

than 10 ppm sulfur. Refiners producing only high sulfur distillate today should have an added advantage in meeting a 15 ppm sulfur cap for nonroad fuel over that for highway fuel. They would be able to design their hydrotreater from the ground up, while most refiners producing 15 ppm diesel fuel for highway use will be trying to utilize their existing 500 ppm hydrotreaters, which may not be designed to be revamped to produce 15 ppm fuel in the most efficient manner.

Based on our review of the limited catalyst performance data in the published literature and the one set of confidential data submitted, we believe that the projections of the more optimistic vendors are the most accurate for the 2010 timeframe given this additional leadtime. For example, the confidential commercial data indicated that five ppm sulfur levels could be achieved with two-stage hydrotreating at moderate hydrogen pressure despite the presence of a significant amount of light cycle oil (LCO). The key factor was the inclusion of a hydrogenation catalyst in the second stage, which saturated many of the poly-nuclear, aromatic rings in the diesel fuel, allowing the removal of sulfur from the most sterically hindered compounds. In addition, refiners that are able to defer production of 15 ppm highway diesel fuel through the purchase of credits, as well as refiners producing 15 ppm nonroad in 2010, would have the added benefit of being able to observe the operation of those hydrotreating units starting up in 2006. This should allow these refiners to be able to select from the best technologies which are employed in the highway program.

In addition, a number of alternative technologies are presently being developed which could produce 15 ppm fuel at lower cost. ConocoPhillips, for example, has developed a version of their S-Zorb technology for diesel fuel desulfurization. This technology utilizes a catalytic adsorbent to remove the sulfur atom from hydrocarbon molecules. It then sends the sulfur-laden catalyst to a separate reactor, where the sulfur is removed and the catalyst is restored. Unipure is developing a process which selectively oxidizes the sulfur contained in diesel fuel. This process has the advantage that the sulfur containing compounds which are most difficult to desulfurize via hydrotreating are quite easily desulfurized via oxidation. Finally, Linde has developed a method which greatly improves the concentration of hydrogen on hydrotreating catalysts. This process promises to greatly reduce

the reactor volume necessary to produce 15 ppm diesel fuel.

These three new technologies are at various stages of development. This is discussed in more detail in the next section. Due to the projected ability of these technologies to reduce the cost of meeting a 15 ppm sulfur cap and the leadtime available between now and 2010, we project that 80% of the new volume of 15 ppm nonroad diesel fuel would be produced using advanced technologies.

7. Has Technology to Meet a 15 ppm Cap Been Commercially Demonstrated?

EPA just completed a review of refiners' progress in preparing to produce 15 ppm highway diesel fuel.²⁶¹ The information we obtained during that review confirm the projections we made in the HD 2007 program—refiners are technically capable of producing 15 ppm sulfur diesel fuel using extensions of conventional technology and, in fact, they are moving forward with their plans to comply with the program. Thus, we believe there are no technological hurdles to producing 15 ppm diesel fuel.

The European Union has also determined that diesel fuel can be desulfurized to meet a sulfur cap in the range of 10–15 ppm. Europe has established a 10 ppm sulfur cap on highway diesel fuel, effective in 2009, with plans underway for a 10 ppm sulfur cap for nonroad diesel fuel soon thereafter. As with our standards, Europe's 10 ppm cap applies throughout the distribution system. However, fuel tends to be transported much shorter distances in Europe. Therefore, we believe that both the 10 and 15 ppm sulfur caps will require refiners to meet the same 7–8 ppm sulfur target at the refinery gate. Given this, the European standard will require the same technology as that required in the U.S. Most European diesel fuel must meet a higher cetane number specification than U.S. diesel fuel, which causes it to be predominantly comprised of straight run material. This material is easier to desulfurize to sub-15 ppm levels using conventional hydrotreating technology. In some European countries, nonroad diesel fuel is the same as heating oil and contains significant amounts of cracked material. Thus, on average, it should be easier for European refiners to meet a 10 ppm sulfur cap with their highway diesel fuel than in the U.S. As the 10 ppm cap is extended to nonroad diesel fuel, the stringency of the European standard will be much closer to that of a 15 ppm cap here in the U.S.

²⁶¹ *Ibid.*

We have met with a number of diesel fuel refiners to learn about their plans to produce 15 ppm highway diesel fuel by the June 2006 program compliance date. Since the 15 ppm diesel fuel sulfur standard was established based on the use of extensions of conventional diesel desulfurization technologies, diesel fuel refineries are well positioned to make firm plans for implementation by 2006. Our review has found that this is exactly what refiners are doing. We are very encouraged by the actions some refiners have already taken in terms of announcing specific plans for low sulfur diesel fuel production. It may still be early in the process, but virtually all refiners are already in the stage of planning their approach for compliance. Thus, the refining industry is where we anticipated it would be at this point in time. Moreover, some refining companies are ahead of schedule and will be capable of producing significant quantities of 15 ppm sulfur diesel fuel as early as next year. Thus, we expect that the capability of conventional hydrotreating to produce 15 ppm diesel fuel in refinery-scale quantities will be demonstrated in the U.S. by the end of 2003.

Phillips Petroleum is currently in the process of designing and constructing a commercial sized S-Zorb unit to produce sub-15 ppm diesel fuel at their Sweeney, Texas refinery. This plant is scheduled to begin commercial operation in 2004. This would provide refiners with roughly 3 years of operating data before they would have to decide which technology to use to meet the 15 ppm nonroad sulfur cap in 2010. This should be enough operating experience for most refiners to have sufficient confidence in this advanced process to include it in their options for 2010 compliance. Based on information received from Phillips Petroleum, we estimate that this technology could reduce the cost of meeting the 15 ppm cap for many refiners by 25 percent.

Linde has also developed a new approach for improving the contact between hydrogen, diesel fuel and conventional desulfurization catalysts. Linde projects that their Iso-Therming process could reduce the hydrotreater volume required to achieve sub-15 ppm sulfur levels by roughly a factor of 2. Linde has already built a commercial-sized demonstration unit at a refinery in New Mexico and has been operating the equipment since September 2002. Thus, refiners would have 4–5 years of operating data available on this process before they would have to decide which technology to use to meet the 15 ppm nonroad sulfur cap in 2010. This should be ample operating experience for