commercial boats produced annually in the United States. However, based on the 2004 Workboat Construction survey of approximately 400 commercial boats scheduled to be delivered in 2005, we estimate that 40 percent of them were C1, 55 percent were C2, and 5 percent were C3 (Workboat, 2005). Using these estimates, we find that 160 C1 engine-powered commercial vessels were produced in the United States in 2004. Once again, this number does not correspond with 6,389 engines listed by PSR. More than likely Workboat Construction journal's survey lists the largest commercial ships and boats, and many smaller commercial boats are unaccounted for.

1.1.2.3.3 Commercial C2 Applications

Commercial C2 engines might be used on crew and supply boats, trawlers, and tug and tow boats. Many of the engines are also used as large auxiliary engines on ocean-going vessels. Based on the Workboat Construction survey estimate, there were 220 C2 engine-powered commercial vessels built in the United States in 2004.[7] This number is lower compared with 2002 production volume (277 engines) listed by PSR.

Like commercial C1 engines, commercial C2 engines are inputs in vessels, which are in turn inputs in production processes that generate products and services. Therefore, demand for commercial C2 engines is linked directly to the demand for commercial C2 vessels and indirectly to the demand for products and services produced with these vessels.

1.1.2.4 Market Structure

Recreational ApplicationsFigure 1-2 and Figure 1-3 present small and recreational C1 marine diesel engine market breakdown by the type of a supplier. In 2002, a majority of the small marine diesel engines (60 percent) were supplied by engine marinizers, with about half of that value supplied by engine dressers, and only 11 percent by FEMs that oversee the entire production process. No DEMs supplied engines to this market. The situation is opposite for the recreational C1 market, where DEMs supply 45 percent of engines, and FEMs supply 26 percent. Marinizers accounted for 28 percent, and dressers for less than 1 percent of the recreational C1 market supply.

Table 1-11 details the top three engine manufacturers and marinizers in the small (at or below 37 kW) and C1 recreational categories. The majority of the engines in the small category are supplied by U.S.-based marinizer Westerbeke (48 percent). In 2002, Japanese manufacturer Yanmar and U.S.-based marinizer Kohler both had approximately 10 percent of the market share. Cummins, a DEM, serves as a marinizer in this market. Kubota engines, marinized by Cummins, accounted for approximately 3.5 percent of small marine diesel engine market supply in 2002.

Figure 1-2 Small (≤37 kW) Marine Diesel Engine Market Supply by Manufacturer Type (2002)

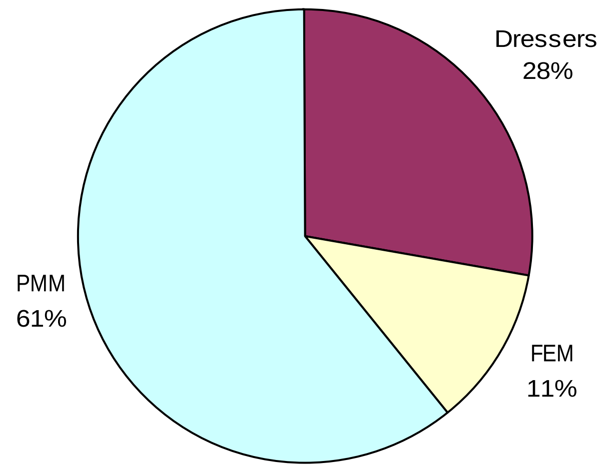


Figure 1-3 C1 Recreational Marine Diesel Engine Market Supply by Manufacturer Type (2002)

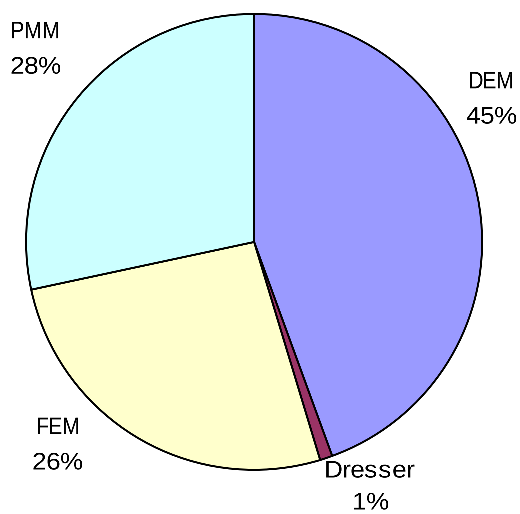


Table 1-11 Top Three Small and Recreational C1 Marine Diesel Engine Manufacturers and Marinizers (2002)

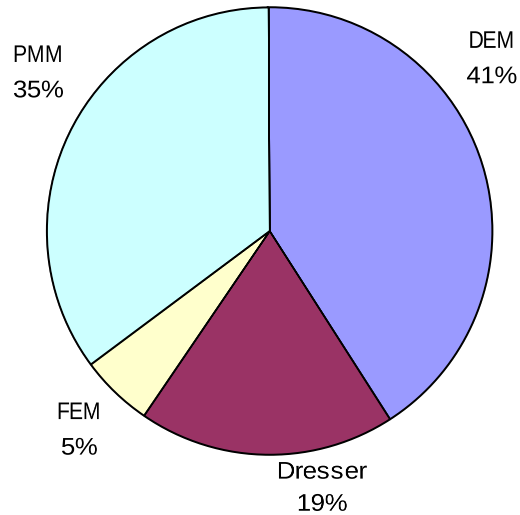
	2002 Production	Market Share
C1		
Engine Manufacturers		
Caterpillar		
Cummins		
Yanmar		
Top 3 Firms' Production	9,524	68.3%
Engine Marinizers		
Westerbeke		
Peninsular Diesel		
Brunwick Corporation		
Top 3 Firms' Production	2,800	20.1%
Total Dressers	23	0.2%
Total C1 Market	13,952	
Small (≤37 kW)		
Engine Manufacturers	(D)	(D)
Yanmar		
Engine Marinizers		
Westerbeke		
Valley Power Systems, Inc.		
Kohler		
Top 3 Firms' Production	7,136	66.3%
Total Dressers	2,000–3,000[a]	25%–30%[a]
Total Small Market	10,761	

a. The range is provided to avoid disclosing proprietary information of individual companies.
(D) = Data have been withheld to avoid disclosing proprietary information of individual companies.

1.1.2.4.1 C1 Commercial Applications

The supply structure of the commercial C1 marine diesel engines market resembles the supply structure of the recreational C1 market, with DEMs and PMMs supplying 76 percent of the engines to the market (Figure 1-4). As opposed to the recreational C1 market, dressers supply a larger portion of the commercial C1 market (19 percent), with FEMs supplying 5 percent.

Figure 1-4 Commercial C1 Marine Diesel Engine Market Supply by Manufacturer Type (2002)



Commercial C1 marine diesel engine market shares are listed by the type of manufacturer in Table 1-12. DEMs Caterpillar and Deere and engine marinizer Kohler have approximately equal market shares of 15 percent each. They are followed by U.S.-based marinizer Westerbeke with an 11 percent market share. Even though engine dressers are not covered by this rule, it is worth noting that the vast majority of the engines supplied in the commercial C1 market by these companies are auxiliary engines.

Table 1-12 Top Three Commercial C1 Marine Diesel Engine Manufacturers and Marinizers (2002)

C1	2002 Production	Market Share
Engine Manufacturers		
Caterpillar		
Deere & Company		
Cummins		
Top 3 Firms' Production	6,452	40.8%
Engine Marinizers		
Kohler		
Westerbeke		
Valley Power Systems, Inc.		
Top 3 Firms' Production	5,690	36.0%
Total Dressers	1,383	8.7%
Total C1 Market	15,826	

1.1.2.4.2 Commercial C2 Applications

The commercial C2 marine diesel market is not supplied by dresser companies; most of the supply comes from marinizers, which supply approximately half of its volume. U.S.-based companies are dominant in the commercial C2 marine diesel engine market. Among engine manufacturers, Caterpillar, and among marinizers, General Motors and Stewart and Stevenson, together compose 78.4 percent of the market. Caterpillar is followed by Japanese manufacturer Yanmar and German MAN B&W with 11 and 6 percent, respectively (Table 1-13).

Table 1-13 Top Three Commercial C2 Marine Diesel Engine Manufacturers and Marinizers (2002)

C2	2002 Production	Market Share
Engine Manufacturers		
Caterpillar	87	
Greenbriar Equity LLC	73	
Yanmar	31	
Top 3 Firms' Production	191	69.0%
Engine Marinizers		
Stewart and Stevenson	(D)	(D)
Total Dressers	—	0.0%
Total C2 Market	277	

(D) = Data have been withheld to avoid disclosing proprietary information of individual companies.

1.1.2.4.3 Pricing Behavior of Marine Diesel Engine Markets

Discussions about market competitiveness usually focus on two types of pricing behavior: perfect competition (price-taking behavior) and imperfect competition (lack of price-taking behavior). Under the former scenario, buyers and sellers take (and thus are "price takers") the market price set in a competitive equilibrium: the market price equals the value consumers place on the marginal product, as well as the marginal cost to producers. Under this scenario, firms have some ability to influence the market price of the output they produce. For example, a firm might produce a commodity with unique qualities that differentiate its product from its competitors' product. The value consumers place on the marginal product, the market price, is greater than the cost to producers. Thus, the social welfare is reduced under this scenario.

As evident from the market share information presented in this report, marine diesel engine markets are moderately (small and commercial C1) to highly (recreational C1 and commercial C2) concentrated and thus have a potential for emergence of imperfect competition. Nevertheless, our analysis suggests mitigating factors will limit prices from rising above the marginal cost; therefore, the assumption of perfect competition is justified.

First, the threat of entry encourages price-taking behavior. Industries with high profits provide incentives to new firms to enter the market and lower the market price to their competitive levels. In all of the marine diesel markets, domestic and foreign candidates can enter any of these markets without incurring significant costs.

Second, the data on capacity utilization rates published by the Federal Reserve (for machinery, NAICS 333) suggest that excess capacity exists in the broad category that also includes converted internal combustion engines industry (NAICS 333618B106). February 2006 data present an industry utilization rate of 82.6 percent. If these data do, in fact, indicate excess capacity in the marine diesel engine industry, then the ability to raise prices is limited by excess idle capacity.

Third, other theories place less value on market shares as a determinant of pricing behavior and examine the role of potential competition instead. For instance, three conditions of perfectly contestable markets demonstrate how potential competition may lead to perfect competition:[8]

- New firms have access to the same production technology, input prices, products, and demand information as existing firms
- All costs associated with entry can be fully recovered
- After learning about new firms' entry, existing firms cannot adjust prices before these new firms supply the market

Although the extent to which these conditions apply to marine diesel engine markets is not clear, the theory suggests that market shares alone should not necessarily be considered as an indicator of imperfect competition in the market.

1.1.2.5 Historical Market Data

1.1.2.5.1 Recreational Applications

The historical market statistics are presented as a means to assess the future of marine diesel engine production. Information on production trends is presented here.

Historical production volumes for recreational C1 and small marine diesel engine markets are presented in Table 1-14. The small marine diesel engine market demonstrated continuous growth in production between 1998 and 2002, growing by 37 percent since 1998. The recreational C1 market experienced a slight peak in 2000 with 7 percent growth and then leveled off in 2002 at a slightly higher volume than it was in 1998.

Table 1-14 Historical Market Trends for Small and Recreational C1 Marine Diesel Markets

	Recreational C1	Small
2002	13,952	10,761
2001	13,754	9,833
2000	14,408	9,576
1999	13,836	7,997
1998	13,446	7,853
Percentage Change	3.8%	37.0%

1.1.2.5.2 Commercial C1 Applications

The commercial C1 engine market demonstrated a strong steady growth in the past 5 years. Starting at 10,508 engines produced and imported into the United States in 1998, it grew by more than 50 percent and equaled 15,826 engines in 2002 (Table 1-15).

Table 1-15 Historical Market Trends Commercial C1 Marine Diesel Market

Year	Production
2002	15,826
2001	14,078
2000	12,838
1999	12,178
1998	10,508
Percent Change	50.6%

1.1.2.5.3 Commercial C2 Applications

The commercial C2 market has a relatively small volume of sales compared to the recreational and commercial C1 markets. Nevertheless, the commercial C2 market experienced significant growth in the past 5 years. In the period from 1998 to 2002, market volume more than doubled and equaled 277 engines in 2002 (Table 1-16).

Table 1-16 Historical Market Trends Commercial C1 Marine Diesel Market

Year	Production
2002	277
2001	231
2000	200
1999	138
1998	134
Percentage Change	106.7%

1.1.3 Marine Vessel Manufacturers

Marine vessels include a wide variety of ships and boats. Several alternative definitions exist to distinguish between ships and boats. For this profile, ships are defined as those marine vessels exceeding 400 feet in length. They are built to purchasers' specifications in specialized "Main Shipyard Base" ship yards, and typically powered by Category 3 diesel engines. Under this definition most of the vessels powered by small, C1 or C2 diesel engines would be considered boats. In this section, the terms "vessel" and "boat" will be used interchangeably. Vessels powered by C1 and C2 engines vary widely; they may be made from fiberglass-reinforced plastic (FRP or fiberglass), aluminum, wood, or steel. Some vessels are serially produced using assembly line methods; others are individually built to meet purchasers' specifications in boatyards or in the same yards that build ships. Small boats may be powered by small spark-ignition (gasoline) engines. Vessels covered by this profile include a small share of recreational boats: inboard cruisers, especially those over 40 feet in length. In addition the profile covers diesel-powered commercial and governmental vessels such as tug/tow boats, fishing vessels, passenger vessels, cargo vessels, offshore service vessels and crew boats, patrol boats, and assorted other commercial vessels.

The Economic Census includes two industry sectors, NAICS 336611 Ship Building and Repairing and NAICS 336612 Boat Building, that together cover the marine vessel types addressed in this profile. Each NAICS includes some vessels not included in this profile. NAICS 336612 defines boats as "watercraft not built in shipyards and typically of the type suitable or intended for personal use."; thus, NAICS 336612 includes essentially recreational vessels; within this NAICS, NAICS 3366123 covers inboard motor boats, including those powered by diesel engines. Thus, the diesel-powered recreational vessels covered by this profile represent only a relatively small share of NAICS 336612. NAICS 336611 comprises establishments primarily engaged in operating a shipyard, fixed facilities with drydocks and fabrication equipment capable of building a "watercraft typically suitable or intended for other than personal or recreational use."[9] Commercial and governmental vessels powered by small, C1 and C2 diesel engines are included in NAICS 336611, along with larger ships that are powered by C3 engines and thus not covered by this profile.

1.1.3.1 Overview of Vessels

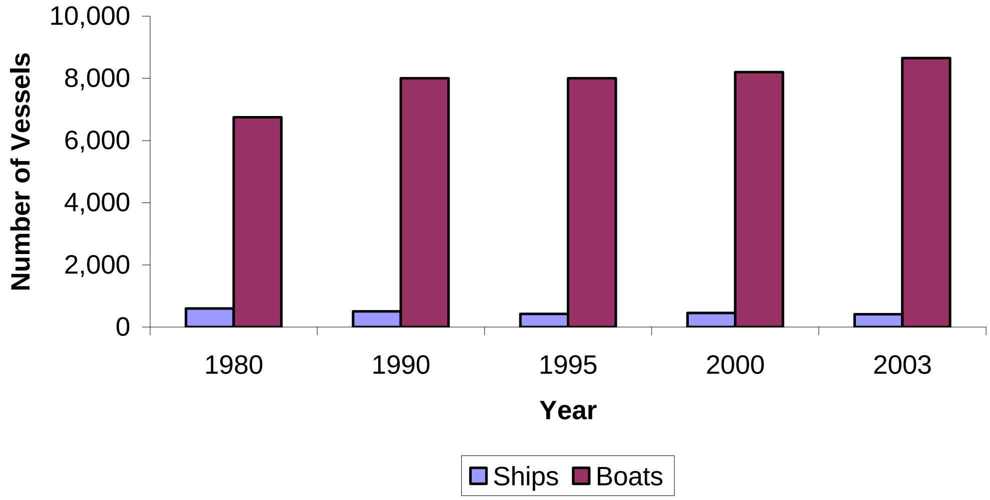
This profile covers a wide variety of vessels, including recreational vessels and smaller commercial, service, and industrial vessels, generally less than 400 feet in length. Commercial vessels under 400 feet long dominate inland and coastal waters where shallow drafts restrict access by larger ships. Depending on their mission, C1- and C2-powered vessels also may operate in the Great Lakes, coastwise, intercoastal, noncontiguous, and/or transoceanic environments. The principal commercial boat types are tugboats, towboats, offshore supply boats, fishing and fisheries vessels, passenger boats, and industrial boats, such as cable- and pipe-laying boats, oceanographic boats, dredges, and drilling boats. Passenger boats include crewboats, excursion boats, and smaller ferries.

Most commercial vessels covered by this profile are U.S.-built, U.S.-owned and U.S.-operated. Under provision of the Jones Act (Section 27, Merchant Marine Act, 1920), vessels transporting merchandise between U.S. ports must be built in and documented under the laws of the United States and owned and operated by persons who are citizens of the United States. Because C1 and C2 diesel engines are frequently used to power vessels that operate in inland waters or coastwise, they are generally operating between U.S. ports. Thus, many cargo vessels powered by C1 and C2 diesel engines are required to be U.S.-built, -owned, and -operated, unless a waiver is granted by the Secretary of the Treasury.

Generally excluded from this profile, because they are powered by C3 engines, are larger merchant and military vessels, typically exceeding 400 feet in length, that engage in waterborne trade and/or passenger transport or military operations. Commercial and government-owned (e.g., military) ships operate in Great Lakes, coastwise, intercoastal, noncontiguous (between United States mainland and its noncontiguous territories, such as Alaska, Hawaii, and Puerto Rico), and/or transoceanic routes. The principal commercial ship types are dry cargo ships, tankers, bulk carriers, and passenger ships. Dry cargo ships include break bulk, container, and roll-on/roll-off vessels. Passenger ships include cruise ships and the largest ferries. Military ships include aircraft carriers, battleships, and destroyers. Also excluded from the profile are the smallest recreational, commercial, and government vessels, which are powered by gasoline outboard, stern-drive, or inboard engines. Figure I-5 illustrates the size of the U.S. commercial fleet over time from 1980 to 2003 and the distribution between larger and smaller vessels. Compared with smaller commercial vessels, larger commercial vessels represent a small fraction of the U.S. commercial fleet.

Figure 1-5 includes vessels as small as 1,000 gross tons in the ship, rather than boat population, and omits key categories of boats (smaller vessels), such as supply boats and fishing boats.[10] It is very difficult to develop useful criteria which will allow the separation of vessels populations into those powered by the various engines categories. Nonetheless, this analysis provides some insight as to the relative proportion of vessel in the U.S. fleet powered by C1/C2 engines versus C3 engines.

Figure 1-5 U.S. Commercial Fleet (1960 to 2003)



1.1.3.2 Overview of Vessel Manufacturers

This report classifies vessel manufacturing facilities ("yards"), according to the types of vessels manufactured. The Economic Census reports on two industry segments that are related to vessel manufacture—shipbuilding and repairing (NAICS 336611) and boatbuilding (NAICS 336612). Shipbuilding facilities typically have drydocks. NAICS 336612 encompasses facilities that build "watercraft suitable for personal or recreational use," which corresponds closely to recreational boats, and NAICS 336611 includes facilities that build larger commercial and government vessels. Both NAICS codes include vessels not covered by this profile.

NAICS 336611 includes generally one-of-a-kind vessels built in a shipyard with drydock facilities, including vessels powered by Category 1 and 2 diesel engines, as well as the larger Category 3 engines. Most vessels manufactured by this NAICS code are for commercial or governmental applications (e.g., Coast Guard, military, Army Corps of Engineers, municipal harbor police).

NAICS 336612 covers generally recreational vessels. These may be built using repetitive methods, such as an assembly line process or individually; it includes those powered by gasoline, alcohol, and diesel engines. Within NAICS 336612, only larger (over 40 feet) inboard cruisers are predominantly powered by diesel engines. This segment of NAICS 336612 (NAICS 3366123 Inboard Motorboats) includes only 82 establishments, less than 7 percent of the total in the NAICS code. Because most of the smaller inboard motorboats are SI-powered, the number of facilities manufacturing diesel-powered recreational vessels is even smaller. The information summarized in Table 1-17 shows information about establishments and companies in NAICS 336611 and 336612, and indicates that there are a large number of small establishments in both of these industry segments.[11] Most companies in both NAICS codes are single-establishment companies.

Table 1-17 2002 Economic Census Data on Shipbuilding and Boatbuilding Industries

	NAICS 336611 (shipbuilding)	NAICS 336612 (boatbuilding)
Number of establishments	639	1,123
Number of companies	586	1,063
Establishments with 100+ employees	91	134
Establishments with 500+ employees	21	16

Within NAICS 336611, the U.S. Maritime Administration (MARAD) classifies yards as either first-tier or second-tier according to building capacity. In the Report on Survey of U.S. Shipbuilding and Repair Facilities, MARAD (2003) identifies 24 first-tier yards, which form the "major shipbuilding base" (MSB) in the United States. The 24 MSB yards satisfy several requirements, including at least one construction position capable of accommodating a vessel that is 400 feet in length or over and an unobstructed waterway leading to open water (i.e., locks, bridges) and the channel water must be a minimum of 12 feet deep. While MSB yards are the only ones to manufacture large ships, many of them also produce smaller commercial vessels. Second-tier yards do not meet these criteria and include many small- and medium-sized yards that construct and repair boats.[12]

1.1.3.3 Recreational Vessels

This section describes the recreational boat manufacturing industry, with special attention to the segment of the industry using diesel engines.

1.1.3.3.1 Types of Recreational Vessels

U.S. boatbuilders construct a variety of recreational boats, including ski/wakeboard boats, powerboats, racing boats, sailboats, recreational fishing boats, and yachts. Only a small segment of recreational boats are powered by diesel engines and thus addressed by this profile. Diesel-powered types of vessels include inboard cruisers and most of the larger yachts.

1.1.3.3.2 Supply of Recreational Vessels

Boats for personal and recreational use can be manufactured from many different materials, including fiberglass-reinforced plastic (FRP), aluminum, rotationally molded (rotomolded) polyethylene or other thermoplastic materials, and wood. Only relatively large (over 40 foot) inboard cruisers commonly use diesel engines; diesel engines used in recreational vessels are almost exclusively C1 engines, although C2 engines may be used on the largest yachts. Among recreational boats, large inboard cruisers are less likely to be serially produced; because they are quite costly, they tend to be customized to buyers' specifications. Like smaller serially produced boats, the most common hull material is FRP.

1.1.3.3.3 Production Process

The most common material used in boat manufacturing is FRP. Boats made from FRP are typically manufactured serially. Using FRP makes it very difficult to incorporate purchaser preferences into a vessel's design because 1) many features are designed into fiberglass molds, making customization time consuming and expensive and 2) vessels constructed from FRP are very sensitive to changes in their vertical or horizontal centers of gravity, making it difficult to change a particular design. In some cases, boat manufacturers produce the FRP hulls and decks used in constructing their boats; in other cases the FRP hulls and decks of boats are manufactured by a contractor for the boat manufacturer.

The process typically used to manufacture these boats is known as open molding. In this process, separate molds are used for the boat hull, deck, and miscellaneous small FRP parts such as fuel tanks, seats, storage lockers, and hatches. The parts are built on or inside the molds using glass roving, cloth, or mat that is saturated with a thermosetting liquid resin such as unsaturated polyester or vinylester resin. The liquid resin is mixed with a catalyst before it is applied to the glass. The catalyzed resin hardens to form a rigid shape consisting of the plastic resin reinforced with glass fibers.

The FRP boat manufacturing process generally follows the following production steps:

- Before each use, the molds are cleaned and polished and then treated with a mold release agent that prevents the part from sticking to the mold

- The open mold is first spray coated with a pigmented polyester resin known as a gel coat that will become the outer surface of the finished part. The gel coat is mixed with a catalyst as it is applied so that it will harden

- After the gel coat has hardened, the inside of the gel coat is coated with a skin coat of polyester resin and short glass fibers and then rolled with a metal or plastic roller to compact the fibers and remove air bubbles. The fibers are applied in the form of a chopped strand mat or chopped roving from a chopper gun; the skin coat is about 90 mils (0.09 inches) thick and is intended to prevent distortion of the gel coat (known as "print through") from the subsequent layers of fiberglass and resin

- After the skin coat has hardened, additional glass reinforcement in the form of chopped roving, chopped strand mat, woven roving, or woven cloth is applied to the inside of the mold and saturated with catalyzed polyester resin. The resin is usually applied with either spray equipment or by hand using a bucket and brush or paint-type roller. The saturated fabric is then rolled with a metal or plastic roller to compact the fibers and remove air bubbles

- More layers of woven glass or glass mat and resin are applied until the part is the desired thickness; the part is then allowed to harden while still in the mold. As the part cures, it generates heat from the exothermic reactions that take place as the resin hardens; very thick parts may be built in stages to allow this heat to dissipate to prevent heat damage to the mold

- After the resin has cured, the part is removed from the mold and the edges are trimmed to the final dimensions

- The different FRP parts of the boat are assembled using small pieces of woven glass or glass mat and resin, adhesives, or mechanical fasteners

- After the assembly of the hull is complete, the electrical and mechanical systems and the engine are installed along with carpeting, seat cushions, and other furnishings and the boat is prepared for shipment

- Some manufacturers paint the topsides of their boats to obtain a superior finish; the larger boats generally also require extensive interior woodwork and cabin furnishings to be installed

As noted above, only the larger inboard cruisers are likely to have diesel propulsion engines. Of all inboard cruisers, 56 percent are diesel-powered. For boats less than 40 feet in length, less than 35 percent are diesel-powered; for those over 40 feet in length, 85 percent are diesel-powered. Table 1-18 provides estimates of inboard cruiser retail sales by engine type and length of boat. In 2003, 5,191 diesel-powered inboard cruisers were sold; of these, 3,032 were 41 feet or longer. Another 988 diesel-powered cruisers ranged from 36 to 40 feet in length. Only 454 were 30 feet long or less.[13]

Table 1-18 Estimates of Inboard Cruiser Retail Unit Sales by Engine Type and Length of Boat

	1997		1999		2001		2003	
Boat Length	Gas	Diesel	Gas	Diesel	Gas	Diesel	Gas	Diesel
30' and under	917	178	1,064	435	1,059	495	279	454
31'–35'	1,525	309	2,199	673	2,458	953	1,294	717
36'–40'	1,048	492	1,142	804	1,280	991	1,984	988
41' and over	529	1,302	428	2,655	420	3,144	572	3,032
Total	4,019	2,281	4,833	4,567	5,217	5,583	4,109	5,191

Table 1-19 summarizes the sales data from 1997 through 2003 for recreational boats. In 2003, an estimated 9,200 inboard cruisers were sold; 97 percent of inboard cruisers over 31 feet long were powered by twin engines. Sales in the United States are expected to continue to decrease as more and more of the larger recreational boats are being built overseas (e.g., Taiwan).[14]

Table 1-19 Estimates of Inboard Cruiser Retail Unit Sales by Single vs. Twin Engine and Length of Boat

	1997		1999		2001		2003	
Boat Length	Single	Twin	Single	Twin	Single	Twin	Single	Twin
30' and under	789	306	1,028	471	1,004	550	463	271
31'–35'	91	1,742	97	2,775	155	3,256	86	1,925
36'–40'	51	1,490	112	1,834	233	2,038	136	2,815
41' and over	30	1,801	23	3,060	32	3,532	20	3,584
Total	961	5,339	1,260	8,140	1,424	9,376	705	8,595

While not all inboard cruisers are diesel-powered, the production costs for inboard cruisers as a group are likely representative of the relative costs of various inputs used in producing diesel-powered inboard cruisers. Production costs for builders of inboard cruisers include the costs of materials, labor, and capital equipment. Materials costs are more than double the cost of labor for these producers and represent roughly half of the value of shipments of inboard cruisers (see Table 1-20).[15] Because diesel engines are generally more expensive than gasoline engines, materials may represent an even larger share of diesel-powered inboard cruiser costs.

Table 1-20 Costs of Production for NAICS 3366123, Inboard Motorboats, Including Commercial and Military, Except Sailboats and Lifeboats

Establishments	Number	Payroll ($1,000)	Number	Hours (1,000)	Wages ($1,000)	Cost of Materials ($1,000)	Capital Expenditures ($1,000)	Value of Shipments ($1,000)
82	13,412	427,949	10,457	20,773	299,815	1,197,464	39,900	2,384,478

1.1.3.3.4 Demand for Recreational Vessels

Recreational boats are final consumer goods, and are generally considered discretionary purchases. Demand for recreational boats is typically characterized by elastic demand.

1.1.3.3.5 Industrial Organization for Recreational Vessel Manufacturers

Recreational boat builders are located along all coasts and major waterways. Table 1-21 provides sales and employment information of recreational diesel boat builders.[16,17,18] Of the 36 companies for which data were identified, only 9 employ more than 500 employees. Two large, multi-facility companies (Genmar and Brunswick) employ 21,000 and 6,000 employees respectively. Companies with fewer than 500 employees would be considered small businesses under the criteria of the Small Business Administration for NAICS 336612. Based on that definition, the majority of firms producing recreational diesel boats would thus be considered small entities.

Table 1-21 Employment Distribution of Companies that Build Recreational Boats

Employment Range	Number of Firms	Revenue Range ($Millions)
0–100	11	1.3 – 8.5
101–250	9	9.2 – 45.0
251–500	7	20.2 – 101.7
501–1,000	4	63.2 – 131.0
1,000+	5	45.60 – 5,229
Total number of firms	36	

Although there are a few large companies in the recreational diesel boat building industry, there are many more small companies. The boat yards are located on water bodies throughout the country, and many serve somewhat regional markets. Because there are a relatively large number of suppliers, because there is increasing competition from foreign suppliers, and because barriers to entry and exit are low, it is reasonable to characterize the markets for recreational diesel vessels as competitive. As described in section 1.1.2.4.3, the potential for competition and entry (contestable markets) forces existing producers to behave in a competitive manner.

1.1.3.3.6 Markets and Trends in the Recreational Vessel Manufacturing Industry

As summarized in Table 1-22, prices for inboard cruisers 41 feet and longer have displayed no clear trend during the period 2001–2003.[19] Prices in most categories dipped in 2003, reaching prices below 2001 levels. This may result from increased competition from foreign suppliers.

Table 1-22 Estimated Average Retail Selling Price of Recreational Inboard Boats by Length of Boat

Boat Length	1997	1998	1999	2000	2001	2002	2003
41' and over	$490,409	$475,869	$469,866	$516,146	—	—	—
41'–49'	—	—	—	—	$449,990	$419,873	$384,329
50'–59'	—	—	—	—	$963,197	$898,256	$842,578
60'–65'	—	—	—	—	$2,166,030	$2,280,029	$2,220,833
66' and over	—	—	—	—	$3,627,189	$4,464,111	$2,816,731

Information from NMMA indicates that the number of larger recreational boats being built abroad, in places like Taiwan, has increased significantly in the last few years. A recent NMMA report on recreational boat sales compiled U.S. Department of Commerce import and export data, as reported in the U.S. International Trade Commission database. The 2003 data confirmed that the trade imbalance continues to grow. Factors affecting this growth include the rising cost of shipping, trade disputes between the U.S. and Europe, and the strength of the dollar, which makes it difficult for U.S. boatbuilders to offer competitive pricing overseas.

Table 1-23 shows that exports of vessels declined from 1997 to 2001, then increased, posting a substantial increase between 2002 and 2003.[20] Imports continue to outpace exports, with the trade balance deficit roughly tripling between 1997 and

2003. However, because of the substantial increase in exports, the deficit actually fell between 2002 and 2003.

Table 1-23 Value of Imported and Exported Vessels (in $Millions)

	1997	1998	1999	2000	2001	2002	2003
Boats export	$678.6	$674.8	$698.5	$662.0	$560.4	$600.5	$746.5
Boats import	$835.0	$874.7	$984.2	$1,074.8	$1,113.1	$1,157.7	$1,207.2
Trade balance	–$156.40	–$199.90	–$285.70	–$412.80	–$552.70	–$557.20	–$460.70

1.1.3.4 Commercial Vessels

This section builds on earlier work by EPA to characterize commercial vessels and identify how many of each type are powered by C1 and C2 diesel engines. U.S. boatbuilders construct a wide variety of commercial vessels. Most of these boatbuilders are single-establishment companies and manufacture a limited number of boat designs. A handful of yards (e.g., Halter Marine) also have the capacity to build ships that would be powered by C3 engines. Most commercial and government boats are manufactured individually or customized to purchaser's specifications.

U.S. boatyards build boats primarily used on inland and coastal waterways between U.S. ports. Cargo vessels on these routes must satisfy Jones Act requirements and, therefore, be built in the United States (U.S. Department of Transportation, 1998). As described above, the Jones Act (Section 27 of the Merchant Marine Act of 1920) requires that any vessel transporting merchandise between U.S. ports be built in the U.S., owned and operated by U.S. citizens. For this reason, the U.S. commercial boatbuilding industry has a protected local market and does not face the intense foreign competition that recreational boat builders or shipbuilders building vessels for international trade do. Clients include American waterways operators (e.g., tugboats), offshore petroleum exploration and drilling companies (e.g., liftboats, crewboats, supply boats), fisheries companies (e.g., fishing and fish processing boats), industrial companies, (e.g., cable-laying boats), and research organizations (e.g., oceanographic research vessels).

The markets for commercial and governmental vessels can be modeled as if they were competitive. While the Jones Act prohibits foreign manufacture of cargo vessels trading between U.S. ports and the Passenger Services Act imposes a fee of $200 per passenger on carriers transporting passengers between U.S. ports unless the vessels are U.S.-built, -owned, and -operated, most markets for commercial vessels have relatively low barriers to entry and exit. There are a significant number of firms in each market segment, and they compete for both government and commercial contracts.

For the commercial boat market, we collected much of the background information in a separate report.[21] Although the objective of that report was to develop inputs for emissions inventory modeling, the report provides a general characterization of commercial vessels, and estimates both C1 and C2 vessel counts of some types. This report adopts the same commercial/governmental vessel categories and definitions.

1.1.3.4.1 Tug and Towboats

Towboats, also known as tugboats, include boats with rounded bows used for pulling (towboats) and boats with square bows for pushing barges, known as pushboats. Towboats that pull or push barges are referred to as line-haul boats, and are the largest category of towboats. Specialized towboats may also be used for maneuvering ships in harbors, channel dredging, and construction activities. Towboats vary widely in size and configuration, ranging from small harbor tugs less than 30 feet in length to large ocean-going tugs over 100 feet.

Data from WorkBoat Magazine's annual construction survey are shown in Table 1-24.[22] Participating in this survey is voluntary, and only 56 of more than 500 companies that build commercial boats and ships responded. The voluntary nature of the survey may result in some selection bias such that the respondents are not fully representative of the nonrespondents. This effect may be relatively stable over time, however, so that trends in the data may be indicative of trends in the industry as a whole.

Table 1-24 shows that the number of towboats (including towboats, pushboats, tugs, and AHTS) in production increased from 39 in 2003 to 57 in 2004, and 73 in 2005. The Category 2 Vessel Census[23] estimated that 3,164 of 4,337 towboats in existing databases had C1 engines. Thus, it is likely that the majority of the newbuilt towboats are also powered by C1 engines. According to the Vessel Census, the majority of these towboats operate in the Gulf Inland and Inland areas.

Table 1-24 U.S. Commercial Boat Orders, 1993, 1994, 1997 and 2003, 2004, 2005

	Number of Boats Produced					
Vessel Type	1993	1994	1997	2003	2004	2005
Number of survey respondents	85	83	84	40	46	56
Casino/gaming	34	27	6			
Passenger (dive, dinner, excursion, ferries, sightseeing, water taxi, charter)	102	95	68	44	31	40
Crew, crew/supply pilot, personnel launch	27[a]	41	44	17	31	18
Supply/service		5	81	37	25	29
Liftboat, utility	26[b]		34	5	7	8
Pushboat, towboat, tug	28	60	88[c]	39	57	73
Fire, rescue		5	7	2	12	2
Boom, spill response	60	33	38	4	10	6
Small craft (assorted), tender	44[d]	124[e]	38	17	7	14
Patrol (military, nonmilitary)	99[f]	89	48	74	69	92
Other military			79	27	6	24
Others	26	33	38	110[g]	149	155

	Number of Boats Produced					
Total number of boats	446	512[h]	569	376	405	460

a Supply boats were consolidated with crew/supply boats and pilot boats.
b General workboats were consolidated with utility boats in the 1993 survey.
c AHTSs were consolidated with pushboats, towboats, and tugs.
d Research and survey boats were consolidated with tenders in the.1993 survey and in the table for 2004 and 2005.
e Research, survey, and utility boats were consolidated with the assorted small craft and tenders in the 1994 survey.
f Fireboats were consolidated with the patrol boats in the 1993 survey.
g The total number of "other" boats in included nonself-propelled vessels (2003–42 vessels, 2004–92 vessels, 2005–80 vessels).
h The total number of boats in 1994 did not include the 111 RIBS, skiffs, or small utility, or the 26 support, minehunter, or landing craft reported.

1.1.3.4.1.1 Supply of Tugs and Towboats

The majority of towboats are manufactured individually according to buyer specifications. Some of the smallest ones may be serially produced. Towboats are strongly built and have relatively large engines for their dimensions. All but the very smallest tugs and towboats are made of steel.

Shipyards and boatyards building commercial ships including towboats use a variety of manufacturing processes, including assembly, metal finishing operations, welding, abrasive blasting, painting, and the use of engines for crane operation and boilers. The typical ship construction process begins with steel plate material. The steel is formed into shapes, abrasively cleaned (blasted), and then coated with a preconstruction primer for corrosion protection. This is typically done indoors at the bigger shipyards and most facilities have automated these steps. Using the preformed steel plates, small subassemblies are then constructed and again a primer coat is applied. Larger subassemblies are similarly put together and primed to protect the steel substrate material. At some point in the construction, components are moved outdoors to work areas adjacent to the drydock. Final assembly and engine installation are done at the drydock.

Based on statistics for the shipbuilding NAICS code, NAICS 336611, materials account for more than 50 percent of the cost of production, and labor for approximately 40 percent. Energy costs, investment in capital equipment, rental payments, and business services all account for smaller shares of total value of shipments.

1.1.3.4.1.2 Demand for Tugs and Towboats

Towboats are purchased by towing companies that move cargo on barges on coastal routes or on the nation's rivers. According to the American Waterways Operators, the tugboat, towboat, and barge industry include more than 4000 operating tugs/towboats and more than 27,000 barges. These vessels move more than 800 million tons of raw materials and finished goods each year, including more than 20 percent of the nation's coal, more than 60 percent of the nation's grain exports, and most of New England's home heating oil and gasoline.[24] In addition to commodity transportation, tugs are needed within harbors to maneuver ships to and from their berths, and to assist with bunkering and lightering. The demand for towboats is thus derived from the demand for commodity transportation services, which in turn is derived from the demand for the commodities being transported.

1.1.3.4.2 Commercial Fishing Vessels

Commercial fishing vessels are self-propelled vessels dedicated to procuring fish for market. Commercial fishing boats may be distinguished by whether they tow nets or are engaged in "hook and line" fishing, or are multipurpose vessels that support a variety of fishing activities. Fishing vessels vary widely in size and configuration. Smaller fishing vessels may be serially produced using fiberglass, similar to recreational boats. Larger fishing vessels are generally built individually to buyer's specifications. The largest fishing vessels also serve as factory ships with the capacity to sort, clean, gut, and freeze large quantities of fish.

The Vessel Census, based on the Coast Guard's Merchant Vessels of the U. S. (MVUS) database, estimates that there are more than 30,000 commercial fishing vessels operating in the U.S., with the largest number being in Alaska, followed by Washington and Texas. Other states with large numbers of commercial fishing vessels include California, Florida, Louisiana, and Maine. Of the roughly 30,000 commercial fishing vessels identified, 8,130 are listed as definitely C1 and another 21,300 are characterized by the report's authors as probably C1. If accurate, this means that all but 700 or so commercial fishing vessels are powered by C1 engines, and that the remaining 700 are powered by C2 engines. The C2 vessel census[25] suggests that the actual number of C2 powered fishing vessels may be less than half this number. Less than 1 percent of commercial fishing vessels were identified as gasoline-powered.

Given that the vast majority of commercial fishing vessels are powered by C1 engines, it seems reasonable to assume that the majority of these vessels are also similar to recreational vessels in construction. Small commercial fishing vessels must be able to travel rapidly to and from fishing grounds given that their operations have them going to fishing grounds and returning to port each day. Thus, many of these vessels have fiberglass hulls and are designed for planning operation, much like recreational vessels.

1.1.3.4.2.1 Supply of Commercial Fishing Vessels

Smaller commercial fishing vessels are generally produced using fiberglass with a production method similar to that used for recreational boats. Mid-size fishing boats may be made of fiberglass, aluminum, or steel, and are likely produced individually to buyers' specifications. The largest fishing boats, factory ships, are produced individually at shipyards and a few exceed the 400 foot length that is covered by this profile. Serial and individual production methods are described above.

1.1.3.4.2.2 Demand for Commercial Fishing Vessels

Commercial fishing boats are inputs into the production of fish for sale to consumers, restaurants, retailers, and processors. Reduced catch in many of the nations' fisheries has resulted in lower returns for fishermen, and thus in a declining number of commercial fisherman and declining demand for commercial fishing vessels. This decline is projected to continue.[26] To the extent that governmental efforts to replenish stocks and increase catch are successful, some increase in the number of commercial fishermen and fishing boats may occur in the future.

1.1.3.4.3 Patrol Vessels

Patrol boats such as Coast Guard vessels (government, Department of Homeland Security), include small boats used by harbor police and other patrols and larger vessels such as cutters. Small boats used by the Coast Guard include approximately 1,400 boats ranging from 12 to 64 feet, which operate close to shore. Coast Guard cutters are at least 65 feet in length, and range up to more than 400 feet in length. The Vessel Census identified 158 of 235 cutters that were powered by C2 engines. The smaller boats operated by the Coast Guard were determined to be powered by C1 engines. Fast pursuit boats may be powered by gasoline engines. The majority of patrol boats not operated by the Coast Guard are relatively small and thus most likely powered by C1 engines, or SI outboards for the smallest patrol boats.

1.1.3.4.3.1 Supply of Patrol Boats

Patrol boats are generally manufactured from aluminum (two major manufacturers of patrol boats, Seaark Marine and SAFE Boats, Inc., both manufacture aluminum boats in large numbers). Other aluminum boatbuilders with government work, including military as well as state and local agencies, include Kvichak Marine, Northwind Marine, Rozema, All American Marine, ACB, Almar, Munson and Workskiff. While their designs can be customized, these aluminum boats are largely serially produced. Significant inputs include aluminum, engines, and labor. Some small patrol boats are inflatable, with reinforced rigid hulls made of steel. Larger patrol boats such as Coast Guard cutters are made of steel.

1.1.3.4.3.2 Demand for Patrol Boats

Government agencies, including the Coast Guard, the Military, the Army Corps of Engineers, as well as harbor police and municipalities are the major demanders of patrol boats. The need to increase vigilance along our coasts and in our harbors since the September 11 attacks has led to a tremendous increase in demand for Coast Guard patrol boats, which is likely to continue to be strong for several more years as the fleet is built up.[27] The Workboat Construction Survey shows that contracts have risen from 48 in 1997 to 92 in 2005.

1.1.3.4.4 Passenger Vessels

Passenger vessels powered by C1 or C2 diesel engines include ferries, excursion boats, and water taxis. Ferries are self-propelled vessels that carry passengers from one location to another, either with or without their automobiles. Ferries may be owned by states or private companies, and generally operate over set routes according to regular schedules. Water taxis are generally smaller than ferries and operate on a for-hire basis. The Vessel Census studied ferries, and identified 106 that were powered by C2 engines and 508 powered by C1 engines. Water taxis are generally powered by SI engines, although some may be powered by C1 inboard engines. Excursion boats are generally powered by C1 engines, although some of the larger ones that approach small cruise ships in size, are powered by C2 engines.

1.1.3.4.4.1 Supply of Passenger Vessels

Passenger vessels may be made of aluminum or steel. For example, Derektor Shipyards had orders to deliver three aluminum ferries ranging from a 92 foot high speed catamaran ferry to a passenger/vehicle ferry that was 239 feet long. Two other companies had orders for large steel ferries, including two 310-foot Staten Island Ferries. Larger ferries and other passenger vessels are likely powered by C2 engines, while smaller ones are likely C1 or even SI outboard or sterndrive for the smallest and lightest ones.

1.1.3.4.4.2 Demand for Passenger Vessels

Ferries and water taxis are needed for transportation services, and are generally used in urban areas. Other types of passenger vessels, including excursion boats, dinner boats, and floating casinos, are needed for recreational purposes. Some of these, such as whale watching boats, are very small; others such as floating casinos and some excursion boats may be more than 100 feet in length. Workboat’s 2005 Construction Survey showed orders for 19 dinner, excursion, or sightseeing boats and also for 19 ferries or water taxis. Both types of passenger boats are likely to respond to cyclical patterns in the economy, as both commuting and recreation increase when the economy is strong.

1.1.3.4.5 Research Vessels

Research vessels include vessels equipped with scientific monitoring equipment used to track wildlife, map geological formations, monitor coastal water quality, measure meteorological conditions, and conduct other scientific investigations. They vary widely in size and complexity and may be made of aluminum, fiberglass, or steel. They may be powered by SI outboard engines, C1, or C2 inboard engines, depending on their size. While they may be built on a standard hull design, the fittings are highly individualized based on their task, and may be technically complex. Of 12 research vessels reported in the Workboat 2005 Construction Survey, most are made of aluminum and are less than 80 feet in length. Two are made of steel and are about 150 to 200 feet in length. Of the purchasers listed, three of the vessels were ordered by the National Oceanic and Atmospheric Administration (NOAA) and one by a university. The instruments and other scientific equipment are a special and potentially expensive cost element for these vessels. Demand for the vessels is a function of demand for the research products that they support.

1.1.3.4.6 Offshore Support Vessels

Offshore support vessels include a variety of vessels used to construct, operate, maintain, and service offshore oil platforms. Of the categories listed in Table 1-24, crew, crew/supply, personnel, supply/service and liftboat/utility vessels are all vessel types that support the offshore oil industry. This is a heterogeneous category, including a wide range of sizes, materials, and configurations. Platform supply boats and crew/supply boats tend to be over 150 feet in length and may be made of steel or aluminum. Lift boats tend to be about 150 feet in length and made of steel. OSVs listed in Workboat's 2005 Construction Survey range from 145 feet to 280 feet and are made of steel. At the other end of the spectrum are smaller aluminum crew and utility boats. Most offshore oil activity in the U.S. is in the Gulf of Mexico; thus, most offshore support vessels operate there.

Demand for offshore support vessels depends largely on the status of the offshore oil industry. Changes in that industry over the past 15 years have resulted in reduced numbers of rigs, but some much farther from shore. Thus, while fewer support vessels may be needed, they may be required to be larger and more seaworthy. The Gulf Coast hurricanes of 2005 had a substantial impact on the offshore oil industry and offshore support vessels. Many platforms and offshore support vessels suffered damage due to the storms. Demand for offshore support vessels increased drastically, and day rates more than doubled. This will likely result in an increase in construction of offshore support vessels in the next few years, relative to recent years.

Table 1-25 gives a summary of the types of boats currently under contract to be built at U.S. boatyards based on information taken from the Marine Log website and Workboat's 2005 Construction Survey, using the commercial boat categories described above.[28]

Table 1-25 Boats Under Construction by Type and Client, December 2005 Contracts

Type of Boat	Commercial Clients	Government Clients	Total
Tow/Tug	31	7	38
Fishing	0	1	1
Coast Guard	0	92	92
Ferry	19	2	21
Cargo	75	0	75
Research	1	2	3
Offshore Support	31	0	31
Great Lake/Others	3	1	4

Military	0	64	64
Total	140	169	329

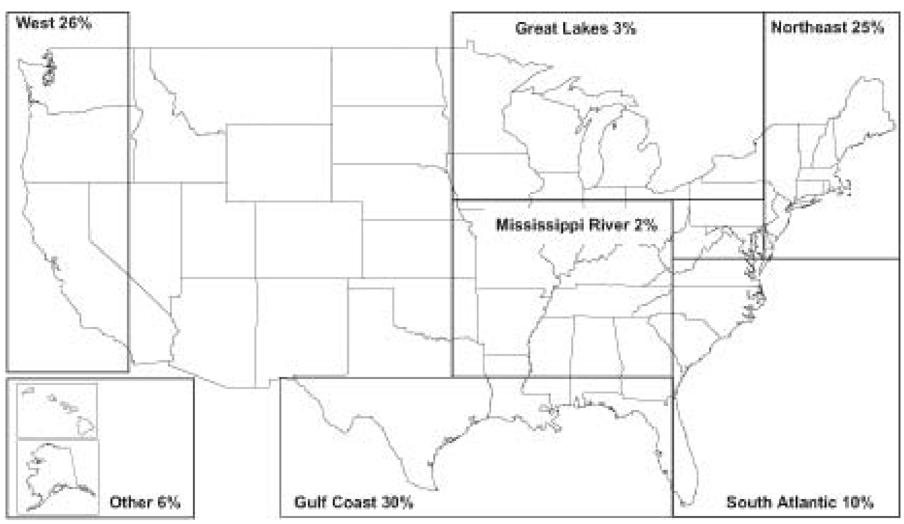
1.1.3.5 Industry Organization

This section examines the organization of the boat building industry, including characterizing firms in the industry, and examining market structure.

1.1.3.5.1 Location and Number of Vessel Manufacturers

There are several hundred yards that build many different types of boats powered with small (≤37 kW), C1 and C2 engines. Boatbuilders are located along all coasts and major inland waterways of the United States. Figure 1-6 shows the geographic distribution of boatbuilders in the United States. A majority of these boatbuilders are located in the Gulf Coast, the Northeast, and the West Coast. The number of boatbuilders in these three regions account for approximately 30 percent, 25 percent, and 26 percent of the boatbuilding industry, respectively. A majority of boatbuilders are located in the Gulf Coast (128), the Northeast (107), and the West Coast (110). Collectively, these three regions represent 345 boatbuilders, or 80 percent of all companies in the 1998 Boatbuilder Database.

Figure 1-6 Major Boatbuilding Regions of the United States



1.1.3.5.2 Firm Characteristics

Table 1-26 summarizes company financial data for companies that produce commercial vessels powered by C1 and C2 engines.[29,30,31] The available data capture total company employment and sales figures including any subsidiaries and operations, such as boat repair, that may not be related to boatbuilding; similarly, because many companies may produce boats powered by both SI and CI engines, or may produce larger vessels powered by C3 engines, not all of the boatbuilding employment and revenues are related to vessels powered by C1 and C2 engines.

Table 1-26 Employment Distribution of Companies that Build Commercial and Government Boats

Employment Range	Number of Firms	Revenue Range ($Millions)
100 or fewer	29	0.15 – 7.0
101–250	12	12.0 – 50.0
251–500	5	11.0 – 30.9
501–1,000	3	42.0 – 73.0
1,001 or more	13	82.0 – 29.9
Total number of firms	62	

Almost all companies that produce commercial or governmental vessels powered by C1 or C2 engines would be classified under NAICS 336611. Of an estimated 589 firms in that NAICS code, company names, employment, and sales data were obtained for only 62. Using the Small Business Administration’s small business criterion for NAICS 336611 (1,000 employees), 49 of the 62 (79 percent) of the companies for which data were obtained would qualify as small entities.

1.1.3.5.3 Markets and Trends in Commercial Vessel Manufacturing

Markets for commercial and governmental vessels can be modeled as competitive. While products are differentiated rather than homogeneous, there are many yards that produce similar types of vessels, and compete for both commercial and governmental contracts. Barriers to entry and exit are relatively low, at least domestically. For commercial cargo vessels working between U.S. ports, foreign competition is limited by the Jones Act. Similarly, passenger vessels plying exclusively domestic routes are constrained by the U.S. Passenger Services Act. Nevertheless, because the technology and materials for boat building are widely available, costs of entry into the market are fully recoverable, and barriers to entry and exit are thus low, domestic commercial boat manufacturers face markets that are contestable and therefore behave as if the markets were competitive.

The U.S. boatbuilding industry is currently influenced by several key factors. These factors suggest a continued increase in the number of commercial boats built in the United States:

- Increasing demand for the T-class vessels. (The U.S. Coast Guard defines T-class boats as boats not designed to see the open ocean, such as cruise boats, dinner and gambling boats, crew boats in the Gulf of Mexico, and off-shore vessels)

- Increasing demand for offshore supply vessels to repair and service offshore oil rigs, including repairing or replacing rigs and OSVs damaged or destroyed by Gulf Coast hurricanes in 2005

- Increasing demand for oil (e.g., drillships and semisubmersible rigs)

- Expansion in casino boats

- Decisions by leading boatbuilders to reopen facilities and expand their labor forces are strong indications that they anticipate continued growth in the market for commercial and governmental vessels. An increase in demand for new boats will mean more business for the commercial U.S. boatbuilding industry, as foreign builders are ineligible to build for segments of this market. Some of the larger boatbuilders in the United States also build boats for foreign owners/operators, particularly for foreign militaries. As noted in the table summarizing current shipyard/boatyard contracts, there are at least three yards doing work with foreign governments (e.g., Egypt and Oman)

In summary, U.S. boatbuilders are cautiously optimistic about the future because almost every segment of the U.S. flag fleet is facing significant replacement requirements. The commercial boatbuilders are expected to continue to be a major consumer of marine diesel engines.

1.2 Locomotive

The regulations for locomotives and locomotive engines are expected to directly impact three industries. These industries are: (1) locomotive and locomotive engine original equipment manufacturers (OEMs); (2) owners and operators of locomotives (railroads); and (3) remanufacturers of locomotives and locomotive engines including OEMs, railroads, and independent remanufacturers. Locomotive manufacturers are companies that make or import complete "freshly" manufactured locomotives[B].

Remanufacturers are companies that certify kits for remanufactured locomotives.[C] A brief overview of these industries follows, along with descriptions of the national economic impact of railroads and current regulations in effect for railroads.

[B] Freshly manufactured locomotives are those which are powered by freshly manufactured engines, and contain fewer than 25 percent previously used parts (weighted by the dollar value of the parts).
[C] Remanufactured locomotives are locomotives in which all of the power assemblies are replaced with freshly manufactured (containing no previously used parts) or refurbished power assemblies. Remanufacturing includes the following: replacing an engine, upgrading an engine, and converting an engine to enable it to operate using a fuel other than it was originally manufactured to use.

1.2.1 Current Emission Regulations

The Agency's 1998 Locomotive Rule (63 FR 18978; April 16, 1998) created a comprehensive program that both the large Class I and small Class II and III railroads were subject to, including emission standards, test procedures and a full compliance program. The unique feature of this program was the regulation of the engine remanufacturing process, including the remanufacture of locomotives originally manufactured prior to the effective date of that rulemaking. Regulation of the remanufacturing process was critical because locomotives are generally remanufactured four to eight times during their total service lives of approximately 40+ years. Electric locomotives, historic steam-powered locomotives, and locomotives freshly manufactured prior to 1973 were not covered by the 1998 regulations.

Several requirements are currently applicable to Class I railroads. First, railroads purchasing a new locomotive must insure it meets the current standards and has a valid certificate of conformity. Second, with regard to in-use testing, railroads must reasonably supply locomotives to the locomotive engine manufacturers for purposes of testing them under the manufacturer in-use testing program. In cases where the railroads fail to meet this requirement EPA could, under section 114 of the Act, require the railroads to perform the testing itself. Third, the railroads must also comply with the in-use testing requirements of the post-useful life railroad in-use testing program. Fourth, failure of a railroad to perform all proper maintenance on certified locomotives, so they continue to meet the applicable emissions standards, are subject to civil penalties for tampering. Railroads must also keep records of this maintenance. Finally, when remanufacturing all 1973 and later locomotives, railroads must remanufacture to new standards. (Note: small railroads are generally exempt from these provisions.)

Small railroads have three requirements under the existing emission regulations. First, small railroads are subject to the prohibition against remanufacturing their locomotives without a valid certificate of conformity. However, the regulations exempted their existing noncompliant locomotives as well as any noncompliant locomotives that they purchase from other railroads in the future. The prohibition only applies to previously certified locomotives. For example, if a Class I railroad had a 1990 locomotive that was remanufactured in 2005 to meet the Tier 0 standards, any small railroad that purchased that locomotive would need to comply with the Tier 0 requirements for all subsequent remanufacturing. Second, small railroads must properly maintain (with respect to emissions) all certified locomotives, and they must keep records of this maintenance. Finally, if any small railroad purchased a totally new locomotive, they would need to ensure that it meets the current standards and has a valid certificate of conformity.

Three separate sets of emission standards (Tiers) have been adopted, with applicability of the standards dependent on the date a locomotive is manufactured. The first set of standards (Tier 0) applies to locomotives and locomotive engines originally manufactured from 1973 through 2001. The second set of standards (Tier

1) applies to locomotives and locomotive engines originally manufactured from 2002 to 2004, and the final set of standards (Tier 2) applies to locomotives and locomotive engines originally manufactured in 2005 or later. All of these standards must be met when a locomotive is "freshly manufactured" and at each subsequent remanufacture. The emission standards set in 1998 for Class I and large Class II and II line-haul and switch duty-cycles are shown in Table 1-27.

Table 1-27 Maximum Permissible NO_x, CO, HC, and PM Rates by Tier

(g/bhp/hr)	Tier 0 Line-Haul Duty-Cycle	Tier 0 Switch Duty-Cycle	Tier 1 Line-Haul Duty-Cycle	Tier 1 Switch Duty-Cycle	Tier 2 Line-Haul Duty-Cycle	Tier 2 Switch Duty-Cycle
NO_x	9.5	14.0	7.4	11.0	5.5	8.1
CO	5.0	8.0	2.2	2.5	1.5	2.4
HC	1.00	2.10	0.55	1.20	0.30	0.60
PM	0.60	0.72	0.45	0.54	0.20	0.24

1.2.1.1 Certification

Locomotive manufacturers must produce compliant locomotives, and they must be certified. In order for a locomotive to be certified, a company must certify the engine together with the locomotive. An engine manufacturer can certify, but it must certify the complete locomotive. Currently, engine manufacturers have only certified locomotives they manufactured themselves. Class I and all Class II and III railroads must purchase all new locomotives with a valid certificate of conformity, and when remanufacturing a locomotive must have a valid certificate of conformity. Small Class II and III railroads are, however, provided an exemption for their existing noncompliant locomotives as well as any noncompliant locomotives that they purchase from other railroads in the future.

1.2.2 Supply: Locomotive Manufacturing and Remanufacturing

1.2.2.1 Locomotive Manufacturing

1.2.2.1.1 Types of Locomotives

Locomotives generally fall into three broad categories based on their intended use: switcher, passenger, and line-haul locomotives. Switch locomotives, typically 2000 hp or less, are the least powerful locomotives, and are used in freight yards to assemble and disassemble trains, or for short hauls of small trains. Some larger road switchers can be rated as high as 2300 hp. Passenger locomotives are powered by engines of approximately 3000 hp, with high-speed electric passenger locomotives powered by 6000hp or more. Freight or line-haul locomotives are the most powerful locomotives and are used to power freight train operations over long distances. Older line-haul locomotives are typically powered by engines of approximately 2000-3000 hp, while newer line-haul locomotives are powered by engines of approximately 3500-5000 hp. In some cases, older line-haul locomotives (especially lower powered ones) are used in switch applications. The industry has been producing higher powered locomotives, with some new models having 4400hp. The development of line-haul locomotives with even higher horsepower ratings, such as 6000 hp or more continues, but it is not clear if this will be the future of locomotive engines.

1.2.2.1.2 Type of Propulsion Systems

Locomotives can be subdivided into three general groups on the basis of the source of energy powering the locomotive: 1) “all-electric” 2) “engine-powered” 3) “hybrid”. In the "all-electric" group, externally generated electrical energy is supplied to the locomotive by means of an overhead contact system, these types of locomotives have existed for over 125 years. An example of this type of locomotive is commonly seen on commuter trains. Power to operate the locomotive is not generated by an onboard engine. Emission control requirements for all-electric locomotives would be achieved at the point of electrical power generation, and thus are not included in this rulemaking.

In the "engine-powered" group of locomotives, fuel (usually diesel in the U.S., although natural gas options are still being pursued) is carried on the locomotive. The energy contained in the fuel is converted to power by burning the fuel in the locomotive engine. A small portion of the engine output power is normally used directly to drive an air compressor to provide brakes for the locomotive and train. However, the vast majority of the output power from the engine is converted to electrical energy in an alternator or generator which is directly connected to the engine. This electrical energy is transmitted to electric motors (traction motors) connected directly to the drive wheels of the locomotive for propulsion, as well as to motors which drive the cooling fans, pumps, etc., necessary for operation of the engine and the locomotive.[D] In the case of passenger locomotives, electrical energy is also supplied to the train’s coaches for heating, air conditioning, lighting, etc. (i.e., "hotel power"). In some passenger trains, electrical energy required for the operation of the passenger coaches is supplied by an auxiliary engine mounted either on the locomotive or under the floor of passenger cars.

The third category "hybrid" is a combination of the "electric" and "engine-powered" groups, and was first developed and used in the 1920’s, although at the time it wasn’t very successful. Today’s technology is considered “battery dominant” and uses a small diesel engine and generator to charge a battery pack; the battery pack will then supply energy on demand to the traction motors.[32] The engine can be 250-640hp (200-480kW) and will typically operate at a constant speed, which is optimized for efficiency and will only run to keep the batteries at a certain charge

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[D] Essentially all "engine powered" locomotives used in the U.S. employ a diesel engine and the electrical drive system described. The term "diesel-electric" has therefore become the most common terminology for these locomotives.

level.[33] This technology is currently only available for switcher locomotives, although it is being developed for use in line-hauls.

1.2.2.1.3 Locomotive Design Features and Operation

1.2.2.1.3.1 Sizing Constraints

Similar to the variation in horsepower, locomotive size determines the work it will perform. Switch locomotives tend to be about 40 to 55 feet long, while line-haul locomotives are typically 60 to 76 feet long. Locomotive length is roughly correlated with engine size, and thus the difference in length has become more significant as locomotive engines have become larger and more powerful. Locomotive length is also related to the number of axles that a locomotive has. In the past, the typical locomotive had four axles (two trucks with two axles each). While there still are a large number of four-axle locomotives in service, all newly manufactured line-haul locomotives have six axles (two trucks with three axles each). There are two primary advantages of having more axles on the locomotive. First, additional axles allow locomotives to be heavier, without increasing the load on each individual axle (and thus the load on the rail). Second, six-axle locomotives typically have greater tractive power at low speeds, which can be critical when climbing steep grades. The use of six-axles on a locomotive does increase its overall length, and continues to lead to the discontinuation of the practice of converting old line-haul locomotives into switch locomotives, since these larger six-axle locomotives are typically too long to be practical in most switch applications.

1.2.2.1.3.2 Operation

One unique feature of locomotives that makes them different than other, currently regulated mobile sources is the way that power is transferred from the engine to the wheels. Most mobile sources utilize mechanical means (i.e., a transmission) to transfer energy from the engine to the wheels (or other point where the power is applied). Because there is a mechanical connection between the road, vehicle engine and the wheels, the relationship between engine rotational speed and vehicle speed is mechanically dictated by the gear ratios in the transmission and final drive (e.g., the differential and rear axle). This results in engine operation which is very transient in nature, with respect to changes in both speed and load. In contrast, locomotive engines are typically connected to an electrical alternator or generator to convert the mechanical energy to electricity. As noted above, this electricity is then used to power traction motors which turn the wheels. The effect of this arrangement is that a locomotive engine can be operated at a desired power output and corresponding engine speed without being constrained by vehicle speed. The range of possible combinations of locomotive speed and engine power vary from a locomotive speed approaching zero with the engine at rated power and speed, to the locomotive at maximum speed and the engine at idle speed producing no propulsion power. This lack of a direct, mechanical connection between the engine and the wheels allows the engine to operate in an essentially steady-state mode, in a number of discrete power settings, or notches, which are described below.

Dynamic braking is another unique feature of locomotives setting them apart from other mobile sources. Dynamic braking is especially important given the traction problems that locomotives must overcome. Locomotives generate an enormous amount of power that can be applied to the wheels when they start to roll, however, the use of steel wheels (which provide less rolling resistance) also make it difficult to start moving a locomotive. The ridges on the sides of the wheels provide traction during cornering to keep the wheels on the rails, and some locomotives are equipped with an oil system that puts oil on the sides of the rails to reduce friction on the sides of the wheels during turns and cornering. On straight sections of rail, some locomotives have a built-in system that will put sand on the rails and in order to increase traction.

In dynamic braking the traction motors act as generators, with the generated power being dissipated as heat through an electric resistance grid, this feature decreases overall braking distance and wear on the wheels. While the engine is not generating motive power (i.e., power to propel the locomotive, also known as tractive power) in the dynamic brake mode, it is generating power to operate resistance grid cooling fans, and is essentially dissipated into the air as heat. As such, the engine is operating in a power mode that is different than the power notches or idle settings discussed above. While most diesel-electric locomotives have a dynamic braking mode, some do not (generally switch locomotives). The potential energy that could be recovered during dynamic braking and utilized by the locomotive is one area researchers are focusing on to increase locomotive efficiency. GE has noted that "the energy dissipated in braking a 207-ton locomotive during the course of one year is enough to power 160 households for that year"[34]. It is, however, very difficult to capture and store this energy, the power generated from dynamic breaking is instantaneous and high enough that it cannot be effectively used by the locomotive at the time it is generated. If the energy could be stored in batteries, or a mechanical device such as a flywheel, tremendous fuel savings could be gained, and therefore development of these types of systems continues.[35]

Hotel power or "Head End Power" (HEP) is power used to operate lighting, heating, ventilation and air conditioning, and all other electrical needs of the crew and passengers alike. This power can be provided by the lead locomotive, or by an additional engine, which is then distributed to the rest of the cars as needed. The design of locomotives for use in passenger train service (without additional engines used to provide HEP) provides for a locomotive to be operated in either of two distinct modes. In one mode, the locomotive engine provides only propulsion power for the train. In this mode, the engine speed changes with changes in power output, resulting in operation similar to freight locomotives. In the second mode, the locomotive engine supplies HEP to the passenger cars, in addition to providing propulsion power for the train. Hotel power provided to the passenger cars can amount to as much as 800 kW (1070 hp). In contrast to operation in the non-hotel power mode, the engine speed remains constant with changes occurring in power output when operating in hotel power mode. Thus, the two modes of operation utilize different speed and load points to generate similar propulsion power. These differences in speed and load points mean that locomotive engines will have different emissions characteristics when operating in hotel power mode than when operating in non-hotel power mode.

1.2.2.1.3.3 Design Characteristics

In 1909 Rudolph Diesel helped construct the first diesel locomotive, and in 1918 the first diesel-electric switch locomotives were put into service. By the 1950's diesel-electric had replaced steam powered locomotives because they required less fuel, maintenance, and man-power.[36] Locomotives use diesel engines because they are much more efficient, reliable, and can generate tremendous power. The diesel engine is the most efficient transportation power plant available today. Thermal efficiency of locomotive diesel engines is 40% or higher, which results from high power density (via high turbocharger boost), high turbocharger efficiencies, direct fuel injection with electronic timing control, high compression ratio, and low thermal and mechanical losses. Many locomotive engines achieve the equivalent of one million miles before overhaul. Durability is critical as a locomotive breakdown on the tracks can bottleneck the entire system; road failures are very costly to the railroads because the importance of timeliness to their customers, and the difficulty in getting replacement locomotives to the location of the failure. The trend toward higher power locomotives is naturally resulting in a trend of fewer locomotives per train, thereby increasing the likelihood that a train would become immobilized by the failure of a single locomotive.

Another unique design feature of locomotives is the design of the engine cooling system and procedures used to control engine coolant temperature. Normal practice in locomotive design has been to mount the radiator on the roof of the locomotive and not to use a thermostat. Control of coolant temperature is achieved by controlling the heat rejection rate at the radiator. The rate of heat rejection at the radiator can be controlled by means such as turning fans on and off or employing a variable speed fan drive, or by controlling the amount of coolant flow to the radiator (using non-thermostat controls). A related point of difference between road vehicle and locomotive engine cooling systems is that antifreeze is not generally used in locomotives. Locomotives use water, not antifreeze to cool their engines because water is much more efficient at removing heat. Using antifreeze would require a cooling system approximately 20% larger than the current design (which holds approximately 450 gallons of water).[37] The size of a locomotive is limited by the existing track and tunnel infrastructure which restricts the height, width and length of a locomotive. Locomotives usually run in consists (groups) which means that the one following the lead locomotive will not have the same effective cooling as the one in front since the air it encounters will be warmer. The practice of following creates additional cooling problems especially in tunnels which call for special design considerations.

The final unique design feature noted here is the manner in which new designs and design changes are developed. The initial design of any new models/modifications and production of prototype models are done in much the same manner as is the case with other mobile sources. Locomotive manufacturers indicated that this process can be expected to require from 12 to 24 months for significant changes such as those required to comply with the new Tier 0 standards. Prototype locomotives are typically sold or leased to the railroads for extended field reliability testing, normally of one to two years duration. Only after this testing is completed can the new design/design change be certified and placed into normal production.

1.2.2.2 Line-Haul Manufacturing

1.2.2.2.1 Manufacturers

Locomotives used in the United States are primarily produced by two manufacturers: Electromotive Diesel (EMD) and General Electric Transportations Systems (GETS). EMD manufactures its locomotives primarily in London, Ontario and their engines in La Grange, Illinois. The GETS locomotive manufacturing facilities are located in Erie, Pennsylvania, while their engine manufacturing facilities are located in Grove City, Pennsylvania. These manufacturers produce both the locomotive chassis and propulsion engines; they also remanufacture engines. MotivePower Industries has produced some mid-horsepower locomotives suited for commuter or long-distance service using engines manufactured by Caterpillar, Inc,. MotivePower's Wabtec division also manufactures a switcher locomotive that runs on liquefied natural gas. The Cummins Engine Company, Inc. produces V12 and V16 diesel engines for use in locomotives. The EPA has identified four locomotive diesel manufacturers, one of which can be considered a small business according to SBA guidelines. There are also a few companies such as Steward and Stevenson or Brookville Mining Equipment that manufacture small switch locomotives (under 700 bhp) for use in mines or for companies who need to move a few cars around a local yard.

EMD was founded in 1922 and acquired by General Motors in 1930; EMD was sold in 2005 by General Motors to the Greenbriar Equity Group and Berkshire Partners, and is now called Electro-Motive Diesel, Inc. While they primarily manufacture a 2-stroke diesel locomotive engine, they started manufacturing a 4-stroke engine in 1997. They currently produce five national models ranging from 3000-6000hp, and have other international models as well as custom built locomotives.[38] EMD employs approximately 2,600 people and designs, manufactures, market, sells and services freight and passenger diesel-electric locomotives worldwide. GE was formed by Thomas Edison who developed his first experimental electrical locomotive in 1880, they also built and put into the service the world's first diesel-electric switcher locomotive in 1924 that remained in service until 1957. GE currently produces at least five national models, two international models, passenger locomotives and is developing a hybrid locomotive.[39] GE's Transportation division employs approximately 8,000 people and also engineers, manufactures, markets and services their diesel locomotive products worldwide.

1.2.2.2.2 Production

Due to the long total life span of locomotives and their engines, annual replacement rates of existing locomotives with freshly-manufactured units are very low. EPA estimated a replacement rate for locomotives and locomotive engines based on historical data supplied by AAR, Table illustrates the historical replacement rates for locomotives in the Class I railroad industry. Sales of new locomotives have averaged approximately 780 units per year over the last ten years. This replacement rate indicates a fleet turnover time of about 30 years for Class I railroads. Fleet turnover is the time required for the locomotive fleet to be entirely composed of locomotives that were not in service as of the base year. Class II an III railroads generally buy used locomotives from Class I railroads, although some are purchasing new switchers and a few line-hauls.

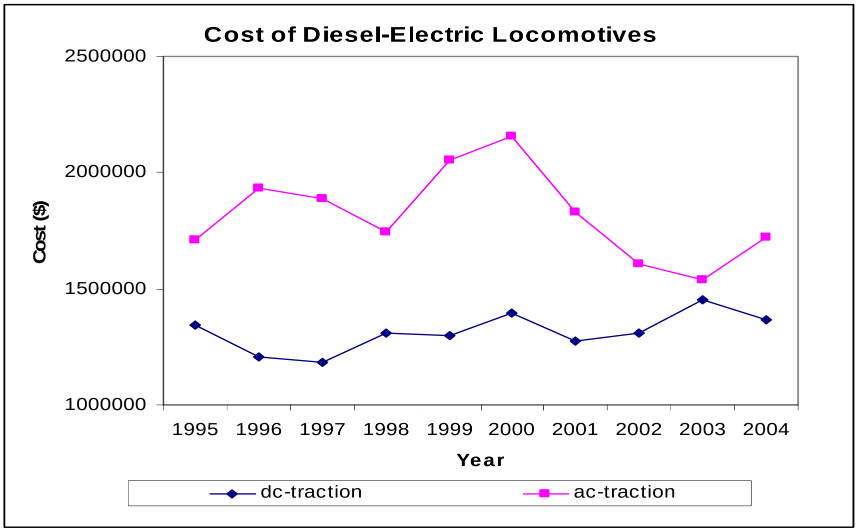
Table 1-28 Class I New Locomotive Turnover Rates[40]

Year	Number of New Locomotives Installed	Number of Remanufactured Locomotives Installed	Total Number of Locomotives in Service	Percent Turnover of New
1995	928	201	18,812	4.9%
1996	761	60	19,269	3.9%
1997	743	68	19,684	3.8%
1998	889	172	20,261	4.4%
1999	709	156	20,256	3.5%
2000	640	81	20,028	3.2%
2001	710	45	19,745	3.6%
2002	745	33	20,506	3.6%
2003	587	34	20,774	2.8%
2004	1,121	5	22,015	5.1%

1.2.2.2.3 Cost

The cost of AC-traction locomotives can be as high as $2.2 million, while DC locomotives are usually less than 1.5$ million. Figure 1-7 shows data from the AAR's Railroad Ten-Year Trends 1995-2004 publication. Some of the variation from year to year can be attributed to differences in features, but it appears the overall trend is the price of AC locomotives seems to be coming down, while DC locomotives remain about the same.

Figure 1-7 Cost of New Locomotives[1]



1.2.2.3 Switcher Manufacturing

1.2.2.3.1 Manufacturers

The majority of switchers in operation today are former line-haul locomotives that have been assigned to a yard, and they are usually quite old. This trend will most likely wane over time because of the size and power of most new locomotives, which make them unsuitable for switching operations. While EMD does offer a traditional new switch locomotive, other companies are offering switchers with alternative power plants that are usually built off of an old switcher platform.

Motive Power, headquartered in Wilmerding, PA offers a switching locomotive fueled by liquefied natural gas, which they will build on a core supplied by a railroad. Motive Power is a large company with nearly 5,000 employees; they service other industries such as marine, transit and power generation. National Railway Equipment Co. (NREC) based in Houma, Louisiana with facilities also in Illinois manufactures a “gen-set” switcher locomotive (powered by multiple smaller diesel engines) that is completely built by them from the ground up. They employ approximately 150 employees. RailPower Technologies, is headquartered in Brossard, Quebec but also has an American office in Erie, Pennsylvania; they employ approximately 100 people. RailPower manufactures the Green Goat® hybrid yard switcher and is developing a natural gas switcher locomotive as well, and they also use an old switcher locomotive core to build their platform on.

1.2.2.3.2 Production

Multi gen-set switchers are a falling back into favor; they were originally used in the late 1920's in some applications. The existing fleet of retired line-haul switcher locomotives turns over very slowly, and production of alternative technology switchers is beginning to increase. NREC is working with UP and is building sixty

2,100hp triple-engin GS21B gensets equipped with four-cycle, six-cylinder 700hp Cummins QSK-19 engines, these switchers are purported to reduce NO_x and PM by 80% as compared to reduce fuel consumption by up to 40%. Railpower has also been asked by UP to build 80 triple-engine switchers on the GreenGoat platform and they have noted that their system can reduce fuel consumption by up to 35% and NO_x and PM emissions by 80%, Norfolk Southern has ordered two of these from RailPower in the form of rebuild kits where their own maintenance staff will install this triple-engine system during a switcher rebuild.[41] New switchers can cost upwards of $1.5 million dollars, the GreenGoat hybrid switcher can cost as little as $700,000 if a customer supplies a completely reconditioned GP-9 locomotive.[42] The price of these and other switchers depends on whether or not a core is supplied and what features it will be built with.

1.2.2.3.3 Trends

Trends: remote control locomotives have been used in Canada and the U.S. for many years; however, Class I railroads have recently begun to implement this on a wider scale according to the FRA. Although this is mainly a switch yard function, this type of operation may be applied on line-hauls as well in the future. This may affect cab design and what necessary equipment is built into future switchers, for example if it is a remote control unit it wouldn't need cab comfort equipment such as heaters or air conditioners. Many new switchers have been retrofitted with idle reduction devices to decrease fuel consumption and increase the railroads efficiency.

1.2.2.4 Remanufactured Locomotives

Since most locomotive engines are designed to be remanufactured a number of times, they generally have extremely durable engine blocks and internal parts. Parts or systems that experience inherently high wear rates (irrespective of design and materials used) are designed to be easily replaced so as to limit the time that the unit is out of service for repair or remanufacture. The prime example of parts that are designed to be readily replaceable on locomotive engines are the power assemblies(i.e., the pistons, piston rings, cylinder liners, fuel injectors and controls, fuel injection pump(s) and controls, and valves). Within the power assemblies, parts such as the cylinder head in general do not experience high wear rates, and may be reused after being inspected and requalified (determined to be within manufacturers specifications). The power assemblies can be remanufactured to bring them back to as-new condition or they can be upgraded to incorporate the latest design configuration for that engine. In addition to the power assemblies there are numerous other parts or systems that may also be replaced.[E] Engine remanufactures may be performed either by the railroad that owns the locomotive or by the original

[E] Bottom end components, such as crankshafts and bearings, are often remanufactured only during every other remanufacture event. Remanufacture events that do not include these bottom end components are sometimes referred to as "partial remanufactures" manufacturer of the locomotive. Remanufactures are also performed by companies that specialize in performing this work.

During its forty-plus year total life span, a locomotive engine could be remanufactured as many as ten times (although this would not be considered the norm). Locomotive engine remanufacturing events are thus routine, and are usually part of the scheduled maintenance. It is standard practice for the Class I railroads within the railroad industry to remanufacture a line-haul locomotive engine every four to eight years. Typically newer locomotives, which have very high usage rates, are remanufactured every four years. Older locomotives usually are remanufactured less frequently because they are used less within each year. Such remanufacturing is necessary to insure the continued proper functioning of the engine. Remanufacturing is performed to correct losses in power or fuel economy, and to prevent catastrophic failures, which may cause a railroad line to be blocked by an immobile train.

When a locomotive engine is remanufactured, it receives replacement parts which are either freshly-manufactured or remanufactured to as-new condition (in terms of their operation and durability).[F] This includes the emission-related parts which, if not part of the basic engine design, are also generally designed to be periodically replaced. The replacement parts are also often updated designs, which are designed to either restore or improve the original performance of the engine in terms of durability, fuel economy and emissions. Because of a locomotive engine's long life, a significant overall improvement in the original design of the parts, and therefore of the engine, is possible over the total life of the unit. Since these improvements in design usually occur in the power assemblies (i.e., the components where fuel is burned and where emissions originate), remanufacturing of the engine essentially also makes the locomotive or locomotive engine a new system in terms of emission performance. A remanufactured locomotive would therefore be like-new in terms of emissions generation and control.

While Class I locomotives are remanufactured on a relatively frequent and scheduled basis of 4 to 8 years, Class II and III locomotives may be remanufactured on a longer schedule or may not be remanufactured at all. The typical service life of a locomotive (40 years) is often exceeded by small railroads that continue to use older locomotives. It is important to note that there is no inherent limit on how many times a locomotive can be remanufactured, or how long it can last. Rather, the service life of a locomotive or locomotive engine is limited by economics. For example, in cases, where it is economical to cut out damaged sections of a frame, and weld in new metal, an old locomotive may be salvaged instead of being scrapped. Remanufacturers can also replace other major components such as the trucks or traction motors, to allow an older locomotive to stay in service. However, at some point, most railroads decide that the improved efficiency of newer technologies

[F] In some cases, some components are remanufactured by welding in new metal and remachining the component to the original specifications.

justifies the additional cost, and thus scrap the entire locomotive. Nevertheless, many smaller railroads, especially switching and terminal railroads, are still using locomotives that were originally manufactured in the 1940s.

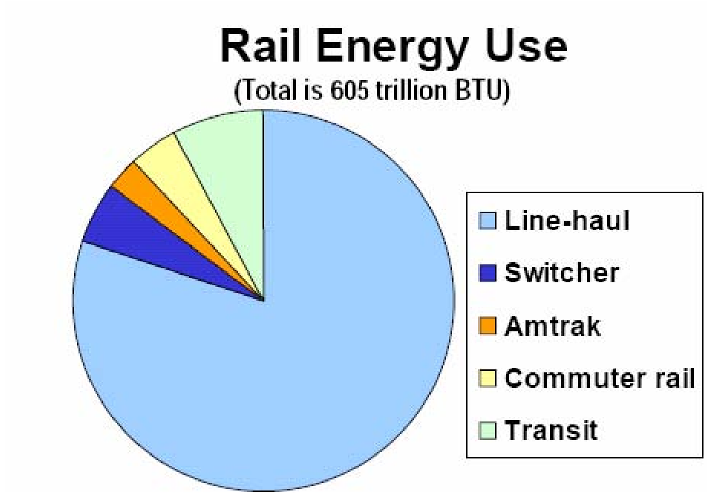
1.2.2.4.1 Remanufacturers

While the original manufacturers provide much of the remanufacturing services to their customers, there are several smaller entities that also provide remanufacturing services for locomotive engines. These businesses can be rebuilders licensed by the OEMs, in addition to the OEMs themselves. Moreover, some of the Class I and II railroads remanufacture locomotive engines for their own units and on a contract basis for other railroads. EPA has been able to identify nine independent locomotive remanufacturers, four of which are small business entities. Many of these businesses are full service operations that remanufacture locomotive assemblies (such as trucks or air brake systems), sell new and used parts, repair wrecked locomotives or provide routine maintenance. A few apparently remanufacture locomotives primarily for resale or lease, while others remanufacture engines for operating railroads or industrial customers. A few also offer contract maintenance; this may be tied to a locomotive lease, or may be offered separately to owners of locomotives. The size of these companies vary tremendously as some have as few as two employees, while others can have up to 5,000 employees. The cost of remanufacturing kits can vary depending on the model of locomotive and year of manufacture, an estimated range is $15,000 - $30,000 per kit.

1.2.3 Demand: Railroads

Railroads transport freight more efficiently than other modes of surface transportation because they require less energy and emit fewer pollutants.[43] The 2006 Transportation Energy Data Book shows that rail transportation used approximately 7.4% of all diesel fuel used in transportation and 2.1% of the total energy used by all forms of transportation to move 22.1% of all freight ton-miles (miles one ton of freight is moved). It also shows that this is less than 1% of the total U.S. energy use, but that locomotives currently emit slightly less than one million tons of NO_x each year, which is about 4% of total NO_x emitted by all sources. It is important to recognize, however, that the 2.1% of energy used by rail transportation (625.5 trillion BTUs) is the total of all rail sectors including: line-haul, switcher, Amtrak, commuter rail, and transit rail, as shown in Figure 1-9. This means that the freight railroads use approximately 1.86% of all energy consumed by every source of transportation to haul 22.1% of all ton-miles.

Figure 1-8 Rail Energy Use

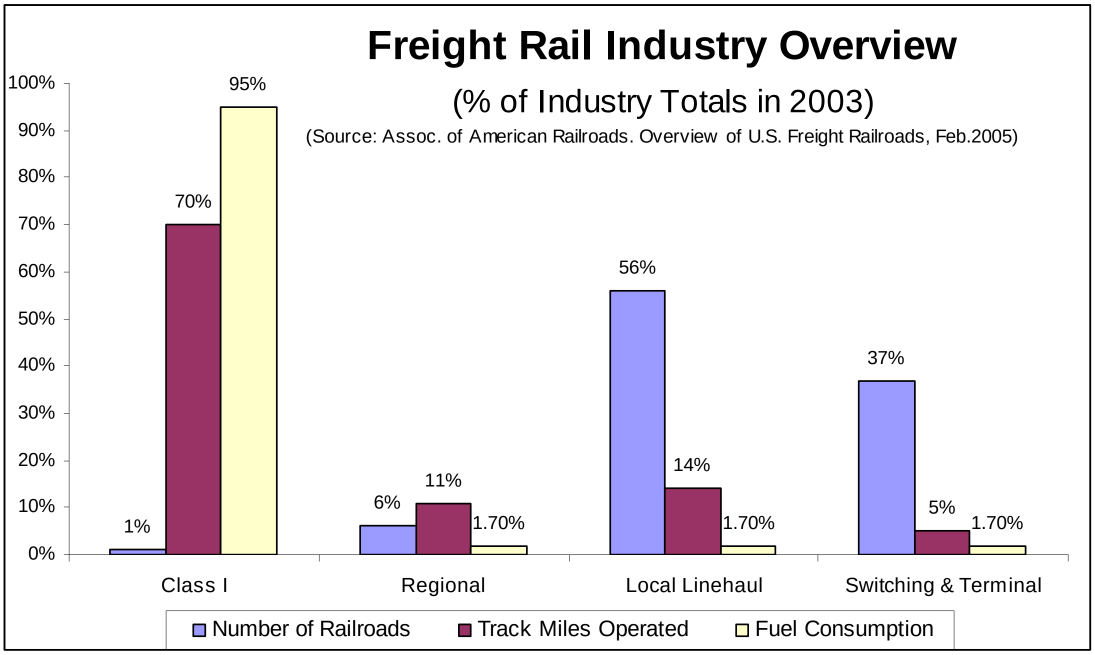


There are many other unique characteristics of the railroad industry such as track sharing, locomotive sharing, and fleet age. Unlike most other methods of shipping, railroads are responsible to maintain their own infrastructure such as tracks, and bridges, which is a very expansive network. The Class I railroads spent more than $320 billion or approximately 44% of their operating revenue between 1980-2003 to maintain and improve their infrastructure and equipment.[44] As locomotives grow larger and heavier, and as cars are designed to hold more weight, track is required that can handle this increased load, and this is quite costly. To date, of the 549 short line and regional railroads in existence, 333 have track that cannot handle these increased loads.[45]

1.2.3.1 Railroad Classification System (Class I, II and III)

In the United States, freight railroads are subdivided into three classes based on annual revenue by the Federal government's Surface Transportation Board (STB) (STB regulations for the classification of railroads are contained in 49 CFR Chapter X). The STB regulations divide the railroads into three classes based on their annual carrier operating revenue[46]. As of 2004, Class I railroads are those with annual carrier operating revenues of at least $289.4 million, Class II railroads are those with annual carrier operating revenues between $23.1-$289.3 million, Class III railroads are those with annual carrier operating revenues of $23.1 or less. The AAR further subdivides Class II and III railroads based on the miles of track over which they operate and their revenue. These categories are then called Short Line and Regional Railroads and usually belong to the American Short Line and Regional Railroad Association (ASLRRA).

Figure 1-9 Freight Rail Industry Overview



1.2.3.2 Class I Characteristics

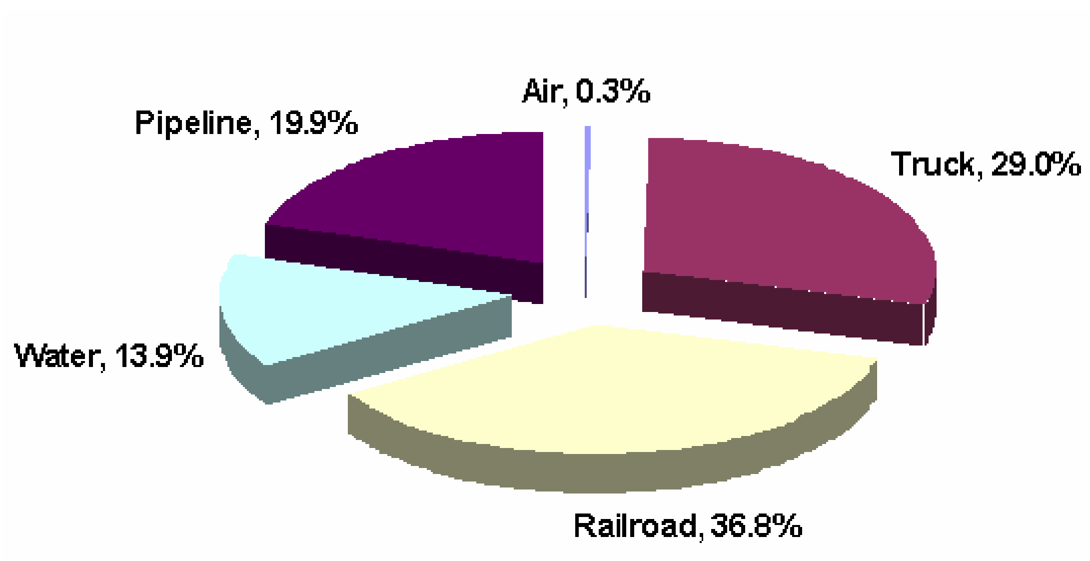
Current railroad networks (rail lines) are geographically widespread across the United States, serving every major city in the country. Approximately one-sixth of the freight hauled in the United States is hauled by train. There are few industries or citizens in the country who are not ultimate consumers of services provided by American railroad companies. According to statistics compiled by AAR, Class I rail revenue accounted for 0.36 percent of Gross National Product in 2004. Thus, efficient train transportation is a vital factor in the strength of the U.S. economy.

In order for Class I railroads to operate nationally, they need unhindered rail access across all state boundaries. If different states regulated locomotives differently, a railroad could conceivably be forced to change locomotives at state boundaries, and/or have state-specific locomotive fleets. Currently, facilities for such changes do not exist, and even if switching areas were available at state boundaries, it would be a costly and time consuming disruption of interstate commerce. A disruption in the efficient interstate movement of trains throughout the U.S. could have an impact on the health and well-being of not only the rail industry, but the entire U.S. economy as well.

The Class I railroads are the nationwide, long-distance, line-haul railroads which carry the bulk of the railroad commerce. There are currently 7 Class I freight railroads operating in the country, two of which are Canadian owned. Class I railroads operated approximately 22,400 locomotives in the U.S., over 97,662[G] miles of track and accounted for approximately 90 percent of the ton-miles of freight hauled by rail annually and consumed 4.1 billion gallons of diesel fuel in 2004.[47,48] Of these, the two largest Class I railroads, BNSF, and Union Pacific, accounted for the vast majority (63%) of the Class I locomotives in service in the U.S as of the end of 2004.[49] According to the 2004 AAR's' Analysis of Class I Railroads, Class I railroads paid on average $1.06 for a gallon of fuel in 2004 for a total expenditure of $4.2 billion which was 11% of their operating revenue. U.S. Class I railroads employ approximately 177,000 people, the vast majority of whom are unionized, and as of 2004 receive an average compensation of $65,500.[49]

The Bureau of Transportation Statistics 2006 report shows that in terms of ton-miles of freight, railroads haul 36.8% of total ton-miles, followed by trucking (29%), pipline (19.9%), river/canal/barge (13.9%), and air (0.3%), also shown in Figure 1-10 . Rail is a primary means of transport for many bulk commodities, according to AAR, 65% of all coal produced in the U.S., 33% of all grain harvested in the U.S. and 75% of all new automobiles manufactured in the U.S. were transported by rail. Being a primary source/mode of transporting these items, the railroad industry normally sets the industry standard price ($/ton-mile). Rail transport is typically more fuel efficient and less expensive than other land-based sources of transport. In terms of BTUs of energy expended per ton-mile of freight hauled, Department of Energy statistics indicate that rail transport can be as much as three to four times more efficient than truck transport. The AAR has asserted that one double-stack train can carry the equivalent of 280 truckloads of freight.[50]

Figure 1-10 U.S. Freight Transportation Share by Mode



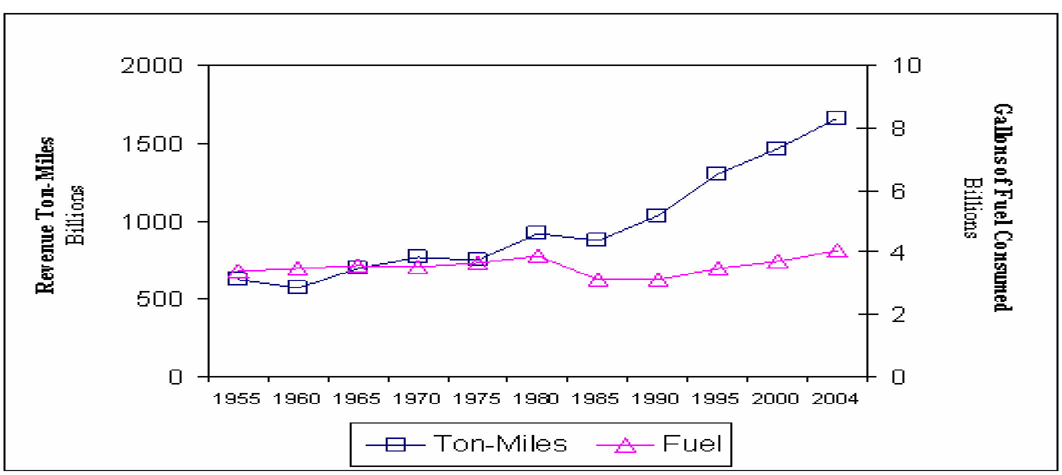
[G] This is the road length of track or the aggregate length of track excluding sidings and parallel tracks, actual track miles are 167,312.

Figure 1-12 and Table 1-29 show the long term growth trends for the amount of freight carried by Class I railroads and the amount of fuel consumed in carrying that freight.[51] As can be seen from these data, the ton miles of freight carried have almost tripled, while total fuel consumption has risen only 10-20%, showing an approximate 250% improvement in freight hauling efficiency.[i] The reason for this is that locomotive manufacturers have made continual progress in improving the fuel efficiency of their engines and the electrical efficiency of their alternators and motors, and railroads have made significant improvements to their operational efficiency. Fuel efficiency of the railroad industry overall has improved 16% over the last decade. It is reasonable to project that the growth in the amount of freight hauled will continue in the future. It is less certain, however, whether fuel consumption will increase significantly in the near future.

Table 1-29 Annual Fuel Consumption and Revenue Freight For Class I Railroads

Annual Fuel Consumption and Revenue Freight For Class I Railroads			
Year	Revenue Freight (Million Ton-Miles)	Fuel Consumption (Million Gallons)	Ton-Miles of Freight moved per gallon of fuel
1960	572,309	3,463	165
1970	764,809	3,545	216
1980	918,958	3,904	235
1990	1,033,969	3,115	332
1995	1,305,969	3,480	375
2000	1,456,960	3,700	394
2001	1,495,472	3,710	403
2002	1,507,011	3,730	404
2003	1,551,438	3,826	405
2004	1,662,598	4,059	410

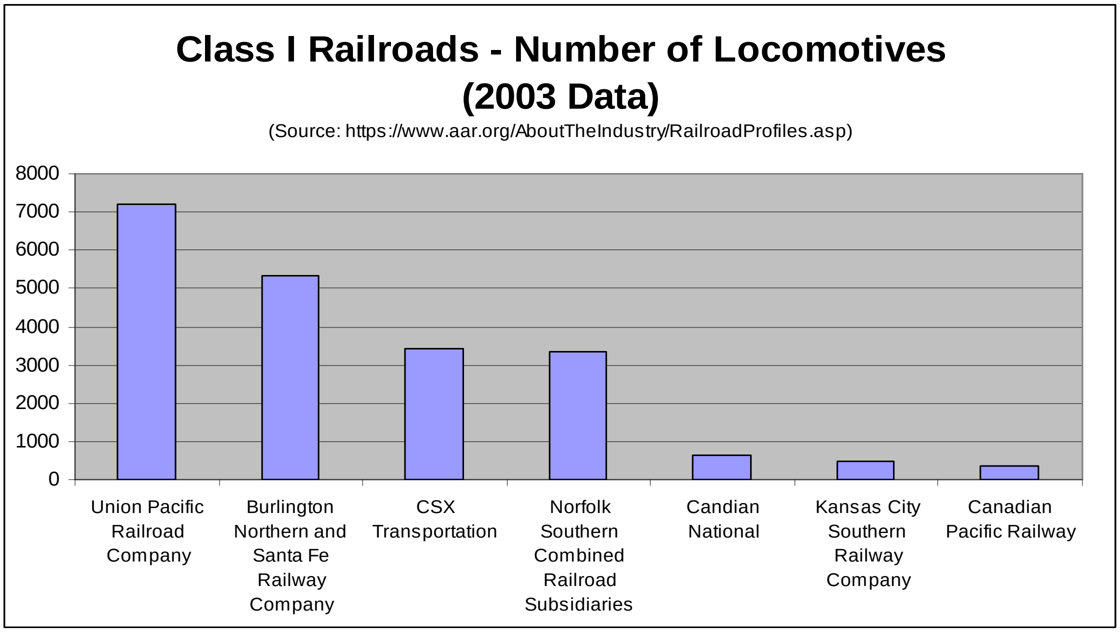
Figure 1-11 Fuel Consumption and Revenue Ton-Miles for Class I Railroads



1.2.3.2.1 Class I Market Share

Union Pacific (UP) operates over the most miles of track (32,616), has the largest number of employees (49,511), the greatest operating revenue ($12,180 million), but is surpassed in revenue ton-miles[H] by BNSF (569 billion). UP owns more miles of track than any other Class I (27,123), and operates the most locomotives (7,680), as show in Table I-30.

Table 1-30 Class I Railroads - Number of Locomotives



1.2.3.2.2 Locomotive Fleet

Purchasing practices have historically been for Class I railroads to buy virtually all of the freshly-manufactured locomotives sold. As the Class I railroads replace their equipment with freshly-manufactured units, the older units are either sold by the Class I railroads to smaller railroads, are scrapped, or are purchased for remanufacture and ultimate resale (or leasing) by companies specializing in this work. The industry-wide replacement rate for locomotives would therefore actually be lower than those indicated for the Class I railroads only. This would mean that the time required for the total locomotive fleet to turn over would be longer.

Additionally, independent of cyclic changes in the industry, future locomotive replacement rates could actually decrease. Locomotive manufacturers are now producing locomotives that have significantly more horsepower than older

[H] A revenue ton-mile is calculated by dividing freight revenue by total freight ton-miles, it is a measure of the level of revenue received by a railroad for hauling weight over distance. (AAR Railroad Facts, 2006) locomotives. Railroads have requested this change so that fewer locomotives are needed to pull a train. Placing more horsepower on a locomotive chassis increases overall train fuel efficiency. For example, it would be more fuel-efficient to use two 6000 hp locomotives, rather than three 4000 hp locomotives, to pull the same weight train, because the weight of an entire locomotive can be eliminated. Thus, whereas three old locomotives may be scrapped, only two new locomotives may need to be bought as replacements.

On the other hand, the business outlook for the railroad industry has been improving in the last few years. As railroads have become increasingly cost-competitive, they are attracting more business. This in turn increases demand for locomotive power to move the additional freight. Thus, while purchases of new locomotives may increase in the next few years, these locomotives will likely supplement, rather than replace, existing locomotives. Moreover, if freight demands continue to increase, it may become cost-effective to operate locomotives for longer periods than are estimated here.

1.2.3.2.3 Operation Profile

1.2.3.2.3.1 Fuel consumption.[52]

Class I railroads consumed 531 trillion BTUs in 2003. Locomotives traveled 1,538 million unit-miles in 2004, and averaged 69,900 miles per locomotive in 2004. The Surface Transportation Board reported that Class I railroads consumed 4.1 billion gallons of diesel fuel in 2004, for an average mile traveled per gallon of 0.13. Amtrak traveled 37 million train miles in 2004, and consumed 69.9 million gallons of fuel. The 4.1 billion gallons of diesel fuel used by the Class I railroad's is 96% of all locomotive fuel used in the U.S. and 7.4% of all diesel fuel used for transportation in the United States. Class I railroads spent $4.2 billion which is 11% of total operating expenses on fuel in 2004. The railroads are continually trying to reduce their fuel consumption through efforts such as idle reduction, and other operational improvements. In a study done by the Department of Energy, the aerodynamic drag of coal cars has been shown to account for 15% of total round-trip fuel consumption for a coal train, intermodal cars that are double stacked also carry an aerodynamic fuel consumption penalty of about 30% loss due to drag. Experiments have developed some fairings and foil that can reduce this drag loss on coal cars by up to 5% which would save 75 million gallons or 2% of total Class I fuel consumption in 2002.

1.2.3.2.3.2 Maintenance Practices

Locomotive maintenance practices also present some unique features. As is the case with other mobile sources, locomotive maintenance activities can be broken down into a number of subcategories. Routine servicing consists of providing the fuel, oil, water, sand (which is applied to the rails for added traction), and other expendables necessary for day-to-day operation. Scheduled maintenance can be classified as light (e.g., inspection and cleaning of fuel injectors) or heavy, which can range from repair or replacement of major engine components (such as power assemblies) to a complete engine remanufacture. Wherever possible, scheduled maintenance, particularly the lighter maintenance, is timed to coincide with periodic federally-required safety inspections, which normally occur at 92-day intervals. Breakdown maintenance, which may be required to be done in the field, consists of the actions necessary to get a locomotive back into service. Because of the high cost of a breakdown in terms of lost revenue that could result from a stalled train or blocked track, every effort is made to minimize the need for this type of maintenance. In general, railroads strive to maintain a high degree of reliability, which results in more rigorous maintenance practices than would be expected for most other mobile sources. However, the competitive nature of the business also results in close scrutiny of costs to achieve the most cost-effective approach to achieving the necessary reliability. This has resulted in a variety of approaches to providing maintenance.

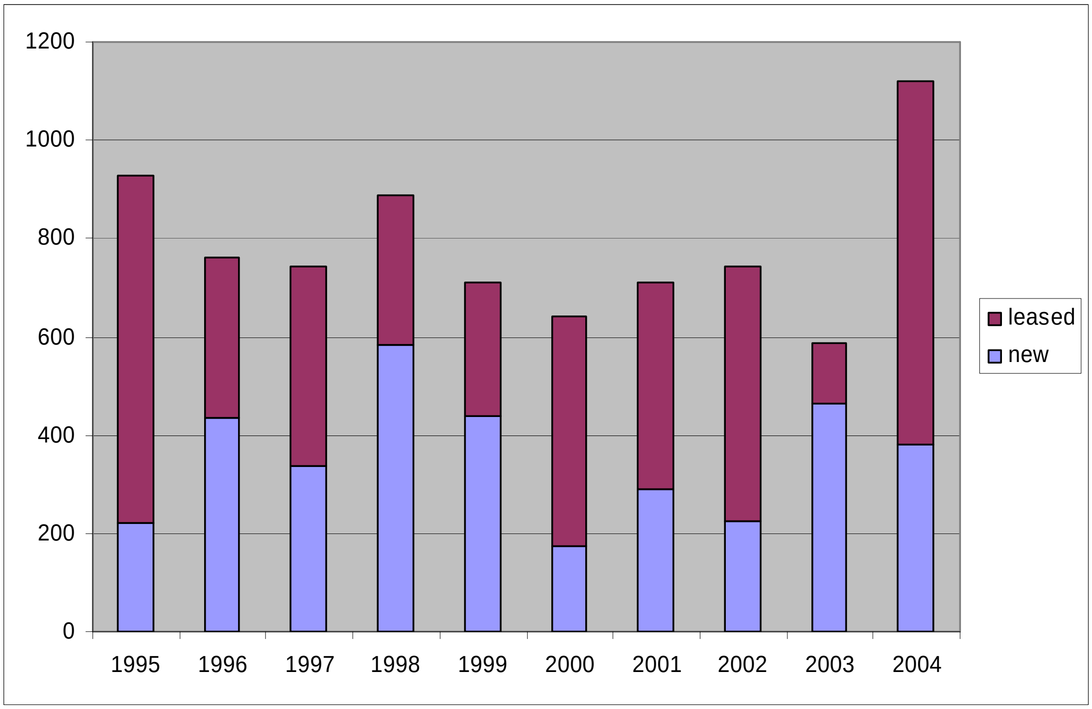
Maintenance functions were initially the purview of the individual railroads. Some major railroads with extensive facilities have turned to providing this service for other railroads, and a few of the smaller railroads also have done the same, in particular for other small railroads. However, the tendency in recent years has been toward a diversification of maintenance providers; a number of independent companies have come into existence to provide many of the necessary, often specialized services involved (e.g., turbocharger repair or remanufacture). The trend toward outside maintenance has also been accelerated by the policies of some of the larger railroads to divest themselves of not only maintenance activities, but ownership of locomotives as well. The logical culmination of this trend is the "power by the mile" concept, whereby a railroad can lease a locomotive with all the necessary attendant services for an agreed-upon rate.

1.2.3.2.4 Leasing

Locomotives are available for lease from OEMs, remanufacturers, and a small number of specialized leasing companies formed for that purpose. Leasing practices appear to be fairly standardized throughout the industry. Although lease contracts can be tailored on an individual basis, most leases seem to incorporate standard boilerplate language, terms and conditions. Under a typical lease, the lessee takes on the responsibility for safety certification and maintenance (parts and scheduled service) of the locomotive (including the engine), although these could be made a part of the lease package if desired. The lease duration ranged between 30 days and 5 years, with the average being 3 years

As can be seen from Figure 1-12 leasing has been a continuing trend among Class I railroads, with almost two-thirds of the locomotives placed in service in 2004 being leased. Leasing among Class II and III railroads is not nearly as widespread.

Figure 1-12 Source: AAR Railroad Ten-year Trends 1995-2004 : Number of Purchased and Leased Class I Locomotives



1.2.3.2.5 Traffic

Between 1993-2002 the value of goods being transported by all modes of transportation increased by 43.6% to $8,397.2 billion, and the ton miles increased over that period by 29.6% to 3,137.9 billion ton-miles. The railroads share of the value market increased during that time by 25.7%, and the percent increase in their ton-miles shipped over that time was 33.8%. Ton-miles shipped using multiple modes of transportation also increased over this period such as Truck and Rail (20.8%) and rail and water (63.8%).

Figure 1-13 shows that the overall Class I traffic volumes are still increasing, and as the car miles and train miles converge, this means they are optimizing the number of cars a locomotive can carry most likely by using fewer more powerful locomotives to haul more cars. The average length of a haul for Class I railroads has generally increased every year, and has almost doubled since 1960 when 461 miles was the average haul as compared to 2004 where 862 miles is the average haul length, commuter rail has not really increased its average haul length over this same time period. Class I train-miles, (a train-mile is the movement of a train, which can consist of multiple cars, the distance of one mile) were 535 million in 2004, Class I car-miles (a car-mile measures the distance traveled by every car in a train) were 37,071 million miles in 2004.

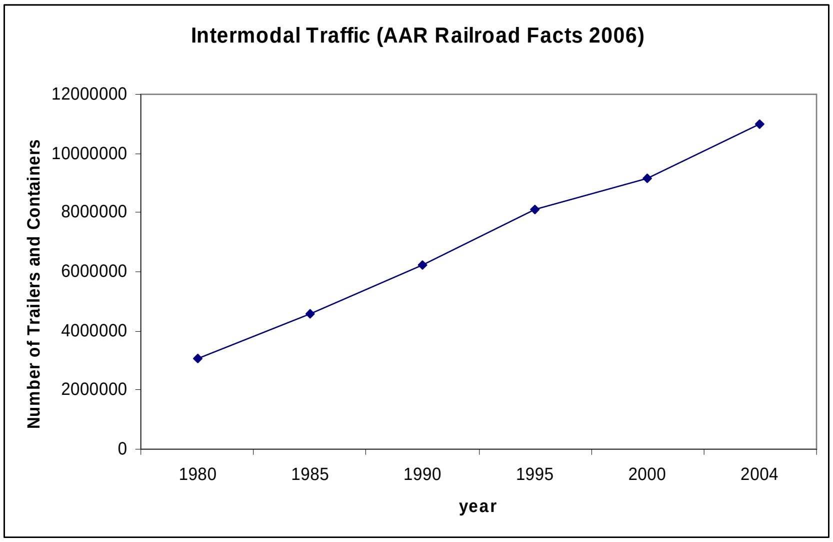
Figure 1-13 Class I Train Miles and Car Miles Source: AAR Ten Year Trends 1995-2004

1.2.3.3 Hauling Statistics

Class I railroads hauled 1,603,564 million ton-miles of freight in 2003, which was 37% of all freight hauled in the US; they also carried 19.8 billion ton-miles of crude oil and petroleum products, which was 2.2% of all those products, trucks carried 3.8%, but the bulk is transported via pipeline (66.8%) or water carriers (27.2%). As of 2002, railroads transported 72.1 billion ton miles of hazardous materials, or 22.1% of all hazardous material being shipped an average of 695 miles per shipment (BTS 2006). Railroads and trucks carry roughly equal hazmat ton-mileage, but trucks have nearly 16 times more hazmat releases than railroads.

The 2006 FRA Freight Railroad Overview indicates that intermodal shipping is the fastest growing segment of rail traffic, doublestack containers were introduced in the 1980's and since then number of trailer and container loadings has risen from 3.4 million to 11.0 million in 2004. Figure 1-14 shows the near doubling of this traffic in each of the past two decades. The Staggers Act of 1980 also legalized railroad-shipper contracts, and according the STB, at least 55% of all traffic moves under contract, which allows railroads to increase efficiency by permitting better planning.

Figure 1-14 Class I Intermodal Traffic Source: AAR Railroad Facts 2006 Edition



1.2.3.4 Track Statistics

As of 2004, Class I owned 97,662 miles of road Since 1980, capital expenditures on roadway and structures has increased 88% from 2.6 billion in 1990 to 4.9 in 2004 as railroad tracks have been upgraded to 130 pound per yard weighted rail to accommodate heavier loads being hauled per car. Class I railroads have increased their traffic (ton-miles) by approximately 81%, while they have decreased the miles of track they own by 41%. This has increased traffic density, and although double-stacking containers has helped to reduce traffic to some degree, this is still a concern due to the continual growth in ton-miles.

1.2.3.5 Class II & III Characteristics[53]

In the 1970's, deregulation allowed the Class I railroads to stop serving many smaller lines that were unprofitable to them. This allowed many small independent railroads to take over that portion of the line and run it more efficiently and sometimes at a lower cost due to their enhanced flexibility as a small business, in 2004 there were 549 Class II and III railroads. In many cases, these smaller railroads are also able to receive financial assistance from local governments or associations of customers to help them upgrade their infrastructure (in many cases, the tracks are quite old and are not rated for the loads that today's cars typically carry).

In 2004, Short Lines originated or terminated one out of every four carloads moved by the domestic rail industry, and operated over approximately 50,000 miles of track, which is nearly 29% of all U.S. rail mileage. They had over 19,000 employees and served over 11,700 customers and facilities. Of the track they operate, only 43% is capable of handling the heavier 286,000 axle weight cars. The total revenue for the Class II and III railroads in 2004 was almost $3 billion, while they spent nearly $433 million on capital expenditures, $397 million on maintenance of equipment, road and structures, and $221 million on fuel. More than half of the short line and regional railroads connect to two or more other railroads, and over 80% operate in one state only.

Statistics compiled by the American Short Line and Regional Railroad Association (ASLRRA) 2004 show that there are approximately 549 Class II and III railroads (not including commuter and insular railroads). A more detailed breakdown of these can be found in Table 1-31. They consist primarily of regional and local line-haul and switching railroads[I], which operate in a much more confined environment than do the Class I railroads. Class II and III railroads operate approximately 3,777 locomotives. In a recent survey taken by the ASLRRA, locomotive fleet age data shows that over 92% of the locomotives owned by the Class II and III railroads are over twenty years old, 5.4% are 10-19 years old, and 2% are newer than 10 years old. Class II and III railroads used 552 million gallons of fuel in 2004, which is about 13% of the amount of diesel fuel used by Class I locomotives in 2004. Employment has declined for all railroads substantially since the 1990's, but all railroads are predicting growth in hiring.

Table 1-31 Profile of Railroad Industry -2004[54]

Type of Railroad	Number of Railroads	Number of Employees
Class I Freight Railroad	7	157699
National Passenger Railroads	1	18,909
Regional Railroads	31	7422
Local/Line-Haul Railroads	314	5349
Switching and Terminal	204	6429
Class I Subsidiaries	102	3687
Commuter Railroads	18	25,29655
Shipper-Owned Railroads	***68***	
Government Owned Railroads	***28***	

Some of the smaller railroads are owned and operated by Class I railroads, many of which are operated as formal subsidiaries for financial purposes, but are run as standalone entities. In 2004, there were 31 regional railroads, 314 local line-haul railroads and 204 switching and terminal railroads, including subsidiaries (regional and local railroads may also have subsidiaries). A few of these are publicly held railroads and some are shipper-owned. Insular in-plant railroads are not included in this total. ASLRRA estimated that there are probably about 1,000 insular railroads in the U.S. These railroads are not common carriers, but rather are dedicated to in-plant use. They typically operate a single switch locomotive powered by an engine with less than 1000 hp. Such locomotives typically use a few thousand gallons of diesel

[I] "Regional railroad" and "local railroad" are terms used by AAR that are similar, but not identical, to "Class II" and "Class III", respectively.

fuel each year, and thus are not a particularly significant source of emissions. Finally, there are a handful of very small passenger railroads that are primarily operated for tours. These tourist railroads are included within the Class II and III railroads.

1.2.3.6 Passenger Rail

1.2.3.6.1 Amtrak

Amtrak was formed in 1971 by Congress through the Rail Passenger Service Act of 1970 (P.L. 91-518, 84 Stat.1327) to relieve the railroads of the financial burden of providing passenger railway service. In return for government permission to leave the passenger rail business and avoid massive losses, many of the freight railroads donated equipment to Amtrak as well as $200 million in startup capital.[56] Amtrak is operated by the National Railroad Passenger Corporation of Washington, D.C. The Secretary of Transportation has the authority to designate Amtrak's destinations, which as of 2004 included 527 cities; other transit rail serves 2,909, some of which may be shared with Amtrak (STB 2006).[52] On average, 777,000 people each day depend on commuter rail services operated under contract by Amtrak, or that use Amtrak-owned infrastructure, shared operations and dispatching; an average of 69,000 people ride on up to 300 Amtrak trains each day. Amtrak relies on receiving federal subsidies in order to operate, although it continually working to become independent and profitable.

Although Amtrak's rates are not regulated, they do depend on the amount of subsidies received from the Federal government; this is not unlike most other forms of passenger rail in the U.S. Their only source of competition is other modes of transportation, and this also affects their rates. Fuel costs can dramatically affect rates and Amtrak’s need for subsidies; between 2004 and 2005, Amtrak’s fuel costs increased 149%, and continue to increase substantially. Despite an increase in passengers between 2004-2005 and improved fuel conservation methods that reduced their fuel consumption by nearly 10%, their fuel cost increased by $43 million.[57]

Amtrak is the sole large-scale provider of inter-city passenger transport. Their fleet includes 436 locomotives, of which 360 are diesel locomotives that used a reported 69.9[58] million of gallons of fuel in 2005, and 76 are electric locomotives. The FRA provided Amtrak with funding to purchase Acela locomotives, which are 4,000 horsepower gas turbine locomotives. These trains consume about the same amount of fuel as a diesel locomotive but produce about 1/10th of the NO_x

They offer service to 46 states on 21,000[59] miles of routes, only 745 miles of which are actually owned by Amtrak, primarily in Michigan, and between Boston and Washington DC.[60] Based on gross revenue, Amtrak is classified as a Class I railroad by the STB. However, unlike the Class I freight railroads, Amtrak's current operating expenses exceed its gross revenue.

The average age of a passenger train from Amtrak is quite young, in fact, since 1980 it has remained under 14.5 years old. Amtrak was on-time 74% of the time in 2003, but the 65% of that delay was caused by a host railroad. A host railroad is a freight or commuter railroad over which Amtrak operates on for all or part of a trip, and delays can include signal delays, train interference, routing delays or power outages. Amtrak must pay these host railroads for their use of this track and any other resources, in 2005, those payments were for more than 25 million train miles (one train-mile is a mile of track usage by each train) which totaled more than $92 million.

The average Amtrak/intercity fair was $55.15, the average revenue per passenger-mile is $0.249 for Amtrak, and the average length of haul was 231 miles[61] In 2006, Amtrak was able to obtain an additional subsidy in order to remain operational in 2006, in the amount of $1.1 billion[62], but the future of Amtrak may change if the Passenger Rail Reform Act is passed, this bill is currently in the House Subcommittee on Railroads, and would split Amtrak up into three different entities, two privately owned and one government corporation.

1.2.3.6.2 Commuter[63]

There are also 21 independent commuter rail systems operating in 16 U.S. cities, consuming 72 million gallons of diesel fuel annually, operating over 6,785 miles of track. They employed approximately 25,000 employees in 2004. Many of these commuter railroads rely on Federal subsidies to improve their infrastructure, in some cases they also rely on state and local government subsidies to support their operations.

The average length of haul for commuter rail in 2004 was 23.5 miles, an average of 414 million people use commuter rail each year to result in over 9.7 billion passenger-miles. The average commuter rail fair in 2004 was $3.90, with an average $0.154 revenue per passenger-mile. The commuter rail is also a young fleet and has remained younger than 17 years old since 1985.

1.2.4 Existing Regulations

1.2.4.1 Safety

Achieving and maintaining the safe operation of commercial (common carrier) railroads in the U.S. falls under the jurisdiction of the Federal Railroad Administration (FRA), which is a part of the Department of Transportation. The FRA was created in 1966 to perform a number of disparate functions, including rehabilitating Northeast Corridor rail passenger service, supporting research and development for rail transportation, and promoting and enforcing safety regulations throughout the railway system.

FRA safety regulations apply to railroads on a nationwide basis. In 49 CFR section 229 the regulations require safety inspections of each locomotive used in commercial operations: daily, every 92 days (i.e. the periodic inspection), annually, and biennial. Each inspection increases in complexity. The inspections are usually performed by the railroad which owns or leases the locomotive. FRA personnel review the findings of these inspections and any corrective actions identified and taken. Since each locomotive is required to be out of revenue service for inspection every 92 days, railroads commonly schedule their performance of preventive maintenance at these times. It appears likely that each locomotive is out of service for 12 to 24 hours during each FRA safety inspection and preventative maintenance period.[J] To limit the time that locomotives are out of service for these safety inspections and preventive maintenance, railroads maintain suitable facilities distributed across the nation. Thus, it appears that the railroads have had a long history of compliance with federal regulations, and have developed strategies to live within the regulations and to minimize any adverse business impacts that may have resulted.

1.2.4.2 Federal

In 1980 Congress passed the Staggers Act (USCA 49 § 10101) which laid out the government's statutory objectives for the Railroad Industry which are to balance the efficiency and viability of the industry with the need for: reasonable rates, fair wages, public health and safety, and energy conservation.

The railroads are governed by two separate Federal Agencies directly, both under the Department of Transportation, a cabinet-level department. The Federal Railroad Administration (FRA) regulates safety issues. The FRA sets safety standards for rail equipment and operation, and also investigates accidents on rail lines and at rail crossings. The FRA also plays a role in labor disputes to a small degree, by monitoring the progress of negotiations, projecting the economic impact of a strike and assisting the Secretary in briefing Congress if necessary. The STB is an adjudicatory body that was formed in 1966 to settle disputes and regulate the various modes of surface transportation within the U.S. Organizationally, the STB is part of the Department of Transportation (DOT), the STB deals with railway rate and service issues, railway restructuring and various other issues, including classification of railroads. The Surface Transportation Board (STB) regulates economic issues such as rates. The STB can also mandate access to locations in order to maintain competition in areas where mergers reduced the number of available carriers

1.2.4.3 Rates

Rail transportation accounts for 8.7% of all for-hire transportation services that are a measured in the GDP, or 0.2% of the total U.S. GDP. The average freight revenue per ton-mile for Class I rail in 2004 was $0.0235, and average operating revenue of $40.5 billion. Freight rates adjusted for inflation have declined by an average of 1.1% a year between 1990 and 2004 due in large part to the passage of the Staggers Act, as shown in Figure 1-15.[64]

[J] Values are an approximate estimate by FRA personnel.

If a shipper believes a rate is unreasonable (only if that shipper does not have access to another railroad, and waterway or highway modes are not feasible), they can complain to the STB, which has a stand-alone rate standard. This means that they determine what a hypothetical new carrier to serve that shipper would need to charge to cover all of its costs including capital and construction. Complaints such as these are typically made by bulk shippers, such as coal or chemicals, who cannot use other modes of transportation such as highway or can't access other railroads.

Figure 1-15 Railroad Rate Trends Before and After Staggers Act of 1980

1.2.5 Foreign Railroads in US

Locomotives that operate extensively within the U.S. are subject to the existing provisions of 40 CFR Part 92.

1.2.5.1 Mexico

In 2004, the BTS says there were a total of 675,305 US/Mexico railcar crossings, that's an average of almost 1900 crossings a day, or one every minute. The Mexican Railroads and 16,415 miles of track have been privately owned since a Constitutional amendment was passed in 1995 (FRA "Border Issues"). They primarily haul NAFTA generated goods, such as cars, automobile parts, and other manufactured products. Mexico has two railroads, Ferrocarril Mexicano, which has a joint venture with UP and Transportacion Ferroviaria Mexicana (TFM) of which Kansas City Southern has controlling interest.

1.2.5.2 Canada

In 2004, the BTS says there were 1,950,909 border crossings into Canada by railcars. Canada is also home to two Class I railroads that operate extensively in the U.S., Grand Trunk Corporation which includes almost all of Canadian National's (CN) U.S. operations, and Canadian Pacific Railway which operates its Soo Line primarily in the U.S.

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