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Executive Summary

Diesel fuel has long been recognized as the world’s transportation fuel workhorse and a primary driver behind global economic expansion. Because of its unmatched power density, energy efficiency and widespread availability, diesel serves as the primary commercial transportation fuel used for goods and people movement by road, rail or water. It powers the majority of industrial construction, agricultural and mining equipment on a global basis.

Diesel is part of a broader class of middle distillates (includes residential, commercial and industrial heating oil) which make up 29% of the global market for refined products. Demand for distillate fuels has grown faster than any other refined petroleum product and will continue to lead other products in future growth.

The movement of goods across the U.S. and development of the country’s economic infrastructure has largely been fueled by diesel. Despite the dominance of gasoline in the U.S. petroleum product market as the preferred passenger vehicle fuel, diesel fuel has been the primary driver of recent growth in petroleum markets. Prior to the economic downturn of 2007-2009, U.S. diesel demand grew by more than 2% annually, versus only 1.2% for gasoline. As the economy recovers from the 2009 recession, diesel will resume its critical role as the primary energy component supporting economic expansion and development.

Introduction of advanced diesel technology in 2007 that relied on ultra low sulfur clean diesel fuel has today reduced emissions of particulate matter and nitrogen oxides—an ozone precursor—by more than 98% in heavy-duty truck applications compared to 2000 models. It has enabled introduction of high performance diesel cars, trucks and SUVs that are cleaner, quieter and safer than ever.

Government has provided limited tax incentives for the purchase of hybrid and advanced lean-burn (diesel) vehicles to stimulate market for these new technologies. Federal and state tax provisions designed to promote production, use and infrastructure for biodiesel and renewable diesel are also available. Federal fuel tax policy currently disadvantages diesel fuel with a premium of 6 cents per gallon as compared to gasoline and other fuels.

With new fuel economy mandates, diesel fuel is poised to take on an even greater role in the U.S. transportation market. To address rising demand for diesel fuel by consumers, diesel fuel is increasingly accessible to consumers at more than half of all local retail filling stations.

Climate change policies based on reducing greenhouse gas (GHG) emissions will place new demands on transportation life cycle costs including the sources, composition, production, manufacturing, and efficiency of fuels. In many respects advanced diesel engine and fuel options will be well positioned to meet these new challenges and goals.

Diesel’s unique capability to utilize a range of renewable fuels and blends further enhances its future prospects and potential for expanded use. Implementation of renewable fuel standards to address climate change will rapidly increase the penetration of biofuels in the mainstream fuel pool, shifting focus to GHG potential and encouraging specific categories of advanced diesel formulations. Advanced biofuels requirements apply to both diesel and gasoline in the transportation fuel pool.
The international refining industry - and U.S. refiners as well - are making adjustments and investments based on shifts in global demand for refined products that include increased demand for diesel fuel. The investments will assure adequate production capacity to meet future global diesel needs.
INTRODUCTION

For more than a century, diesel fuel and other petroleum products have fueled internal combustion engines that enabled unprecedented mobility and facilitated rapid economic growth throughout the world. Diesel technology – engines and fuels – have evolved as the technology of choice for key sectors of the economy. Today, in the United States, increasing concerns over GHG emissions and reliance on imported oil are driving significant changes in the petroleum industry and those sectors which rely on petroleum products. Global demand for transportation fuels – particularly new cleaner, low-sulfur distillate fuels like diesel - is stimulating competition for oil reserves and leading to oil market volatility.

A resource-constrained and carbon-sensitive world will drive permanent changes in fuel, engine and vehicle technology over the coming decades. A search for secure, reliable energy supplies has led policy makers and industry to explore the use of new transportation fuels such as electricity and renewable fuels. Because of diesel fuel’s unique attributes – its energy density, low-sulfur content, widespread availability and compatibility with biofuels, it is easy to recognize diesel’s emergence as a leading fuel of the future.

This paper examines the key facets of diesel fuel and diesel vehicle technology.

- Reviews the past, present and future importance of diesel fuels to the U.S. and other global economies – supporting goods movement, transportation, construction and agricultural industries.
- Highlights the fundamentals of petroleum refining relative to diesel fuel supply and demand along with current and future supply and demand trends.
- Highlights the potential for greater use of diesel fuel in light duty vehicles, and related considerations including fuel taxation and incentive policies and the accessibility to diesel fuel at retail facilities.
- Explains the role of renewable diesel fuels, reviews future investments in diesel refining capacity, and identifies policies impacting diesel fuel refining and vehicle use in the future.
I. DIESEL FUEL REFINING, SUPPLY AND DEMAND BASICS

*Diesel fuel is the world’s transportation fuel workhorse and a primary driver behind global economic expansion. It serves as the primary commercial transportation fuel used in on-highway and off-highway applications. Diesel is part of a broader class of middle distillates (includes residential, commercial and industrial heating oil) which make up 29% of the global market for refined products. Demand for distillates has grown faster than any other refined petroleum product and will continue to lead other products in future growth.*

Diesel is the primary fuel for heavy duty on-road commercial transportation, non-road construction, agricultural machines, stationary source backup power, railroads, inland marine and various types of ocean vessels. It also plays a significant role in light duty commercial and public transportation as well as a growing role in the light duty passenger vehicle market. Diesel fuel is part of a broader class of refined petroleum products referred to as middle distillates which are lighter and less dense than heavy industrial fuel/international marine bunker, but heavier and denser than gasoline. In addition to diesel fuel, middle distillates include residential and commercial heating oil (also designated as Number 2 heating oil), similar industrial boiler fuel and utility supplemental fuel utilized in small generation facilities. (Aviation jet fuel is also a light middle distillate product, but for the purposes of this discussion is considered separately.)

Middle distillate accounts for the largest share of global refined product markets at 29%. This is followed by gasoline at 26% and heavy residual fuel at 11% (Figure 1). Within the distillate category, diesel represents 20% of the refined product pool and other distillates the remaining 9%.

*Figure 1: Global Refined Product Markets*

![Pie chart showing global refined product market share](image)

*Source: International Energy Agency (2009)*

Based on International Energy Agency (IEA) consumption statistics and analysis and Hart Energy Consulting World Refining & Fuels Service (Hart WRFS) projections, total middle distillate demand in 2009 was approximately 24.4 million barrels per day. Diesel fuels represent 17.6 million barrels per day, or 72% of the global distillate pool (Figure 2). On-highway diesel is by far the predominant product, representing 56% of total middle distillate and 78% of the diesel portion.
Globally, distillate has been the highest growth petroleum product, increasing at an annual average rate of 1.3% for the past five years. This was driven by growth in diesel, which prior to the 2008/2009 global economic recession, increased at an annual rate of 4.2%. Diesel was clearly a critical driver behind the rapid economic growth in the world’s economies.

The growth in the diesel market has occurred throughout all regions of the world. Though not all areas have experienced substantial diesel penetration into the passenger vehicle market, growth in diesel demand has outpaced gasoline and other refined products in nearly all developing countries, including China. Diesel fuel is the workhorse of economies throughout the world. As global economies have expanded, so has the demand for diesel-fueled commercial transportation and industrial activities.

U.S. diesel fuel demand was also expanding at a rapid pace despite the fact the gasoline is the predominant passenger vehicle fuel between 1999 and 2007 total diesel demand grew at a rate of 2.0% annually and on-highway diesel by 2.8%. The growth was almost entirely due to increases in heavy duty transportation, occasioned by an expanding economy.

Similarly, as global economy fell into recession so did the diesel fuel market. Diesel demand declined in 2009, for the first time in years. This recent slowdown brought the average annual growth over the five year period (2002 to 2009) down to 2.2%, compared to previous annual growth of 3.6% for the four years prior to 2009.

The economic recession has had a similar negative short term impact on U.S. diesel demand. In 2008, diesel demand declined by 7% in response to rising oil prices and the onset of the economic recession and in 2009 demand fell another 8% as the recession deepened.

With global economies now emerging from the recession, diesel demand is again expected to return to high growth rates, with forecasts depending largely on the outlook for economic recovery. The OPEC World Oil Outlook projected diesel demand to grow at an annual rate of 2.1% between 2009 and 2020. The Hart WRFS projects greater response in diesel demand to economic recovery and therefore a higher diesel growth of 2.7% annually. In either case, diesel will lead growth in oil products globally and will be driven primarily by the heavy duty transportation market.
The U.S. Department of Energy’s Energy Information Administration (EIA) projects annual U.S. diesel growth at 1.7% between 2009 and 2020. Hart WRFS projections anticipate an even more robust recovery in diesel markets with continued growth over the next decade. Growth is projected to return to pre 2008 rates, averaging more than 2% annually.

Both the EIA and Hart WRFS forecasts envision that future diesel demand will be driven primarily by the heavy duty transportation sector. However, opportunities for even greater growth are possible if emerging energy and environmental initiatives result in greater diesel penetration in the light duty passenger market.

II. PAST, PRESENT AND FUTURE IMPORTANCE OF DIESEL ENGINES, FUELS AND TECHNOLOGY

The movement of goods across the U.S. and development of the country’s economic infrastructure has largely been fueled by diesel. Despite the dominance of gasoline in the U.S. petroleum product market as the preferred passenger vehicle fuel, diesel fuel has been the primary driver of recent growth in petroleum markets.

The backbone of the U.S. economy is the movement of products and goods across the country. Since 1970, U.S. exports have doubled and imports have tripled. This trade accounts for 31 million jobs and 25% of the U.S. Gross Domestic Product (GDP). To keep up with this growth, these products need to move from ports to all parts of the country either by truck or railcar – mostly powered by diesel engines and fuel. The efficiency in truck and rail transport helps to ensure that these goods get to markets on time and at minimum cost.

Trends in diesel fuel consumption have long been viewed by economists as a general barometer of economic activity. The correlation between diesel fuel use and U.S. Industrial Production is 0.83, according to data obtained from the Ceridian-UCLA Pulse of the Economy (PCI), a new economic indicator based on real time consumption of diesel fuel. The strong correlation further underscores the importance of diesel fuel to the economy. Ceridian has been tracking diesel fuel sales at roughly 7,000 truck stops across the country since 1999. If you think of the interstate highways crisscrossing the country as the arteries of the U.S. manufacturing economy, “the goods flowing in those arteries are the lifeblood of the system,” says Ed Leamer, chief economist for the Ceridian-UCLA PCI. “This is the supply chain in operation.”

In the U.S., diesel fuel runs the commercial heavy duty transportation and industrial engine. Gasoline still dominates the refined product market but middle distillate (diesel and other heating oil) represents the next largest market with a 20% market share.

U.S. diesel fuel demand is expected to rebound as the economy recovers. Growth is projected to return to pre 2008 rates, averaging more than 2% annually. In either scenario diesel will remain the highest growth refined product in the U.S. market. Because of diesel’s unmatched energy density, efficiency and performance and the existing transportation infrastructure currently in place, there are no near term substitutes for diesel fuel in heavy duty diesel transportation and other off-highway diesel markets.

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1 Ceridian-UCLA Pulse of Commerce Index™, UCLA Anderson School of Management, www.ceridianindex.com

“Diesel: Fueling the Future in a Green Economy”
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III. POLICY INFLUENCES ON TRANSPORTATION FUELS AND TECHNOLOGIES

*Environmental initiatives have promoted development of clean diesel engine technology and fuels that pave the way for diesel as an acceptable alternative for fueling the economy. Meanwhile, vehicle fuel economy standards are now set to improve sharply over the next several years. The Energy Independence and Security Act of 2007 and follow-on requirements established by President Barack Obama require significant improvement in vehicle fuel economy by 2016. Fuel economy targets beyond 2016 are also under consideration and being addressed as part of U.S. EPA CO₂ regulations. The fuel economy targets will test the fundamental limits of traditional gasoline engine technology and introduce more fuel efficient and alternative fuels and powertrains, including an expanded use of diesel fuel alternatives.*

U.S. energy, transportation and environmental policies are increasingly guided by concern for energy efficiency, reduced reliance on imported oil, and the increased production and use of renewable fuels that result in fewer emissions. Because of diesel's unique, inherent energy efficiency and operating characteristics, it is well positioned as the fuel and technology of choice in both its traditional heavy duty transportation/industrial applications and for considerable growth in the light duty passenger vehicle market:

- Introduction of ultra-low sulfur diesel fuels for both on- and off-road applications has been a central part of the new clean diesel system designed to meet near zero emissions standards. Fuel sulfur levels were reduced by 97% beginning in 2006 (from over 2,500 ppm to a maximum allowable 15 ppm). ²

- Emission improvements in the clean diesel engine-fuel system ensure diesel's ability to both improve overall air quality and meet consumer as well as industry energy needs.

- Diesel's inherent efficiency makes it an attractive solution for satisfying U.S. energy security and fuel economy goals.

- Fuel economy advantages of 20% to 35% for diesel fuel/engines over gasoline vehicles will also provide options for meeting low carbon fuel objectives and reducing GHG emissions. California has initiated a low carbon fuel initiative and the U.S. EPA has promulgated its first GHG control requirements in the form of vehicle CO₂ reduction regulations. Congress continues to debate on climate change and related GHG initiatives.

- Renewable fuel programs established by the government represent an opportunity to diversify fuels available for diesel engines and reduce demand on conventional petroleum-based diesel fuel. It has been said that diesel was the original flexible fueled vehicle. Diesel engines are uniquely capable of operating on a range of renewable fuel feed stocks (algae, biomass, soy-based biodiesel, palm oil, etc). Most new and existing diesel vehicles and equipment are compatible with lower level biodiesel or renewable diesel fuel blends (5% to 20% depending on manufacturer warranties). Compliance with production quality standards and ASTM fuel standards will be critical to greater acceptance and successful use of these fuels in diesel engines.

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² Clean Diesel Fuel Alliance, Information Center. [www.clean-diesel.org](http://www.clean-diesel.org)
A. Clean Diesel System enables achieving Ultra-Low Emissions for On-Road and Off-Road Heavy-duty Vehicles

The diesel industry is in the midst of implementing advanced engine and emission control technology and fuel quality improvements across the entire spectrum of on-road and off-road vehicles and equipment.

These new levels of near-zero emissions are being met through advancements in the engine fuel and air management systems that dramatically improve combustion efficiency, and the use of ultra-low sulfur diesel fuel that enables the use of high efficiency exhaust control. As a result, new trucks and buses are more than 98% cleaner than 2000-era models (Figure 3). In fact, results from the first phases of joint government and industry research (Advanced Collaborative Emissions Study, ACES) have demonstrated that the emissions reductions from these technologies have actually exceeded requirements, providing substantially greater performance and benefits than anticipated.³

**Figure 3: U.S. EPA Diesel Emission Standards for Heavy-Duty Diesel Trucks 1990-2010**

The U.S. EPA projects a 2.7 million ton reduction of smog-forming emissions and 109,000 ton reduction in soot emissions in 2030 when the current heavy duty vehicle fleet is completely replaced. The annual emission reduction is equivalent to removing more than 90% of today’s trucks and busses from the road. The program represents a major step in preserving diesel’s place in heavy commercial and public transportation while meeting emission reductions and air quality goals established by government.

Similar environmental initiatives are underway to provide for clean diesel operation for non-highway diesel uses such as farm, construction and industrial equipment. New more stringent engine emissions standards were first applied to the smallest engines in 2008 and will essentially be expanded to all engines by 2015. The non-highway diesel engine standards will reduce emissions of nitrogen oxides and particulate matter by 99% from unregulated levels (Figure 4). As of June 1 2010, the majority of refined diesel fuel for off-road engines is also ultra low sulfur, enabling the use of emissions control and engine combustion technologies similar to

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highway vehicles. When fully implemented, U.S. EPA predicts that the program will result in reductions of pollutants equivalent to having some 2 million fewer trucks on the road.

Figure 4: U.S. EPA Emissions Standards for Very Large Off-Road Machines 1996-2014

While new engines are now on a path to near-zero emissions, the widespread availability of cleaner diesel fuel has created new and substantial efforts to modernize and upgrade emissions performance of existing engines and equipment. A 2009 Report to Congress by U.S. EPA on results of the first year of a federal program to fund diesel retrofits (Diesel Emissions Reduction Program) found it to be among the most cost effective clean air programs, yielding over $13 in environmental and public health benefits for each $1 invested.4

B. Fuel Economy and GHG requirements

The Energy Policy Conservation Act enacted in 1975 established targets for improving vehicle fuel economy through CAFE standards. The standards, expressed in miles per gallon, were designed to double 1974 light passenger car fuel economy, reaching 27.5 miles per gallon in 1985. The standards were lowered from 1986 through 1989, but re-established at 27.5 miles per gallon in 1990. The CAFE has since remained at this level. Under the CAFE program, standards for light duty trucks (gross vehicle weight 8,500 pounds or less) were specified separately and over time have increased from 20.7 miles per gallon in 1979 to 22.2 miles per gallon in 2007.

The U.S. resumed progress on vehicle fuel economy with enactment of the Energy Independence and Security Act of 2007. The law included provisions to increase CAFE standards to 35.5 miles per gallon (mpg) for the combined fleet of cars and light duty trucks by 2020. In 2009, the new standards were accelerated to early implementation in 2016. Meanwhile the U.S. EPA began development of programs to control GHG emissions from motor vehicles. The National Highway Traffic Safety Administration (NHTSA) and U.S. EPA jointly developed rulemaking so that manufacturers can build a single fleet of vehicles which comply with

both CAFE and GHG standards. The final rule was issued in April 2010, and covers light duty (LDV) passenger vehicles and trucks for model years 2012 to 2016. The regulations will:

- Increase CAFE standards for LDV to meet 35.5 mpg by Model Year (MY) 2016.
- Impose the first ever GHG emissions controls for mobile sources in the U.S.
- Result in national combined average GHG emissions level of 250 grams/mile of CO₂.
- Reduce GHG emissions from LDVs by estimated 21% by 2030.

Fuel economy will be the primary factor in the future role for diesel in the U.S. light and medium duty vehicle markets. Diesel engines provide significant fuel economy advantages over conventional gasoline engines. Depending on vehicle size and load, diesel engines typically achieve 20% to 35% better mileage than gasoline vehicles of comparable size and performance. Diesels vehicles deliver superior fuel efficiency because of both the engine technology and fuel characteristics. Diesel engines operate at higher compression ratios allowing for more efficient fuel combustion and lower fuel consumption. Furthermore, the diesel fuel itself has higher energy content (+10-12% BTUs) than gasoline so less fuel has to be combusted to deliver energy to the vehicle.

Recent experience with high oil prices, peaking above $140 per barrel and hovering around $80 per barrel, has shifted consumer focus towards fuel efficiency: between 2006 and 2009, sales of pickup and SUVs declined sharply, and automakers dependent on them saw their profits plummet. Some buyers have returned to using passenger cars, while others have opted for crossovers (CUVs)—vehicles with an SUV-like body type that feature unibody construction and smaller, more-efficient engines but no heavy towing capacity.

Diesels have dominated markets where performance and heavy duty capability are important. Demand for diesel in the heavy duty pickup truck market grew 8.2% a year from 1994 to 2007, and have consistently accounted for more than 70% of the powertrain choices in this segment. These consumers have typically purchased for performance: fuel economy is a bonus. Higher fuel prices will raise the significance of fuel economy; the fuel savings offers greater opportunity to offset additional costs of performance.

The future market potential for light duty diesel passenger vehicle penetration in the U.S. is strong. EIA projects that diesel’s share of the light duty market will increase from less than 2% in 2009 to 6% in 2020 while Hart forecasts an 8.5% market share in 2020. Other forecasts have projected a more significant role for diesel in the U.S. light duty diesel market in response to fuel economy and climate policy initiatives and diesel quality improvements.

Other forecasts (Table 1) call for a more aggressive penetration of diesel into the U.S. light duty vehicle market and therefore an even greater role for diesel in the U.S. energy market. The forecasts suggest as high as 15% penetration by 2015 with continued growth thereafter.

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Early market indications are that these projections could be realistic as companies introducing modern diesels have found strong acceptance of the vehicles. For example, Volkswagen reports selling up to 85% of its Jetta Sportwagen models as diesels. Other manufacturers -- Audi, BMW and Mercedes-Benz -- report that their diesel "take rates" (i.e., the ratio of consumers choosing diesel models where there is a choice between a gasoline and diesel version of a vehicle) have tended to climb the longer the vehicles are in the marketplace. Positive publicity such as the VW Jetta TDI and Audi TDI winning successive "Green Car of the Year" awards have also boosted public opinion of clean diesel technology and spurred retail sales.

By contrast, in Europe, light duty diesel vehicles have become exceptionally popular thanks to tax policies and CO$_2$ legislation which have driven fuel economy advancements and dramatically improved environmental performance. According to the European Automobile Manufacturers Association (ACEA), sales of new cars with diesel engines grew from 32.1% in 2000 to a peak of 53.3% in 2007, with a current pace of 48.3%.

These fuel economy requirements will eventually test the limits of gasoline internal combustion engine technology. Engine manufacturers will be driven to new advanced technologies, including diesel. Diesel will initially compete with the hybrid for market share as efficiency standards become more stringent. Diesel will be particularly advantaged where heavier duty performance such as torque is also a factor. The higher forecasts of diesel penetration into the light duty market (Table 1) project that a large portion of the gains for diesel will come in the heavier performance vehicles.

In the light duty market, diesel is well positioned to play an increasing role as a clean and efficient fuel and compete with alternative fuels to satisfy the demand for clean, efficient fuel source with minimal carbon footprint. As indicated in the fuel comparison of Table 2, the diesel power-train has substantial advantages over other alternatives, especially in the near term. The hydrogen and electric options provide high fuel economy but are hindered by technology development, costs and timing. Diesel fuel economy exceeds other alternatives except for the gasoline hybrid which provides comparable or better fuel economy. However, in certain heavier, vehicle applications, the diesel will provide superior fuel economy as well as driving performance compared to alternatives. While further advancements in gasoline and hybrid gasoline-electric powertrains hold promise for increased fuel economy, diesel technology also is expected to advance and keep pace with those technologies. Alternative fuel and vehicle technologies, such as natural gas (such as liquefied natural gas or LNG or Compressed natural gas of CNG) powered vehicles, would require extensive infrastructure for refueling stations before wide-spread deployment could occur. Similarly, advanced vehicle

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Table 1: Diesel Passenger Vehicle Market Share Forecasts

<table>
<thead>
<tr>
<th>Source</th>
<th>Diesel Market Share Forecast</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ricardo</td>
<td>9% by 2013</td>
</tr>
<tr>
<td>J.D. Power</td>
<td>10% to 15% by 2015</td>
</tr>
<tr>
<td>Bosch</td>
<td>6% by 2010 and 15% by 2015</td>
</tr>
<tr>
<td>Martec Group</td>
<td>10% to 12% by 2013</td>
</tr>
</tbody>
</table>

*Source: Compiled from Various Sources (2010)*

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technologies, such as plug-in electric or fuel cell powered vehicles, require technology advances and infrastructure placement before they can become reliable options.

Table 2: Attributes of Diesel Relative to Fuel Alternatives

<table>
<thead>
<tr>
<th></th>
<th>Gasoline</th>
<th>Diesel</th>
<th>Ethanol</th>
<th>Biodiesel</th>
<th>LPG</th>
<th>DME</th>
<th>Hydrogen</th>
<th>Electricity</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Energy Content</strong></td>
<td>Relative to Gasoline</td>
<td>1</td>
<td>+10%</td>
<td>-35%</td>
<td>+9%</td>
<td>-28%</td>
<td>-70%</td>
<td>-75%</td>
</tr>
<tr>
<td><strong>Vehicle Fuel Economy</strong> Relative to Gasoline</td>
<td>1 (conventional) 25%-30% (hybrid)</td>
<td>+25%+35%</td>
<td>-3% (E10)</td>
<td>-25% (E85)</td>
<td>+23%</td>
<td>-20%</td>
<td>-5%</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>Fuel Availability</strong></td>
<td>Widely available</td>
<td>Widely available</td>
<td>Widely available</td>
<td>Regional availability</td>
<td>Limited: most accessible alternative fuel</td>
<td>Limited</td>
<td>Minimal most for private use</td>
<td>Available: Upgrades Eventually Needed</td>
</tr>
<tr>
<td><strong>Vehicle Availability</strong></td>
<td>All vehicle classes</td>
<td>Most vehicle classes</td>
<td>All vehicles: 10% blends Limited - (E85)</td>
<td>All vehicles: 5% blends Limited (20%)</td>
<td>No OEM Conversions Available</td>
<td>Limited</td>
<td>None</td>
<td>Limited: Hybrids in some classes</td>
</tr>
<tr>
<td><strong>Infrastructure</strong></td>
<td>Existing</td>
<td>Existing</td>
<td>Existing for 10% blends</td>
<td>Limited</td>
<td>Limited</td>
<td>Limited</td>
<td>None</td>
<td>Minimal</td>
</tr>
</tbody>
</table>

Source: Compiled by Hart from Various Source (2010)

The revised fuel economy standards present significant opportunities for auto manufacturers to offer wider light-duty vehicle options, particularly diesel engines. With superior fuel economy of up to 35% compared to equivalent gasoline vehicles, consumers can still have performance, power, and efficiency with clean diesel engines. Innovations creating and deploying advanced technologies for medium- and heavy-duty vehicles also provide the industry with continued improvements for diesel powered fleets.

C. Medium and Heavy-Duty Trucks

In May 2010, President Obama directed the U.S. EPA and the Department of Transportation’s NHTSA to jointly develop, with broad stakeholder participation, a first-ever national policy to increase fuel efficiency and decrease GHG emissions from medium- and heavy-duty vehicles for model years 2014 to 2018. Medium and heavy duty vehicles include those with gross weights above 10,000 pounds (4,536 kg) and are generally considered commercial and freight haul (delivery and track-trailer) vehicles, often reliant on diesel engines.

Recent advances in ULSD and near-zero emissions diesel engines demonstrate the innovative technologies that are laying the foundation for a greener profile in this sector. The goal to establish a new uniform national program for fuel efficiency and GHG emissions in the medium- and heavy-duty vehicle fleet can maximize the use of existing infrastructure for diesel fuel and maintain the functionality of these vehicles to service manufacturers, businesses and consumers. This new initiative is broadly supported by engine and truck manufacturers. Already diesel-electric hybrid buses and other both electric and hydraulic hybrid versions of a variety of vehicles in these segments are increasing the efficiency in a many applications.

IV. BIODIESEL, RENEWABLE and LOW CARBON FUELS

*Renewable fuel standards will rapidly drive biofuel requirements upward and will shift focus to GHG potential and specific categories of advanced diesel formulations. Advanced biofuel requirements apply to both diesel and gasoline in the transportation fuel pool. Diesel’s unique capability to utilize a range of renewable fuels and blends further enhances its future prospects and expanded use.*

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One of the key policy strategies to reduce GHG emissions and reliance on imported oil is to use more domestically produced fuel from a variety of plant and biomass feedstocks. Diesel’s unique compression ignition cycle and operating characteristics are highly suitable for using renewable fuels from various feedstocks.

The very first diesel engine was designed and demonstrated in 1894 using pure peanut oil. Since that time, interest in use of bio-based diesel fuels from agricultural feedstocks and from waste vegetable oil has been limited primarily to localized niche users and regions. However, the American Jobs Creation Act of 2004, established a $1.00 per gallon federal tax credit that was awarded to produce biodiesel made from oil-crops and animal fats. As a result by 2008, the EIA estimated that in 2008, U.S. production of biodiesel was 682 million gallons.

First generation biodiesel is a basic renewable fuel produced primarily from soybeans, and some canola and other oil-based beans and is referred to as fatty-acid methyl esters (FAME). Fueled by the producer tax credit, aggressive growth in small and medium scale production facilities for first-generation biodiesel fuels has led to concerns about the quality and consistency of production and storage, blending and vehicle performance of the biodiesel fuel blends. The biodiesel industry has worked to address these initial challenges and implemented substantial quality assurance programs at the producer level. The first generation biofuels offer minimal improvements in fuel properties and vehicle performance and are still unable to be transported by pipeline. This has increased transportation costs and reduced the pricing competitiveness with regular diesel fuel. Other concerns with FAME biodiesel have included increased emissions of nitrogen oxides at increasing blends of biodiesel fuel.

A second generation of bio-based diesel fuels referred to as renewable diesel fuel can be produced from a variety of bio-based feedstocks including soybeans, biomass, algae, palm oil and other products. This fuel is a non-esterified renewable diesel fuel (NERD) with enhanced performance properties which is suitable for blending into conventional refining processes and transported using pipelines.

The “Energy Policy Act of 2005” (EPAct) established the first nationwide mandate to use renewable fuels in transportation, the Renewable Fuels Standard (RFS-1) program, which began in 2006 and required increasing volumes to achieve 7.5 billion gallons of renewable fuels blending by 2012. The RFS-1 program mainly covered bioethanol blending into gasoline, but biodiesel and renewable diesel fuels were awarded extra compliance credits based on their higher energy content. By 2009, EIA estimated that 682 million gallons of biodiesel fuel was produced in the U.S., and significant amount of this volume used by obligated parties for compliance with the RFS-1 requirements.

Under the “Energy Independence and Security Act of 2007” (EISA), the Renewable Fuels Standard program was substantially expanded to mandate the use of biofuels made from renewable resources, including agricultural crops, forestry waste products (cellulosic materials), recycled vegetable matter, and other similar feedstock. EISA establishes specific volumes of biofuels for fuel producers and providers to use for compliance with the program. This second generation of the Renewable Fuels Standard Program (RFS-2) became effective on July 1, 2010, and includes requirements for refiners and fuel providers to use “bio-mass based diesel” fuel in highway vehicles and engines, non-road, locomotive and many marine engines. For 2010, the EPA’s regulations for the RFS-2 program require that 1.15 billion gallons of bio-mass based diesel fuel be used.
Under the RFS-2 program, renewable fuels must meet certain thresholds for lifecycle GHG emissions reductions to qualify for use (“lifecycle” describes product development from raw material production through combustion in the engine). U.S. EPA has determined that biomass based diesel fuel made from soybean oil or waste oils/fats/greases meets the required 50% GHG emissions reductions compared to the baseline petroleum based diesel fuel. Under the RFS-2 program, biodiesel and renewable diesel fuel continue to demonstrate advantages based on higher energy content compared to bioethanol. Blenders that use biodiesel and/or renewable diesel fuel can secure additional credits within the program, providing an incentive to provide these blends for the marketplace. Furthermore, the blending of biodiesel up to 5 vol% does not require any pump label changes or engine adjustments, while fully maintaining product quality, performance, helping to reduce GHG emissions, and expanding the diesel fuel. The RFS-2 program requirements for biomass-based diesel fuel and advanced biofuels expands the opportunity for developing new fuels options used by clean diesel engine technologies.

V. IMPACTS OF CLIMATE POLICIES ON DIESEL

*Climate change policies based on reducing carbon emissions will place new demands on transportation energy which will impact sources, composition, manufacturing, costs and efficiency of fuels. In many respects advanced diesel engine and fuel options will be well positioned to meet these new challenges and goals.*

Climate change legislation continues to be debated by the U.S. Congress, and timing of any final action is unclear. Nonetheless, several proposals to control and reduce GHG emissions across economic sectors have been offered. In general these bills would establish “cap-and-trade” systems that allocate GHG emissions to industrial facilities, electric power generators, refiners and transportation fuels use. Government allowances (in essence, permits) would be purchased and traded by covered industries to comply with emissions limits, and revenues gained by these sales would be used as rebates to consumers and for other federal budget needs (including deficit reduction). The legislative proposals include incentives, mostly as tax credits and direct funding, to help develop and deploy carbon-reducing technologies and encourage the “green” economy and jobs creation.

Different approaches are being considered for reducing GHG emissions resulting from the combustion of transportation fuels, including diesel fuel. One proposal is to use a “carbon fee” imposed on refiners and fuel providers. Another approach is to award government support in the form of incentives such as tax credits or direct subsidies, to encourage specific fuel conversion and use, mainly to CNG or LNG, thereby raising the relative price differential as compared to convention or non-incentivized fuels. Whatever strategies are chosen, policy makers must carefully evaluate overall costs and benefits, including vehicle refueling and infrastructure deployment costs for selecting new fuels and technologies and their near term and long term potential.

Diversity and reliability in fuel supplies have been identified as key goals. An increased use of CNG, ethanol-blended gasoline and electric-powered cars are contemplated. Likewise, expanded use of clean diesel fuel provides an important strategy for GHG emissions control in the transport sector without the additional infrastructure investments to expand distribution of niche fuels.
GHG emissions come from diverse sources across the economy. According to the U.S. EPA’s “Inventory of U.S. Greenhouse Gases Emissions & Sinks: 1990 – 2008,” the transportation sector is the second-largest source of GHG emissions with just over 27% of total emissions. The greatest contribution comes from electricity generation (36%). Figure 5 shows the breakdown of GHG sources based on major economic sectors.

**Figure 5: U.S. Greenhouse Gases Emissions by Economic Sector**

![Graph showing GHG emissions by economic sector]


Within the transportation sector, gasoline powered vehicles are the largest GHG emissions source with about 63% of total emissions. Diesel vehicles (including passenger, light-, medium- and heavy duty trucks, and buses) contribute about 22% of transport sector emissions, followed by jet fuel with 10% (Figure 6).

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Among currently available fuels, diesel fuels used with new clean diesel technology can be lower in GHG emissions than comparable gasoline vehicles. As part of “well-to-wheels” analysis of GHG emissions from various vehicle systems, the EIA evaluated light-duty GHG emissions, including diesel, conventional gasoline, flex-fuel (FFV), hybrid electric (HEV), and plug-in electric vehicles (PHEV). “Well-to-wheels” analysis considers GHG emissions rates through the entire fuel cycle - from feedstock, fuel production and delivery, and vehicle operations.

According to EIA, total well-to-wheel GHG emissions from diesel vehicles using diesel fuel are 15% lower than those from comparable gasoline vehicles using E10 blend gasoline (10 vol% ethanol and 90 vol% gasoline). In its development of the Low Carbon Fuel Standard (LCFS), the California Air Resources Board (CARB) estimated that diesel has a 22% CO₂ emissions advantage over gasoline.

For diesel vehicles using B20 (20 vol% biodiesel and 80 vol% diesel fuel), the GHG emissions are 30% lower than the E10/gasoline vehicle. When the B20/diesel vehicle is compared with an FFV using corn-based E10 gasoline, the GHG emissions are 14% lower (using only diesel fuel in the diesel powered vehicle, the GHG emissions are about 4% greater compared to the E10 gasoline vehicle). Similarly, the diesel engine using B20 blend emits about 12% less GHG than an FFV using corn-based E85 because of the energy content differential between the fuels and the greater fuel efficiency of diesel vehicles.

EIA determined that diesel vehicles’ GHG emissions for the well-to-pump cycle (production to fuel delivery to vehicle) are generally lower than those for PHEV that draw energy from the electricity grid, depending on the region of the country and resource used for power generation. The GHG emissions for the well-to-pump cycle for HEV can be either higher or lower that those from a B20 fueled diesel vehicle depending on the HEV engine or fuel type. With the pump-to-wheels cycle, an HEV equipped with a diesel engine using either diesel

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fuel or B20 can achieve even greater GHG reductions due to the fuel efficiency advantage with both the onboard battery system and the diesel engine.

The EIA analysis found that at the feedstock stage, there is essentially no difference between GHG emission rates for gasoline and diesel fuel because both follow similar production paths. However, at the refinery, the process for making diesel fuel is less energy-intensive than that for making gasoline on an energy (Btu) content basis. Consequently, making diesel fuel from petroleum results in less GHG emissions at the fuel refining stage (well-to-pump) as compared to gasoline.

Diesel fuels and clean diesel engine technology are available, affordable and offer immediate reductions in energy consumption over other fuels and illustrate the importance of practical and proven approaches from existing technologies as solutions to reduce GHG emissions.

VI. FISCAL POLICIES IMPACTING DIESEL FUELS AND VEHICLES: Incentives and Taxation

The Federal Government has provided limited tax incentives for purchasers of hybrid and advanced lean-burn (diesel) technology to stimulate these new technology consumer markets. Federal and state tax provisions designed to promote production, use and infrastructure for biodiesel and renewable diesel are also available. Federal tax policy currently disadvantages diesel fuel as compared to gasoline and other fuels.

The Energy Policy Act of 2005 provided for federal tax credits for consumers purchasing advanced lean-burn, clean diesel vehicles. As a condition of eligibility, the vehicles had to meet a minimum emissions standard known as a Tier II Bin 5 or cleaner emissions levels. Though available beginning in 2005, the first clean diesel tax credits were not awarded until 2008 due to the introduction of cleaner diesel fuel nationwide in October 2006. The one-time tax credits ranged from $800 to $1800 depending on the fuel economy improvements over a comparable gasoline vehicle and lifetime fuel savings and expire at the end of 2010.

Biodiesel fuel is made from renewable feedstocks like vegetable oils and animal fats and predominately is available as a blend with petroleum-based diesel fuel. Federal tax provisions previously provided for a biodiesel fuel blender credit of $1.00 per gallon that encouraged use of the product and helped producers offset feedstock and operational costs. Although this blender tax credit expired at the end of 2009, at publication of this paper, Congress was still working to reinstate this credit and make it retroactive back to the start of 2010.

Another federal tax incentive available for biodiesel fuel providers is the alternative fuel infrastructure tax credit. This credit is available for installing alternative fueling equipment including biodiesel blends of 20 vol% (B20) or higher. The current credit amount is up to 50% of the cost of installation, not to exceed $50,000 for equipment placed into service after January 1, 2009. This credit expires after December 31, 2010, and Congress is considering an extension.

Under amendments in 2009 to the Energy Policy Act of 1992, federal fleets must include alternative fuel vehicles, such as advanced lean-burn vehicles like those which employ clean diesel engine technology. Fleets that use fuel blends containing at least B20 in medium- and heavy-duty vehicles can earn credits toward their
annual requirements. Presidential executive orders in recent years have directed federal agencies to reduce petroleum consumption and increase alternative fuel use, which can be achieved with the help of diesel engine and biodiesel use.

Various state programs exist to provide incentives for biodiesel fuel use. For example, several states, like Massachusetts\textsuperscript{10}, Minnesota, New York, Oregon and Pennsylvania, are implementing programs to require the use of biodiesel blending (B2 to B10 levels) in motor fuel (diesel), home heating oil, or other distillate fuels, generally dependent on availability of supplies. State tax credits or excise tax exemptions are other mechanisms used to encourage biodiesel fuel production and use. For example, Texas does not impose its state diesel fuel tax on biodiesel volume blended.

Like the federal directive, some states also have renewable and alternative fuel requirements for fleets, like school buses, state-service vehicles or heavy equipment. Most of these regulations are unique and vary based on production or local and regional market availability of the biodiesel fuel blend.

Numerous states also provide alternative fuel vehicle and fueling infrastructure tax credits and allowances to help support the use of these fuels. The specific structures vary and generally allow for the taxpayer to take a credit up to certain amount against the state income tax or excise tax owed. In some cases, the state may provide limited grants or loan guarantees to businesses or individuals for the cost of constructing or equipping a facility to produce or use biodiesel fuel. Agricultural programs are also used to support the growth of crops and biomass that are used for biofuels feedstocks. These programs recognize the importance and value of biodiesel and renewable diesel fuel production for local jobs creation and economic development.

The federal and state tax credits and other incentives used to encourage the production and use of renewable fuels, including biodiesel fuel blends, can help expand fuel supply and give consumer options to choose diesel technology vehicles.

Federal and state tax policy has played a major role in impacting the use and penetration of a variety of industries and technologies and in particular energy sources of all types. Taxes on motor fuels are levied at both the federal and state level on a somewhat arbitrary basis, without regard to the environmental impacts or energy content of the fuels. Motor fuel tax policy has been established at both the federal and state levels primarily as a means to fund the maintenance and upkeep of the infrastructure of roads and bridges. However, considerable discretion has in recent years raised questions about the use of fuel tax revenues to offset government general fund non-transportation projects or for deficit reduction.

\textsuperscript{10} In June 2010, Massachusetts Department of Energy Resources delayed implementation of the state’s biodiesel requirement because of cost concerns associated with the expiration of the $1.00/gallon federal blender tax credit. The state has proposed a voluntary program to encourage biofuels use that would meet the standard.
The Federal government levies a motor fuel tax of 24 cents per gallon of diesel fuel sold, as compared to 18 cents per gallon for unleaded gasoline. In addition, some 16 states have taxes on diesel fuel that are higher than gasoline, ranging from $0.075 to over $0.13 per gallon.\(^\text{11}\)

Paradoxically, fuels with more energy content such as diesel are taxed at a higher rate than less energy-dense fuels. The theory behind the differential with diesel fuel taxes has been linked to its use as a primary fuel for commercial trucks, which are responsible for significant use and wear on the infrastructure. In 2004, trucking interests support for higher diesel fuel taxes (as compared to gasoline) was linked to additional funding allocated toward improving road networks, thereby reducing vehicle wear and tear and downtime.

Since that time, as diesel passenger car use has grown, this tax policy creates a more consistent fuel price disparity for diesel fuel costing more than compared to gasoline, even if the cost of providing the fuel is the same, diesel fuel will still cost more due to the tax structures. This has been identified as one potential barrier to expanded use of diesel cars in the U.S. Future taxation policy will likely be reviewed at some point in the future as carbon intensity and GHG impacts may be considered along with taxation schemes for non-petroleum fueled vehicles (i.e. electric) which still use the road networks, yet fail to contribute to their upkeep through payment of conventional petroleum-assessed fuel taxes.

**VII. FUTURE REFINING CAPACITY AND SUPPLY SHIFTING TO OPTIMIZE LOW-SULFUR DISTILLATES**

The international refining industry - and U.S. refiners as well - are making adjustments and investments based on shifts in global demand for refined products that include increased demand for diesel fuel. The investments will assure adequate production capacity to meet future global diesel needs.

There are several trends driving future investments in the global refining industry: the projected decline in the mainstream gasoline demand due to increased renewable fuel penetration and mandates; increase in more fuel-efficient vehicles due to fuel economy mandates and introduction of non-petroleum fuels (electricity); and economic growth (diesel driven) in developing countries. These factors will force refiners to adjust refined product yield to address changes in the fuel marketplace, including changes to keep up with the growing demand for diesel fuel. The industry has already been moving in this direction and plans for future refining capacity expansions will continue this trend. The majority of planned refining investments are focused on diesel technology as opposed to traditional gasoline oriented capacity.

The middle distillate (diesel plus diesel-like heating oil) share of refined products will grow from 29% in 2009 to an estimated 32% by 2020, requiring a shift in yield from gasoline and heavy residual fuel to distillate (Figure 7). More importantly, refiners will need to direct about 46% of their incremental product output to distillate production (far right bar in Figure 7).

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Refineries can shift product yields by adjusting operating conditions within their existing facilities or by installing new manufacturing technologies specifically designed to maximize gasoline or diesel fuel. The capability to adjust yield within the existing refining infrastructure is typically limited to a 5 to 10% shift from one product to another. Alternatively, optimizing refinery technology choice for the desired product stream provides a greater opportunity for shifts in product yields to well above 20%.

Refineries rely heavily on technologies referred to as conversion processes for production of gasoline and diesel, and to direct their desired product output to gasoline or diesel. The conversion processes convert lower demand heavy residual fuel to gasoline and diesel.

Within the category of the conversion process two primary technologies are employed: Fluid Catalytic Cracking (FCC) and Hydrocracking. Selection of one or the other depends on prevailing market economics and the desired mix of refined product, particularly gasoline and diesel. The FCC process the predominant technology currently used in the refining industry, facilitates gasoline production. The higher cost hydrocracking process can be used to produce gasoline, but also provides the capability to produce very high yields of high quality diesel fuel. The global refining industry currently has installed FCC capacity of about 14 million barrels per day versus only 5 million barrels per day of hydrocracking capacity.

With the growing emphasis on diesel demand, refiners have already turned more toward the hydrocracking process in their expansion projects in order to provide capability to increase production of high quality diesel fuels. Over the past five years, hydrocracking capacity has increased nearly 13% compared to an increase of less than 1% for the gasoline oriented FCC process (Figure 8).

According to the OPEC 2009 World Oil Outlook, refiners’ future capacity expansion plans continue to focus on hydrocracking capacity. OPEC estimates that between 2009 and 2015 planned hydrocracking capacity expansions will amount to 2.1 million barrels per day versus 1.1 million barrels per day of FCC capacity expansion. Projections in Hart’s WRFS indicate less hydrocracking expansion and greater FCC expansion (1.2 and 1.4 million barrels per day, respectively), but still reflect large growth in the share of hydrocracking relative to existing FCC-hydrocracking mix. In any case, hydrocracking expansion over the period will grow by 23% to 41% as compared to FCC capacity growth of only 8% to 10% (Figure 8).
The growth in hydrocracking capacity will provide considerable opportunity to increase diesel production. For those areas of the world where petroleum demand is growing (developing countries) and where refining capacity expansions will be required to meet demand, selection of a hydrocracking configuration for the expanded facilities will facilitate meeting growing requirements for diesel fuel. Refinery expansions incorporating hydrocracking capacity can achieve the incremental 46% diesel market share shown in Figure 7.

In areas such as Europe and the U.S., where overall petroleum demand will not expand, refiners have some limited capability to shift yield to diesel fuel with existing capacity. There is also the option of retiring FCC capacity and replacing conversion needs with hydrocracking.

Europe has and will continue to experience the greatest shift to diesel demand because of its dieselization of the passenger vehicle sector. According to the EIA, Europe increased diesel yield from refining from 44.4% in 1998 to 49.3% in 2008 in an effort to supply incremental diesel product. Over this period, European refineries added nearly 0.7 million barrels per day of hydrocracking capacity, an 86% increase. FCC capacity increased by only 0.2 million barrels per day, only an 8% increase.

Plans in Europe call for continued shifts in refinery yield toward diesel. Although the region’s refining crude distillation capacity is not projected to grow, there is an estimated 0.3 million barrels of additional hydrocracking capacity planned for the region. Some of the expanded hydrocracking capacity will replace existing FCC capacity (to be shut down), further enhancing the potential for increasing diesel yield at the expense of gasoline.

The U.S. will face a similar requirement to shift refinery yields to diesel. According to Hart WRFS projections, U.S. refinery yield of distillate fuel will need to increase from 27.4% in 2009 to 34.1% in 2020, an increase in yield of 6.7%. The higher diesel yield requirement reflects anticipated rebound in diesel demand associated
with economic recovery, declining gasoline demand resulting from implementation of higher fuel economy standards and increased penetration of ethanol into the gasoline market.\textsuperscript{12}

U.S. refineries have already initiated the shift to diesel and plans are underway to further increase diesel production capability. According to EIA statistics, U.S. refinery yield of distillate increased by 4.7\% between 2004 and 2008. U.S. refineries have responded to higher diesel demand by producing more diesel and less gasoline – mostly through operational changes, as opposed to major plant modifications and additions. Distillate yield declined slightly in 2009 due to a drop in diesel demand related to the economic recession. However, U.S. refineries still continued to produce a relatively high yield of diesel and surplus ultra low sulfur product was exported to Europe.\textsuperscript{13}

Going forward the emphasis on diesel production by U.S. refiners will be even greater. Currently, two of the largest expansion projects in the history of the domestic refining industry involve Marathon (in Louisiana, now complete) and Motiva (in Texas, under construction) and both will incorporate hydrocracking technology for maximizing diesel yield. These expansions alone will increase total U.S. hydrocracking capacity by more than 10\% by 2012.

Marathon has expressed its commitment to increasing U.S. diesel supply in both its existing refinery capacity and through the Louisiana expansion. In a March 2009 presentation, Marathon officials reported that their refining system increased distillate yield by 5.3\% between 2003 and 2008, versus a 4.1\% increase in for the U.S. refining industry as a whole. With its hydrocracking expansion, the Louisiana refinery has been tuned to produce more diesel fuel and other distillate than typical U.S. refineries, about 45\% compared to the typical 33\%.

Other major players in the U.S. market have reiterated industry’s commitment to increasing diesel supply to serve the demands of growing future markets. Valero, the nation’s largest refiner, has focused several expansion projects -- in Port Arthur, Texas, and St. Charles, Louisiana -- on increasing distillate output instead of gasoline. “We feel that demand for distillates is going to be higher than gasoline for the next several years”, Valero spokesman Bill Day recently said. Given projections for stronger margins in distillates than gasoline, it makes more sense to do your investments there than other projects.” Although the company has recently cut its refinery capital expenditures budget because of the economic recession and less optimistic outlook for petroleum demand, Valero plans to spend approximately $2.7 billion in equipment upgrades partly in anticipation of the continued profitability of distillate fuel.

The smaller independent refiners are also following a similar pathway of increased diesel fuel production. CHS, the largest U.S. farm cooperative refiner and supplier of refined product, noted that, “diesel sales continue to grow for our northern tier customers. The [recently completed] coker upgrade gives us the flexibility to reduce our asphalt production and increase diesel fuel production. We built the coker at Laurel to help supply demand for diesel fuel.”

\textsuperscript{12} Hart World Refining & Fuels Service, 2010

\textsuperscript{13} U.S. Energy Information Administration, Product Exports by Destination, www.eia.doe.gov
Also from the small independent refiner sector, Jeff Morris, President of Alon Refining, reiterated Alon’s strategy “to increase the company production of distillates, a fuel category that includes diesel and heating oil, versus gasoline.” In several public presentations Mr. Morris highlighted his company’s strategy to emphasize and increase diesel production. He also noted that Alon is considering “equipment upgrades at the Paramount refinery to produce more diesel.” CEO Matt Clifton of Independent refiner Holly Corporation commented about a recent refinery acquisition, “We really view this (Tulsa plant) as kind of a refinery that fits our times: high distillate yield, low gasoline yield.”

The U.S. refining industry is expected to be well positioned to provide adequate supplies of diesel fuel to meet future demand, as evidenced by progress to date in adjusting yields, the focus of the Marathon and Motiva mega refinery expansions and the commitment noted by other major and independent U.S. diesel suppliers. According to Hart WRFS projections, U.S. refining will add nearly 0.3 million barrels per day of hydrocracking capacity between 2009 and 2015 and no FCC capacity. Refinery shutdowns are expected during this period in response to declining gasoline demand. The capacity shutdowns are expected to include FCC capacity. The hydrocracking share of conversion capacity in remaining and expanded refineries will increase the capability to shift yields from gasoline to diesel fuel.

VIII. DIESEL FUEL ACCESS: WELL ESTABLISHED INFRASTRUCTURE AND GROWING CONSUMER ACCESS

Diezel fuel is readily available and increasingly accessible to consumers at local retail filling stations as evidenced by growing number of retail facilities carrying diesel product

Historically there have been perceptions or concerns that U.S. light duty vehicle owners may not have adequate access to retail sites that sell diesel fuel. Access to on-highway diesel on interstates or other major road arteries was not considered an issue because of the number of truck stops and large fuel marketing facilities serving the heavy duty diesel transport market. The concerns resided more with urban and suburban areas where diesel may be less prevalent.

In 2005, the Diesel Technology Forum commissioned a report, Consumer Accessibility to On-Highway Diesel Fuel to access the assess the availability of diesel fuel to consumers in the U.S. The report concluded that the availability and accessibility of diesel fuel did not appear to be an issue and diesel fuel accessibility did not appear to be a concern to consumers considering purchasing a light duty diesel vehicle.

The diesel accessibility report concluded that the percentage of retail fueling facilities offering diesel fuel was somewhere between 36% and 46%, with the non-weighted medium falling around 42%. The report also concluded that the trend in facilities offering on-highway diesel fuel was on the rise and there was no apparent concern on the part of consumers about their ability to purchase diesel fuel.

The U.S. Census Bureau collects comparable statistics on gasoline stations and the types of products and services offered. According to the most recent 2007 survey data, there were 117,908 U.S. gasoline stations accounted in their survey data, and of these, 61,396 also sold diesel fuel. The number of facilities offering diesel fuel has increased over time while the total number of gasoline stations has declined. The percentage of facilities offering diesel fuel has increased from 35.4% in 1997 to 52.1% in 2007 (Figure 9). The survey somewhat confirms the high end of the range concluded in the 2005 diesel accessibility report.
Although not supported by available statistics in the 2005 report, the perceived view is that fuel marketers generally include diesel fuel pumps in new or significantly renovated facilities and that many of the service stations which were shut down were typically smaller facilities, a higher percentage of which did not offer diesel fuel. Directionally, the census statistics support these assumptions. Total U.S. service stations offering diesel fuel increased 23% between 1997 and 2002, and another 11% between 2002 and 2007. Total U.S. gasoline stations declined over both periods, and more significantly, stations offering only gasoline declined by 20% between 1997 and 2002, and another 14% between 2002 and 2007.

**Figure 9: Total Automotive Fuel Stations and Those Offering Diesel**

The RFG Survey Association has collected data on fuel retail facilities to support their statistical activities. Data are not yet available to quantify the portion of stations offering diesel or trends in the market. However, staff was able to confirm that in general new facilities typically included diesel fuel pumps.

**IX. CONCLUSIONS**

Diesel technology – engines and fuels – have evolved as the technology of choice to support global development and economic growth. As the primary fuel for heavy duty transportation and construction and agricultural machinery, diesel has played a vital role in global economic expansion and will be an essential resource for future growth. Because of diesel’s unmatched energy density, efficiency, performance and existing infrastructure, there is no near term substitute for diesel in this role.

Introduction of advanced engine and fuel technology and renewable fuel capabilities will allow diesel to continue its traditional role in economic growth and expand into new market sectors. The technology
improvements along with fuel economy and climate change initiatives will enhance diesel’s value and potential to serve light duty transportation markets.

- Diesel fuel has been the largest growth petroleum product, representing 20% of refined product demand and increasing at an annual rate of 2.8% for the past five years.

- U.S. diesel demand is projected to grow 1.7 to 2.0% per year over the next decade, driven largely by the heavy duty transportation sector. Fuel economy and climate policy initiatives and diesel quality improvements may well result in higher penetration of diesel into the light duty market and greater growth on overall diesel demand.

- Some industry forecasts call for an increase in diesel’s share of the light duty market from less than 2% in 2009 to over 20% by 2020.

The future direction of climate, energy and environmental policies in the U.S. is toward increased efficiency, reduced reliance on imported oil, expansion of renewable fuel use and lower CO₂ emissions. Diesel energy density, energy efficiency and advancements in environmental performance are consistent with the goals of these emerging policies for both heavy duty and light duty markets.

- The diesel industry is in the midst of implementing advanced engine and emissions control technology that will lower emissions from on-road vehicles and non-road machines and equipment by more than 98% relative to 2000 era technology. Continued investments and research to further increase fuel efficiency while lowering emissions will keep diesel engines for light duty vehicles competitive with other technologies.

- Implementation of the recently promulgated fuel economy requirements in the U.S. will test the limits of gasoline internal combustion technology and will drive engine manufacturers to new advanced technology options. With superior fuel economy of up to 35% above gasoline vehicles, diesel provides an option for meeting efficiency requirements while maintaining performance and power.

- Diesel offers energy and environmental improvement without the need for development of an infrastructure to support the advanced technology.

- Diesel’s unique capability to utilize a range of renewable fuels and blends enhances its desirability under emerging renewable fuel requirements.

- The Federal Government’s limited tax incentives for purchasers of advanced lean-burn diesel technology (2005-2010) have been successful in stimulating these new technology consumer markets.

- Federal fuel tax policy currently disadvantages diesel fuel as compared to gasoline and other fuels. This poses one potential barrier to expanded use of diesel cars in the U.S.

The refining industry has made adjustments and plans additional investment designed to meeting increased global and U.S. demand for diesel fuel and other middle distillates.

- Over the past five years global hydrocracking capacity (primarily for diesel production) has increased nearly 13% as compared to an increase of less than 1% for gasoline oriented FCC capacity.
• Future refinery investment plans continue to focus on expansion of diesel versus gasoline emphasis technology.

• Two of the largest expansion projects in the history of the U.S. refining industry will incorporate hydrocracking capacity for maximizing diesel yield.

• Major integrated and smaller independent U.S. refineries have made public statements about their commitment to increasing diesel fuel production and yield.

Diesel fuel has a well established and growing infrastructure and consumer retail access.

• According to the U.S. Census Bureau, the percentage of retail fueling facilities offering diesel fuel has increased from 35.4% in 1997 to 52.1% in 2007.