DIESEL POWERS the U.S. ECONOMY

Providing High-Paying Jobs, Exports and Long-Term Productivity Gains in the Nation's Fundamental Sectors

DIESEL TECHNOLOGY FORUM

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Providing High-Paying Jobs, Exports and Long-Term Productivity Gains in the Nation's Fundamental Sectors

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ABOUT THIS REPORT

The Diesel Technology Forum ("DTF") is a not-for profit educational association representing diesel engine and equipment and vehicle manufacturers, component suppliers, fuel refiners and emissions control technology manufacturers.

DTF commissioned the California-based research team of Aspen Environmental Group and M.Cubed to undertake this analysis of the importance of diesel power to the U.S. economy. This work also updates a previous effort commissioned by the DTF completed in 2000 by Charles River and Associates.

This study is supported by an **extensive** set of Appendices that, along with this section, comprise the full report. These include:

APPENDIX A: Provision of Diesel Technology: *Selling Goods and Services to Diesel Users*

- Vehicle Equipment and Engine Manufacturing
- Light-Duty Vehicles: An Emerging U.S Market
- Fuel Producers, Refiners and Sales
- Oil Production and Refining
- Refining: Volumes, Dollar Values and Trends
- Renewable Diesel Fuels: "Green" Diesel
- Diesel Equipment Sales and Servicing
- Trade and Export In Diesel Technology and Fuel

APPENDIX B: The Economic Benefits of Using Diesel Technology

- Using Diesel to Produce Basic Commodities and Build Infrastructure
- Agriculture: Putting Food On Our Table
- Mining and Construction: Extracting Materials and Building Infrastructure
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APPENDIX D: Methodology: *How Is Economic Activity Engendered by Diesel Technology Measured?*

- How Is Economic Activity Engendered by Diesel Technology Measured?
- The Concept of Total Output, Value Added and Gross Domestic Product
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DIESEL POWERS the U.S. ECONOMY

EXECUTIVE SUMMARY

Today U.S. economic output is on par with the entire European Union composed of 35 nations, and greater than the next two countries, China and Japan, combined. Continued economic growth requires cost-effective transportation of goods, construction of infrastructure and extraction of resources using powerful, efficient, inexpensive motive power.

Diesel is the prime fuel for transporting freight, powering tractors, building roads, and meeting critically important demand for emergency services and national defense. More than four-fifths of products exported from and imported to the U.S. – by truck, train, ship or intermodal means – are moved using diesel technology. Three-quarters of the fossil-fueled equipment used in construction, mining and agriculture are diesel-powered. Diesel engines are the primary motive force for land and sea-route mass transit. Many emergency vehicles, such as fire and rescue vehicles, have diesel engines. Hospitals, government offices and businesses often rely on fast-response times and full load-carrying capability of diesel generators for emergency standby power. Our national defense relies on diesel to move material, munitions and weapons, both between theatres and on the battlefield. In short, diesel's contribution to factories, farms and families is ubiquitous.

The advantages of diesel are manifest, making it a prime choice for these applications. Diesel power is energy-efficient, has high weight and energy power output ratios, has famously reliable and durable engines which can use renewable fuels, is highly portable and compact, and is safer compared to alternatives.

More than four-fifths of products exported from and imported to the U.S. – by truck, train, ship or intermodal means – are moved using diesel technology.

The synergistic relationship between the nation's economic well-being and use of diesel technology can be seen even more clearly by examining the linkage between prosperity and diesel-reliant activity such as freight movement. For example, fuel use in trucks is highly correlated with GDP growth, moving together 98.5 percent of the time. The Ceridian-UCLA Pulse of Commerce Index™ builds on the economic relationships of freight movement and diesel fuel use to track and forecast U.S. economic activity on a nearly real-time basis.

This study measures the shares of U.S. national income and employment that are tied to the use of diesel power using generally accepted economic methods and data. For this study's purposes the scope of diesel technology is defined as (1) production and delivery of fuel; and (2) manufacturing and servicing of engines and equipment using those engines, such as trucks, tractors and pumps. In addition, the importance to the nation of several key industries – freight transportation, construction, agriculture, mining, transit, public safety and national defense – that rely largely on diesel technology to deliver their services is examined.

The diesel technology producing and servicing sectors directly contributed $183 billion and 1.25 million jobs to the U.S. economy in 2009. Another $300 billion was created through indirect and induced ripple effects. These diesel-related jobs are highly productive. Each employee in these industries created $146,000 directly in national income, nearly a third higher the national average of $110,000 per employee. The technology producing sectors were even higher, averaging $207,000 per job. This translates into higher wages for employees in those industries. In 2009, while the national average weekly wage for all workers was $876, the national average for the diesel technology and fuels sector was 60 percent higher at $1,398.

Diesel technology and fuel powered $455 billion, or 3.2 percent of the GDP from diesel-reliant sectors (2009).

Beyond producing engines and fuel, diesel technology and fuel powered $455 billion or 3.2 percent of the 2009 GDP from key diesel-reliant industries. For every dollar of economic value from diesel technology, $4.51 is added elsewhere to national income in related industries that rely on diesel. The total GDP contribution for key diesel sectors, both technology producing and reliant, as well as diesel services, was $638.5 billion in 2009.

The new generation of clean diesel technology, ultra-low sulfur diesel fuel, cleaner engines and advanced emissions control technology, provides both environmental and economic benefits to the U.S. As policymakers look to promote cleaner, more fuel efficient technologies, its use will grow along with other competitive alternatives. Diesel technology's future value is further enhanced by its suitability for hybrid applications and its readiness to utilize a diverse range of first and second generation renewable and biodiesel fuels.

National fuel economy standards for cars and light-duty trucks beginning in 2017 are expected to be met in part by an increasing number of clean diesel passenger vehicle choices. Similarly, first-ever fuel efficiency standards for medium- and heavy-duty commercial trucks and buses beginning in 2014 will drive further innovation and efficiency gains in diesel technology as a key compliance strategy. For the fleet of existing vehicles and equipment, expanded use of new retrofit technologies, repowering and upgrading existing engines and expanded use of lower carbon biofuels are providing green jobs as well as cleaner air.

As policymakers look to further reduce petroleum consumption and greenhouse gas emissions, clean diesel technology has, and will continue to be a key solution.

INTRODUCTION: HOW AND WHY DIESEL TECHNOLOGY IS USED

Over the last century, innovation by U.S. science and businesses have led to an increase in national productivity and output that has spread across the world. The United States of America remains the world's economic engine even in current difficult times despite China and India's rapid growth. Today U.S. economic output is on par with the entire European Union composed of 35 nations, and greater than the next two countries, China and Japan, combined.[1]

Efficient transportation fuels economic growth and requires powerful, cost-effective, inexpensive motive power. Diesel is the prime fuel for transporting freight, powering tractors, building roads, and meeting critically important demand for emergency services:

Diesel is the prime fuel for transporting freight, powering farm tractors, building roads and powering emergency services.

- The vast majority of products exported from and imported to the U.S., by truck, train, ship or intermodal means, are moved using diesel technology. Most commercial trucks, including those used by independent trucking companies and "fleets" (e.g., store- and distributor-owned trucks) rely on diesel-powered engines. Air freight is dependent on diesel lifts, tugs and tractors to load cargo and move planes into position.
- A majority of off-road equipment, including tractors and stationary engines and pumps, depend on diesel. Three-quarters of the fossil-fueled equipment used in construction, mining and agriculture are diesel-powered. Diesel is the primary technology for pumping water for drainage and irrigation, and to generate remote power.
- Diesel engines are the primary power source for land- and sea-based mass transit. Buses, commuter trains and ferries rely predominantly on diesel technology.
- Diesel technology is critically important in protecting public safety and ensuring energy reliability. Virtually all emergency vehicles, such as ambulances, fire engines and tow trucks use diesel engines. Hospitals, data centers, air traffic control towers, pipelines and other critical service sectors often rely on diesel generators for emergency standby power in case the power grid suffers an outage.
- Our national defense relies on diesel to move material, munitions and weapons, both between theatres and on the battlefield.

Diesel's contribution to factories, farms and families is ubiquitous. Thanks to technology which has and will continue to reduce emissions and improve efficiency, diesel power will continue to be the critical fuel for the nation's economy for the years to come.

DIESEL'S ADVANTAGES

Diesel technology is the engine of choice for a variety of reasons:

- ***Energy-Efficiency*** – Compression-ignition diesel engines are typically 25 to 40 percent more efficient than those fueled by gasoline or natural gas-fueled spark-ignition engines in the same applications. A portion of this difference comes from diesel's higher energy content over gasoline; but the majority stems from the greater inherent efficiency in diesel's compression ignition. These fuel savings translate into lower costs for businesses and farms, which are passed on to consumers.
- ***Power Output*** – On a unit of work basis, diesel engines perform more work using less fuel than any other internal combustion engine. Diesel is essentially the only effective option for many heavy-duty engine applications. Diesel engines achieve higher power output at lower engine speeds than spark-ignition (e.g., gasoline or natural gas) engines, which makes them preferable for overcoming the inertia of large loads, and for excavating and moving earth and other heavy materials. In addition, only compression-ignition engines can achieve the high horsepower needed to power large equipment, such as locomotives. Diesel engines in excess of 10,000 horsepower are commonly used in ships and mining equipment.

- ***Durability and Reliability*** – Diesel compression-ignition engines require less maintenance, suffer fewer breakdowns and have longer service lives than spark-ignition engines. Diesel cars are famous for their longevity. Diesel trucks often travel hundreds of thousands of miles before their engines are overhauled, and then dispatched for hundreds of thousands more miles. Many ships rely on a single diesel engine to cross the oceans.

- ***Portability*** – For optimum performance, motive power sources use energy-dense fuel transportable to virtually any location where work is required. Diesel is among the most portable technology platforms. First, its energy density to weight ratio, including storage, is excellent. This allows vehicles to carry larger loads and go longer distances. Second, it is liquid at ambient temperatures so that it does not require any special storage or handling like natural gas which must be compressed or refrigerated,[a] or electricity that requires heavy batteries or a fixed, stationary connection.[b] Finally, diesel can easily power an electric motor either in a vehicle or in a remote location. Locomotives are a prime example of the linking of diesel with electricity to gain the benefits of both technologies.

- ***Fuel Characteristics*** – Diesel fuel has a higher flashpoint and lower auto-ignition temperature making the fuel less volatile, particularly if spilled.

- ***Fuel Flexibility*** – Diesel engines were originally invented to run on vegetable oils. Today, most diesel engines can run on high-quality blends of biodiesel with little modification as well as next-generation, drop-in renewable diesel fuels which offer even further benefits. This flexibility of the diesel platform can accelerate the introduction of these renewable diesel fuels across the economy.

THE APPROACH OF THIS REPORT

This study measures the share of U.S. national income and employment that is tied to the use of diesel in some manner using generally accepted economic methods and data. For this study's purposes the scope of diesel technology is defined as (1) production and delivery of fuel; and (2) manufacturing of engines and equipment using those engines, such as trucks, tractors and pumps. In addition, the importance to the nation of several key industries – freight transportation, construction, agriculture, mining, transit, public safety and national defense – that rely largely on diesel technology to deliver their services is examined.

The report is organized into five main components. The first section provides an overview of diesel's contribution to the U.S. economy. This is followed by sections two and three, which provide a more detailed look at the direct economic contribution of diesel industry (manufacturing, fuels and servicing industries which produce and deliver vehicles and equipment for use in the economy) and the economic activity that is catalyzed by the use of diesel technology by sector and subsector – agriculture, mining and resource extraction, construction, freight hauling, power generation, mass and personal transportation, national defense, and government fleets including public safety. In part four, policies affecting the use of diesel and programs which support diesel technology development, use and promotion are discussed. Finally, there is a more detailed discussion of the report's underlying methodology.

The appendices contain more detailed discussions of the analysis of each sector and the methodology used. Reference source material is listed in the appendices.

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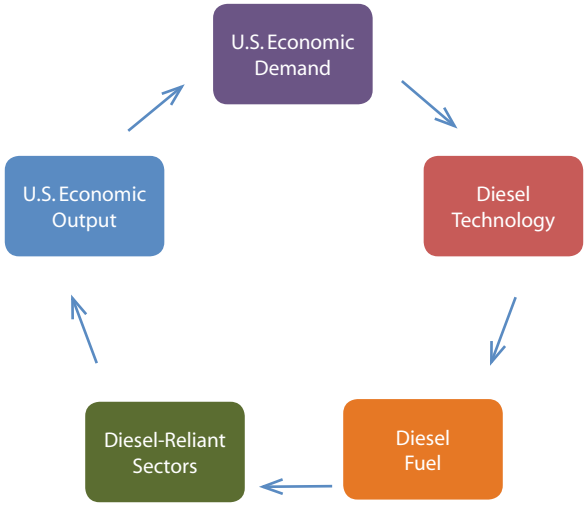
[a] Liquid natural gas (LNG) locomotives require a separate fuel tender car.

[b] A primary alternative to diesel, electricity, has some significant weaknesses that reduce its widespread applicability. Electric motors exhibit many of diesel's characteristics, including power output, durability and reliability. But, electricity requires an external power source; either electric service must be delivered over wires, which limits the motive source's mobility, or the power source must be added to the motor, which adds weight and cost. Electricity can be used for stationary uses, but the cost of installing an electricity connection can be cost prohibitive for temporary uses. In some applications solar arrays are a viable alternative, but their use is constrained by reliability – their ability to generate power is intermittent – and the need for sufficient space. Using electricity for rail poses significant safety problems that add to costs as well.

HOW IS ECONOMIC ACTIVITY ENGENDERED AND CATALYZED BY DIESEL TECHNOLOGY MEASURED?

Diesel technology (engines, fuels, equipment) supports a wide array of economic activities. Producing the inputs to diesel technology also contributes to the economy. Oil extraction, fuel refining, engine and vehicle manufacturing, and equipment servicing all require labor and capital. This fuel and equipment is used in trucks, trains and ships which facilitate the movement of goods and people and generate economic value through the productive work of equipment such as tractors, generators and portable machinery generating economic output in the agriculture, construction and mining sectors. All of these activities can be translated into expenditures of dollars and jobs created. **Figure 1** shows how this cycle of technology demand, production, use and output powers key parts of the U.S. economy.

Figure 1: The Cycle of Economic Activity Related to Diesel Technology



Economic activity is measured with two important concepts.[c] The first is total output, the total expenditures and receipts associated with all transactions in the economy. Total output includes activities which may only reflect a physical transfer, with little associated added economic production, as well as the actual economic activity that is facilitated by or facilitates the transfer. For example, in diesel fuel production the crude oil input, which might come from Saudi Arabia, embodies most of the value in a gallon of fuel, but the refiner located in the U.S. processes the crude so that it can be used in a diesel engine. Thus the refiner's total output includes both the price he paid for the gallon of fuel, and the value he added through the refining process to make it a usable fuel.

The second concept, value added, measures the specific economic activity associated with enhancing the product that has been transferred and is the component of total output that adds wealth to the economy. Value added reflects the economic value added to a product by an industry beyond the costs of purchasing the necessary inputs from other industries, as measured by labor and property income and indirect taxes. Each step of the production, delivery, and service process adds incremental value. The oil producer adds value by extracting the crude, the refiner adds value by processing it into diesel, and the retailer adds value by storing and selling the fuel to the final consumer. The cumulative value added across these industries, plus any out of state imports, equals the total cost to provide the final product to the end consumer. The sum of all of this value added for the U.S. is known as the Gross Domestic Product or GDP. The GDP excludes imports and excludes the multiplier effect from recirculating spending through the economy.[d] The GDP growth rate is followed closely by economists and the media.

[c] How economic activity is measured for this study is described in more detail in Appendix D.

[d] Multipliers translates initial changes in an industry's output or final demand for its products into values reflecting the recirculation of income and spending through the economy. This can amount to two to three dollars for every dollar of direct spending.

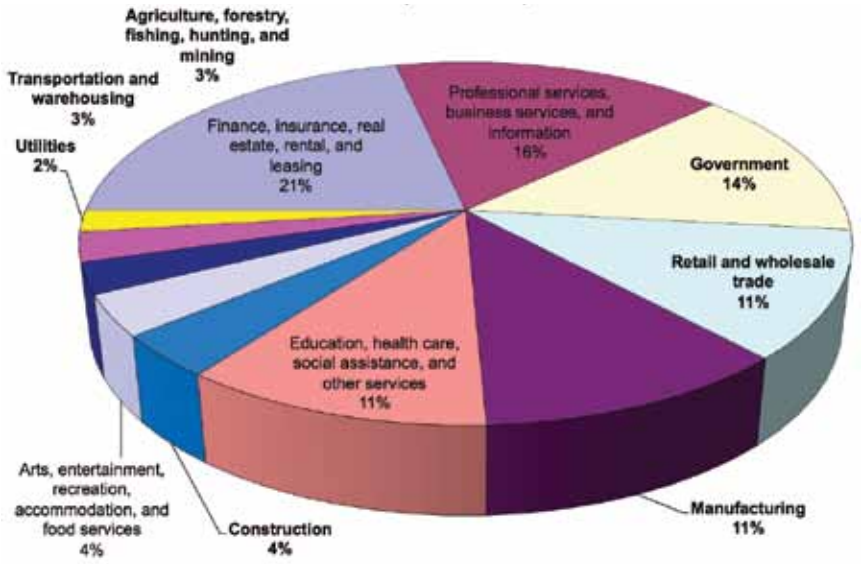
DESCRIBING DIESEL'S ROLE IN THE U.S. ECONOMY

The U.S. economy generated more than $24.8 trillion in total output in 2009, of which $14.1 trillion was value-added production,[2] the latter being the measure of the GDP.[3] This represents 25 percent of the world's GDP. **Figure 2** shows the shares of GDP for each major industry sector in the U.S. in 2009.[4] The diesel producing and reliant sectors are shown in bold. These constitute nearly half of the U.S. GDP. Even those sectors which are not highlighted still rely on diesel power to some extent such as, for example, providing for emergency backup electrical power at hospitals.

The diesel producing and reliant sectors...

constitute nearly half of the U.S. GDP.

Figure 2: 2009 U.S. Gross Domestic Product by Sector {$14.1 Trillion}

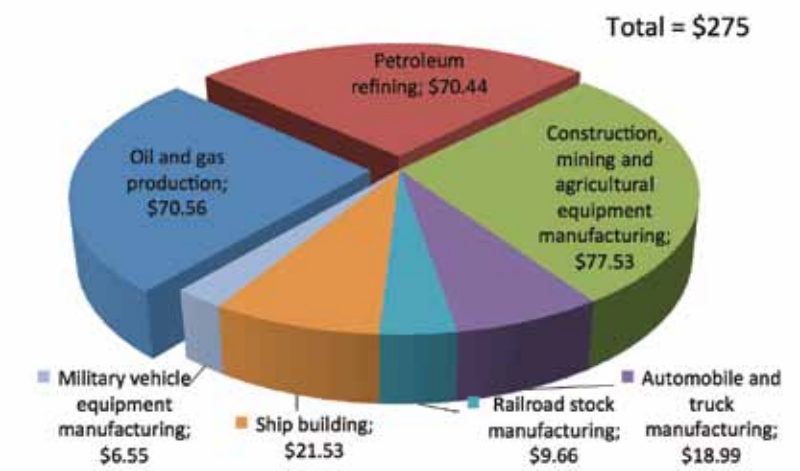


MAKING DIESEL TECHNOLOGY AND FUELS CONTRIBUTES DIRECTLY TO THE ECONOMY

The diesel industry is made up of several smaller components including engine and equipment manufacturing, fuel production and servicing and sales. These smaller components are actually subsectors of various U.S. industries ranging from 15 percent of the oil and gas sector to over 80 percent of the engine, truck trailer, rail and military equipment industries. **Figure 3** shows the value added from the segment of the diesel manufacturing and fuel production industries that produce diesel goods, including the multiplier effect, indirect and induced economic activity, in associated economic sectors.[e]

The diesel-focused segments of these industries generated $101 billion directly, and $275 billion total including indirect and induced activity, or about 1.9 percent of U.S. GDP.[f] This is about the same size as the utilities sector at $269 billion.[5]

Figure 3: Value Added by Diesel Technology Industries {2009] Billions $



Moreover, these industries accounted for 486,000 highly productive jobs. Each employee in these industries created $207,000 directly in national income, nearly double the national average of $110,000 per employee. This translates into higher wages for those employed in those industries. In 2009, while the average national weekly wage for all workers was $876, the national average for the diesel technology and fuels sector was 60 percent higher — $1,398 per week.

Diesel engine and equipment manufacturing, fuel refining and service sectors accounts for over 1.2 million jobs. (2009)

95 percent of heavy-duty truck equipment used in the US is manufactured domestically.

[e] The multiplier effect measures how much additional economic activity is generated by a direct expenditure on a specific activity. See Appendix D for a more detailed discussion.

[f] By comparison, the Diesel Technology Forum's report, Diesel Technology and the American Economy estimated that these sectors contributed $85 billion to the U.S. economy in 2000.

In addition to the industries in **Figure 3**, the diesel services sector, which is often embedded in other related industries for national income and accounting purposes added another $82 billion directly and $207 billion in total to the U.S. economy. These industries hired 764,000 individuals to support deployment, operations and maintenance of diesel vehicles and equipment.

It is important to note that, unlike so many other industries which have shrunk in recent years as companies moved their production overseas, the diesel industry largely remains "home grown". With the exception of oil production and light-duty vehicles, most of these goods are being made in America. This means that the diesel industry is providing jobs for American citizens, adding value to the U.S. economy, and not contributing to the U.S. trade deficit.

The diesel industry makes additional important contributions to the economy through the high quality of jobs and the value of U.S. exports. All 50 states have some diesel industry employment in the case of equipment sales, repair and servicing. A preponderance of diesel manufacturing related jobs can be found in the Midwest, although recent manufacturing expansions have been announced over the last year in several other states including South Carolina, Texas and New York. The anticipated growth in light-duty diesel vehicles over the next several years may further bolster the industry's contribution to the economy.

DIESEL EXPORTS

Total: $46.2 billion (4.4 percent of U.S. exports).

Export-to-value ratio is 5 times higher than the national average.

Refined Diesel Fuel	$9.5 billion
Diesel Trucks	$9.1 billion
Construction Equipment	$7.8 billion
Diesel Engines	$6.9 billion

As the economy grows and the diesel passenger car market grows, so will the need for diesel fuel. The U.S. is self-sufficient in refining its fuel and even exports diesel fuel to other countries. Refineries accounted for the largest proportion of diesel-related exports, at $9.5 billion. Strong U.S. vehicle and equipment manufacturing has resulted in strong U.S. export figures from other diesel industry segments including truck manufacturing ($9.1 billion, or 36 percent of total production); construction equipment ($7.8 billion or 18 percent of production) and engine manufacturing ($6.9 billion of 22 percent of production). Altogether, diesel product and fuel exports represented $46.2 billion or 4.35 percent of U.S. exports in 2009, with an export-to-value ratio that was five times higher than the national average.

In summary, the direct contribution of the manufacturing and production of diesel engines, equipment, technology and fuels is substantial to the U.S. Economy and to U.S. exports. However, the impact of diesel technology – as measured by its contributions to diesel-reliant industries, as discussed below is far more significant.

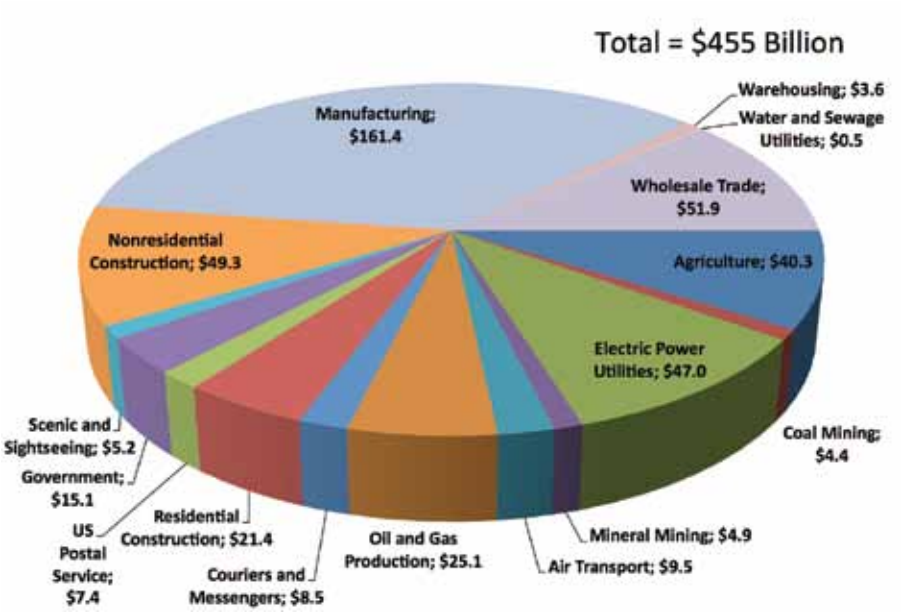
DIESEL TECHNOLOGY ENABLES AN EFFICIENT, EFFECTIVE U.S. ECONOMY

Beyond the diesel manufacturing and fuels sectors' substantial contribution to the nation's economy, diesel technology is used to create the goods and services Americans use in everyday life. This report focuses on a number of key industries that rely heavily on diesel, such as agriculture, mining and resource extraction, construction, freight hauling, passenger transport, and national defense. **Figure 4** shows the value added of diesel technology acting as a catalyst to these industries' output.

For every $1 of economic value from diesel technology, $4.51 is added elsewhere to national income of industries that rely on diesel.

For these sectors diesel technology facilitates $4.51 of value added to the broader economy for every dollar of added value from the diesel technology industries. In other words, for every dollar of economic value from diesel technology, $4.51 is added elsewhere to national income in related industries that rely on diesel. Diesel technology and fuel powered $455 billion or 3.2 percent of the 2009 GDP from key diesel-reliant industries. The total GDP contribution for key diesel sectors, both technology-producing and reliant, as well as diesel, was $638.5 billion in 2009.

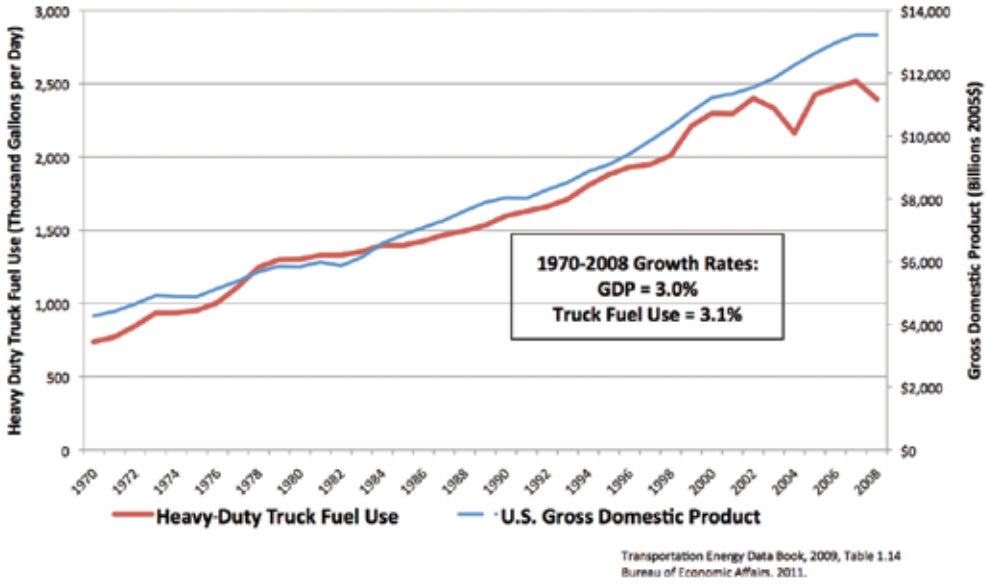
Figure 4: Value Added by Diesel Contribution in Key Sectors [2009] Billions $



The synergistic relationship between the nation's economic well-being and the use of diesel technology can be seen even more clearly by examining the linkage between fuel use, freight movement, and prosperity, as shown in two metrics. In one measure, fuel use in trucks is highly correlated with GDP growth, measuring 0.985; that is the two data sets move together 98.5 percent of the time. In contrast, electricity consumption has grown only 60 percent as fast as the U.S. economy from 1991 to 2010.[6] **Figure 5** shows economic growth and truck-related diesel consumption trends since 1970.

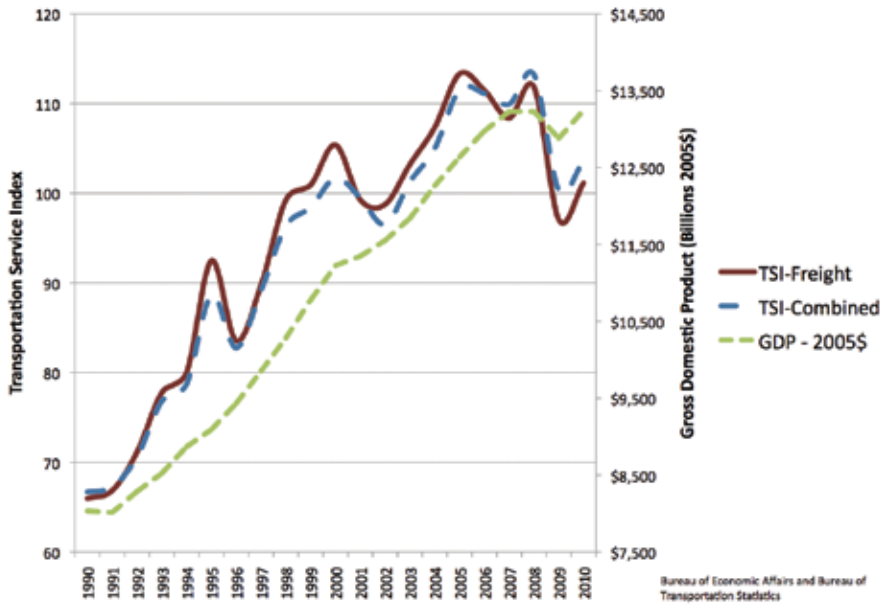
The Ceridian-UCLA Pulse of Commerce Index™ builds on these economic relationships of freight movement and diesel fuel use to track and forecast U.S. economic activity on a near real-time basis.[7] Ceridian provides data on fuel purchase transactions from its electronic card payment services, and generates geographically-disaggregated trends on a daily basis.

Figure 5: Comparison of U.S. Heavy-Duty Truck Fuel Consumption and Gross Domestic Product 1997-2008



Another measure is the U.S. Bureau of Transportation Statistics' (BTS) Transportation Services Index (BTS TSI). The TSI has two components, Freight and Passenger. The TSI's Freight component, as discussed below, is dominated by diesel-powered modes, such as trucks, trains and ships, 82 percent of the national value and 84 percent of the tonnage is moved by diesel-powered vehicles. **Figure 6** compares the Freight and Combined TSIs to a constant-dollar measure of the GDP since 1990. The correlation between the Freight TSI and the GDP is 0.90; that is, the two measures move together in 90 percent of the data. When the economy moves, freight moves, and diesel moves freight.

Figure 6: Comparison of Gross Domestic Product and BTS Transportation Service Index 1990-2010



USING DIESEL TO PRODUCE BASIC COMMODITIES AND BUILD INFRASTRUCTURE: AGRICULTURE, MINING AND CONSTRUCTION

Throughout history, people have depended on the earth's resources for their survival. As civilization advances, men and women have developed these resources, resulting in greater efficiency and productivity. We have learned how to extract the earth's minerals for our advancement, manage its land and waterways to feed ourselves and build structures to create hospitable communities. Today's farming, mining and construction industries all require large, powerful equipment to literally move the earth. Diesel technology is the dominant motive force for these basic economic activities and to date there are few if any alternatives in these applications. High power output is a must; wear and tear is excessive in these environments; and remote locations require portability. Only diesel can deliver this combination. These industries rely heavily on diesel technology and as a result, diesel contributes directly to the value of their products.

In the agricultural sector, diesel catalyzes the greatest share of economic value, estimated at 35 percent, due in part to the fact that there is currently no cost-effective substitute for diesel in tractors and other farm equipment that can provide sufficient power to pull the necessary equipment weight at slow speeds while providing remote portability. In addition, diesel is used in more phases of crop "development" than in other industries. Diesel vehicles are used to plant the product, care for the product (through watering and applying fertilizers and pesticides), harvest the product and even bring the product to market for processing.

As U.S. farms increase in size, a shift occurs from gasoline to diesel-powered equipment for efficiency and productivity.

As U.S. farms have increased in size, they have also become more mechanized and productive, shifting in the process from gasoline-powered machinery to more efficient and powerful diesel-powered equipment. In 2009, agriculture produced $330 billion in output, of which $27.2 billion was for farm sales, contributing $176.6 billion to the nation's GDP. Total added value of agriculture to the U.S. economy is estimated to be $365 billion. Farms employed 2.1 million in 2008.

In the case of extractive industries, over 60 percent of mining and fuel production equipment is diesel-powered. The nation gets 93 percent of its energy from mined sources, such as petroleum, natural gas, coal and uranium. Extracting these resources requires equipment running under extreme stress, often in remote and inhospitable areas. Again, diesel offers the best, and sometimes only power source to productively access these resources. As a result, diesel is fundamental to the mining, fossil fuel production and logging industry, which employed 641,000 people in 2009. The industry mined $413.5 billion of product in 2007. The industry created $254 billion in value-added to the GDP in 2007, and $241 billion in 2009.

Finally, the construction industry is also heavily dependent on diesel technology, and provides links between the diesel industry and virtually all others since construction is a core activity that resonates throughout the rest of the economy. Every building, power plant, reservoir, pipeline, roadway, airport, factory and landfill must be constructed. All economic activity passes through or over a constructed structure.

Diesel is the dominant fuel source of the construction industry, powering 60 percent of equipment and using 98 percent of all energy.

Diesel is the dominant fuel source, powering 60 percent of construction equipment and using 98 percent of all energy. The industry purchased $76 billion in diesel technology-related goods and services in 2009. In 2007, the nation's construction industry employed 7.6 million people with a payroll of $336 billion. Even in the wake of the recent recession in 2010, 5.5 million workers held construction jobs (down from 7.6 million in 2007). Industry spending totaled $1.17 trillion, creating $657 billion in value-added to the GDP that year.

USING DIESEL TO DELIVER GOODS AND SERVICES: FREIGHT HAULING

Unless one lives self sufficiently in a remote location with almost no powered equipment, it is impossible to claim independence from the benefits of diesel technology. Freight, or the "stuff" we all need to eat, work, play, learn and live, comes from somewhere, most likely delivered either directly to the user or to a location where it was purchased, in a diesel-powered vehicle. In some cases, products have been transported by diesel power multiple times, as raw materials, component parts and then as end products. Just as all industry sectors depend on the construction industry to build their necessary infrastructure, they also all depend on diesel technology through goods movement to acquire necessary inputs or to get their product to market. Diesel is an efficient motive source that can haul exceptionally large loads using a fuel that is portable and easily handled. And the engine's durability extends investment value and reduces maintenance costs.

Diesel-powered trucks, trains, ships and intermodal systems moved 83 percent of freight by value ($11.7 trillion) and 85 percent by weight (12.5 billion tons) in 2007.

Diesel-powered trucks, trains, ships and intermodal systems moved 83 percent of freight by value ($11.7 trillion) and 85 percent by weight (12.5 billion tons) in 2007. The U.S. freight hauling and warehousing industry consists of more than 219,000 companies that employed nearly 4.5 million individuals with a payroll of $173.2 billion in 2007. These transportation sectors spend $46 billion on diesel technology inputs, 7.2 percent of their total revenues.

As the U.S. economy grows, freight movement increases across all modes of transportation, however trucking is the dominant mode of freight transportation in the U.S., moving 70 percent of all goods by weight and 71.3 percent by value. The vast majority of commercial trucks, including those used by for-hire independent trucking companies and private fleets rely on diesel-powered engines. In addition to its central role moving the U.S. economy, the trucking sector itself contributes substantially to the nation's prosperity through spending and employment. Approximately 118,507 family- and corporate-owned trucking businesses operated in the U.S. in 2007, directly employing 1,480,000 Americans. The transportation and warehouse sector was responsible for $390 billion of the nation's total gross product in 2009. The trucking industry supports an annual payroll of $57 billion dollars.

Virtually all freight locomotives and 75 percent of commercial marine vessels are diesel-powered.

Railroads provide the second largest portion of freight movement, accounting for approximately 37 percent of the total ton-miles carried by various transportation modes (e.g., trucks, ships, pipelines and aircraft). Locomotives play an important role in reducing highway congestion by shifting traffic away from trucks and providing shippers with a cost-effective way of transporting their goods. Virtually all ocomotives hauling freight in the U.S. are powered with diesel technology and are most efficient for transporting commodities and containers, particularly those moving to a fixed location for further processing. Nevertheless, even as rail transport continues to grow, trucking will remain critically important to the goods movement industry due to the challenges of citing new rail lines and the fact that more than 80 percent of towns are serviced only by truck.[8] The nation's 565 freight railroads employs 183,700 individuals and pays wages and benefits averaging $98,500 per employee. The industry delivered $30.8 billion in value added or national income in 2009.

About 78 percent of the ships that haul freight are diesel-powered and like the railroads, are primarily used for transporting containers of manufactured goods or commodities such as oil, ore, wheat or other goods. Marine vessels have some of the biggest diesel engines in the world, enabling global trade and providing an example of the reliance of virtually all export industries on diesel technology. The water transportation industry employed 66,800 in 2008, with a payroll of $4.47 billion in 2009. Economic value added was $14.3 billion in 2009.

DIESEL ENABLES THE EFFICIENT MOVING OF PEOPLE BY RAIL, BUS, AND CARS

Like most developed countries, passenger cars and trucks account for the largest share of total passenger miles, however diesel moves more large groups of people on the ground and over water than any other motive power. Diesel is fuel efficient and can move a large passenger load with ease. Reliability is key for passenger service and durability lowers operating costs. Fuel portability is particularly important for intercity travel around most of the country. Approximately 71 percent of transit buses and 58 percent of commuter rail passenger-miles are provided by diesel-fueled trains. The transit, and local and interurban personal transportation industry employs 416,000 people, with a payroll of $10.5 billion in 2009. About three-quarters of these individuals are employed by private firms providing ground passenger and school bus transport; the other quarter is employed by local government transit agencies. The industry delivered an economic value added of $41 billion in 2008.

71 percent of transit buses and 58 percent of commuter rail passenger-miles are powered by diesel.

Passenger cars are the dominant mode of transportation in the U.S.; however only 3.4 percent of the cars are presently diesel-powered. Diesel accounts for a larger share of pickup trucks (13.6 percent) due to its superior power and performance for hauling trailers for recreational and commercial purposes.

In recent years, the number of available diesel vehicles has been growing and manufacturers offering these vehicles are being rewarded with strong interest among consumers. In the first eight months of 2011 (Jan. 1-Aug.31) clean diesel automobile sales in the United States increased by an impressive 37.0 percent compared to the same period in 2010 while the overall automobile market experienced a 10.4 percent increase.[9] Some analysts predict that diesel passenger cars will account for 10 percent of the market by 2015.[10] With diesels offering 20 to 40 percent greater efficiency over their gasoline counterparts, a growing share of diesel passenger vehicles can help reduce petroleum consumption and GHG emissions.

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DIESEL IS A PRIME SOURCE OF INDUSTRIAL SITE, REMOTE AND BACK-UP POWER GENERATION

Diesel generators' high reliability, response capabilities, fuel characteristics and relatively low cost make them the technology of choice to supply back-up power in large buildings, shopping malls, hospitals, universities, communications and data centers, waste water treatment facilities, and factories, among other locations. Diesel engines also are relatively portable and are readily adaptable for remote operations.

Dispersed generation, 93 percent of which are internal combustion engines (ICE), is typically remotely located from the utility grid. For most of these applications, the generator is the sole power source and the ICE's reliability and durability is critical. These engines are still the primary source of power for remote Alaskan villages that are beyond the reach of the electricity grid.

The U.S. EPA estimates that 1.15 million engines were in stationary use in 2008. About 26,500 megawatts (MW) of dispersed and distributed generation is located at commercial and industrial premises. Of this, 14,000 MW, 1.3 percent of total U.S. generation capacity, consists of ICEs, often compression ignition.

DIESEL POWERS GOVERNMENT SERVICES

Governments are major vehicle fleet operators, with the federal government operating the largest fleet in the world, numbering about half a million vehicles in 2009 (excluding military vehicles). This fleet includes a mix of on- and off-road vehicles and equipment including highway service and vocational vehicles, construction machines, transit buses, land maintenance-related vehicles (e.g., tractors), and fire and rescue equipment. It also owns industrial back-up diesel generators for public works projects. As one component of this fleet, the federal government maintains about 120,000 diesel trucks.

The U.S. government accounts for two percent of energy use in the United States. The Department of Defense accounts for 80 percent of this total, with the Navy accounting for one-third of that 80 percent. In the 1990s, DOD transformed its land-based fleet to run on diesel. Diesel fuel number 2 (DF-2) and Jet Propellant 8 (JP-8) – a kerosene-based propellant used to operate off-road vehicles, tanks, jets and even field stoves – are the two most common fuels used in the military.

Commitments to use more renewable fuels within the military are strong. The Army is seeking to use 25 percent renewable energy by 2025 while the Navy is hoping to use renewable fuels for 50 percent of its energy needs by 2020. The Air Force is also planning to fly on a 50-50 blend of renewable and conventional fuels by 2016. Based on current estimates, achievement of the Navy and Air Force goals would result in the purchase of over 700 million gallons of renewable fuels each year.

The U.S. military relies heavily on off-road diesel engines for its training and overseas activities. Diesel technology provides the power, durability and reliability that the military needs in many applications. Fuel flexibility also is important in the context of a world-wide fighting force. A Defense Department study conducted found 360,000 diesel engines used more than 83 percent of the fuel powering U.S. Army and Marine Corps vehicles and generators, with the remainder going to the Abrams battle tank, which is powered by a gas turbine. The Navy has another 700 diesel engines in its fleet of 285 vessels.

In addition to the federal government, state and local government fleets managed approximately 3.8 million vehicles, plus a quarter million trailers in 2009. Of these, 485,000 were buses and 1.9 million were trucks, ranging from light-duty to tractor-trailers to emergency response.

EXISTING AND EMERGING PUBLIC POLICIES INDICATE A STRONG FUTURE ROLE FOR DIESEL TECHNOLOGY

Public policies adopted at the state and federal levels will significantly shape the competitive nature of different fuel technologies. Over the past decade, laws and regulations have been adopted which require lower emissions and greater efficiencies from vehicles and stationary sources. Regulatory pressure is now shifting to greenhouse gas emissions, most prominently as embodied in California's Assembly Bill 32 (the Global Warming Solutions Act). Key federal policies include higher fuel economy standards for both light- and heavy-duty vehicles, and increased requirements of biomass-based diesel in the Renewable Fuels Standard Standard (RFS2). The growing requirement for advanced biofuels under the RFS2 regulation is supporting the development of next-generation, "drop-in" renewable diesel fuels, with commercial-scale production of these fuels forecast to grow significantly in the next few years. Federal emission standards also are being tightened for off-road, marine and stationary engines. These policies, combined with higher gasoline prices, are fostering a more diverse set of fuels being used for transportation, construction, cultivation and electricity generation.

The federal government funds various research and development efforts, including those under the Department of Energy's Vehicle Technologies and Biomass Programs. A study by the U.S. Department of Energy found public R&D investment returned large benefits. "The federal return on investment is greater than 60 to 1 ($7.7 billion in fuel savings from $125 million in research funding) for technologies developed from federal research between 1999 and 2007 (benefits were calculated for model years 2004 to 2008)." This report projected that federal research efforts can save as much as 4.5 billion barrels of oil.

One other area where public policies have influenced the diesel industry is its support for voluntary diesel retrofit programs. EPA's regulatory programs have required significantly reduced emissions from on- and off-road diesels, however there is strong interest in retrofitting or upgrading existing (legacy) vehicles as a means of reducing emissions and improving air quality.

According to the Manufacturers of Emission Controls Association (MECA), 24,640 diesel exhaust control devices were sold for retrofit applications in 2010, a figure which has been relatively consistent over the last several years.[11] Many of these have been funded in part with federal or state funds to offset the cost of this investment which does not provide an economic payback to the vehicle or equipment owner. This figure does not account for the value of other retrofit options that may not use an exhaust control device on existing equipment such as engine rebuilds, repowers or e even total vehicle replacements. These projects have actually accounted for a majority of projects funded under the U.S. Environmental Protection Agency's Diesel Emissions Reduction Program (known as DERA for the Act under which it was passed), as well as similar diesel retrofit projects funded by other government programs such as the Department of Transportation's Congestion Mitigation and Air Quality Program and the Department of Agriculture's Environmental Quality Incentives Program.

SUMMING UP: POWERING THE AMERICAN ECONOMY

Simply put, diesel technology is ubiquitous throughout the U.S. economy. Because of its power, efficiency and portability reaching even remote locations, diesel probably touches even more aspects of the American economy than grid-connected electricity. Almost every product is moved by diesel-powered vehicles; almost every structure is built with and uses materials harvested or excavated by diesel equipment. We would not have the abundance of foods that we now take for granted without diesel technology. The national wealth creation enabled by the use of diesel technology is manifest.

Diesel probably touches even more aspects of the American economy than grid-connected electricity.

Almost 1 in every 20 dollars of the GDP is contributed by diesel power.

Tables 1 and 2 summarize the economic contributions of diesel to the U.S. economy through those sectors that produce diesel technologies and fuels, and are most reliant on diesel. The data and analysis conducted on each of these sectors are described in greater detail in the appendices of this report.

The diesel-delivery super sector – technology, fuels and services – produced $517.4 in output, employed one and a quarter million people, and created $183 billion directly towards the national income in 2009 as listed in **Table 1**, and added another $300 billion in multiplier effects through the economy according to the IMPLAN analysis.

Table 1: Diesel Technology and Fuels Industry Statistics

DIESEL INDUSTRY SUBSECTOR	TOTAL OUTPUT	VALUE ADDED	EMPLOYMENT
Vehicle, Equipment & Engine Manufacturing	$178.2 billion	$45.7 billion	349,000
Oil Production & Refining	$218.6 billion	$55.3 billion	137,000
Sales, Repair & Servicing	$120.7 billion	$82.1 billion	764,000
Total	$517.5 billion	$183.1 billion	1,250,000
Multiplier Effect		$300.1 billion	
Total Value Added		**$483.1 billion**	

For the diesel-reliant sectors, diesel facilitated $455 billion in GDP, as delineated in **Table 2**. Agriculture is the most reliant on diesel, with 35 percent of production using the technology to grow crops, raise livestock, and ship products. Manufacturing has the largest absolute amount depending on diesel use at $161 billion based 10.5 percent of product tied to the technology.

In total, both diesel-delivery and diesel-reliant industries contributed a combined $638.5 billion in 2009 to the U.S. GDP or about 4.5 percent, almost one in every 20 dollars. And that does not account for the added downstream influences in consumption of retail commodities and energy. These sectors generated $1,169 billion in output.

Table 2: Diesel Reliance and 2009 U.S. Gross Domestic Product

SECTORS	PERCENT DIESEL CONTRIBUTION OR INFLUENCE	DIESEL GDP SHARE ($ BILLIONS)
Agriculture	35.0 percent	$40.3
Coal Mining	26.8 percent	$4.4
Electric Power Utilities	24.6 percent	$47.0
Mineral Mining	17.0 percent	$4.9
Air Transport	16.8 percent	$9.5
Oil and Gas Production	15.9 percent	$25.1
Couriers and Messengers	15.2 percent	$8.5
Residential Construction	14.0 percent	$21.4
US Postal Service	13.7 percent	$7.4
Government	13.3 percent	$15.1
Scenic and Sightseeing	12.4 percent	$5.2
Nonresidential Construction	11.7 percent	$49.3
Manufacturing	10.5 percent	$161.4
Warehousing	8.8 percent	$3.6
Water and Sewage Utilities	7.0 percent	$0.5
Wholesale Trade	6.8 percent	$51.9
Total for Diesel-Reliant Sectors		**$455**

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