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Testimony

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The Energy and Mineral Requirements for Renewable and Alternative Fuels Used for Transportation and Other Purposes

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Mr. Chairman, Members of the Subcommittee, and guests, thank you for the opportunity to appear here today to discuss with you the study that TIAX conducted for the DOE in 2003 to understand the potential impact of fuel cell vehicle commercialization on the availability and price of platinum.

TIAX LLC is a technology development company founded in 2002 by Dr. Kenan Sahin, when it acquired the R&D laboratories of the former Arthur D. Little, Inc., which was founded in 1886. TIAX, located in Cambridge, MA, has a broad range of technology expertise and experience in various end-use markets, particularly those associated with energy and power (portable, stationary, and transportation).

The use of fuel cells in transportation could play a critical role in developing a hydrogen economy, which could in turn lead to a greatly reduced reliance on foreign oil. Platinum is an essential element in fuel cell performance as it catalyzes the electrode reactions and consequently determines the power density and efficiency of the fuel cell. It is also the largest cost component of the fuel cell system, accounting for approximately 50% to the projected high volume manufacturing cost for systems with today's performance. For this reason, the DOE has invested significantly in R&D to reduce platinum loadings, increase activity of platinum catalysts, and develop platinum-free catalysts in the long term. The DOE commissioned our investigation as part of this effort.

We agree that the Committee's question concerning platinum availability is a timely one given the recent highs in platinum price, China's commodity needs, higher platinum requirements in fuel cell vehicles than today's cars, and the critical role that platinum plays in PEM fuel cell technology. Even though this study was conducted in 2003, we believe the findings are still very relevant to the committee's enquiry.

Scope of Platinum Project

Before beginning the discussion of the project findings, I'd like to summarize the scope of the assessment:

- Timeframe of the projection - 2005 to 2050
- Platinum markets - jewelry, transportation, industrial, and stationary fuel cells
- Vehicle projections for five regions - North America, Western Europe, Japan, India, and China
- Price behavior of platinum – 1880 to 2002
- Market penetration scenarios of fuel cell vehicles by 2050 – 50% and 80%

In developing our findings, we could not account for the impact of:

- Political instability in major platinum producing countries
- Control of platinum production by a limited number of companies in the major producing countries
- Future growth/decline in the world economy

- Significant increases in platinum demand from new applications other than fuel cells

Because of the complexity of this topic, our primary objectives were to:

- Develop insights into key factors and interactions that would influence platinum price and availability
- Identify what factors might limit adoption of fuel cell powertrains for transportation.

The study focused on answering whether the successful introduction of fuel cells in transportation could be threatened by platinum price increases and limitations in platinum supply in the long term. Specifically:

- Can long-term, primary platinum resources accommodate the new demand from fuel cell markets (transportation, stationary, and portable)?
- How will supply operations (mining and refining) respond to increases in market demand?
- What role will recycling play in the supply chain as fuel cell markets develop?
- Will the relationship between supply, demand, and price of platinum change as fuel cell markets develop?

Key Findings

- Fundamental availability of platinum resources in of itself should not be a barrier to mass commercialization of fuel cell vehicles. However, efficient recycling of platinum from the fuel cell stacks will be necessary to minimize the demands on primary platinum production.
- The platinum industry indicated that it could ramp up production rates to approximately 14 Mg/year. This would allow a market penetration scenario of 50% (11 Mg/year) but not the 80% scenario. Consequently, the ability to ramp up production capacity could limit fuel cell commercialization depending on the rate of fuel cell vehicle adoption. For comparison, during the introduction of catalytic converters, production capacity increased at a rate of 3.5 Mg/year.
- Analysis of historical price data showed a constant mean real price of $550/tr.oz. in 2003 dollars. Since 1880, the price of platinum has shown periods of volatility, but it has always returned to its long-term ean, indicating a stationary price. Interviews with the platinum industry confirmed this observation of a stationary real platinum price driven by the desire of the industry to keep end-users from substituting other metals for platinum.
- Mass commercialization of fuel cell vehicles would dramatically change the balance of platinum markets from today's rough 40/40/20 split between transportation, jewelry, and industrial applications to a market dominated by transportation (e.g.., 75-90%).

Basis for the Study

*Platinum Supply and Market*s

As part of the study we delved into the background of platinum and PGM materials. Aside from their unique chemical properties, platinum group metals (PGMs) have their own geology, supply, and markets. Due to the unique geology of the Bushveld Complex, South Africa dominates the supply and projected resource of platinum, accounting for roughly 70-80% of both. Russia is the next major supplier of platinum, with about 10-20%. The rest of the world, including the US accounts for the balance, about 10%. The geographic concentration of supply and resources naturally raises concerns.

In 2003, markets were largely driven by the demand for autocatalysts and jewelry (40% each). Industrial (glass, chemical, petroleum) and electrical applications consumed the remaining 20%. However, since the study was conducted, several factors have led to steadily increasing demand from the transportation sector: increasingly stringent auto emissions regulations on both gasoline and diesel vehicles, the unique ability of PGMs to catalyze auto exhaust clean-up, and rising auto markets in China.

Project Methodology

In addition to the technology capabilities within TIAX (e.g., fuel cells, catalysis, and automotive powertrains) we retained two university professors to assist with economic modeling (Professor Walter Thurman, Department of Agriculture and Resource Economics, North Carolina University) and PGM mineralogy (Professor Grant Cawthorn, Platinum Industry's Professor of Igneous Petrology, University of the Witwatersrand, South Africa). During the project, we obtained inputs and feedback from the car companies and the platinum industry.

To develop projections of platinum demand arising from fuel cell vehicle introduction, we had to:

- Estimate how much platinum would be required per vehicle and created a timeline for the technology evolution (amount of platinum per kilowatt of stack power)
- Estimate vehicle sales in the considered regions
- Define scenarios for fuel cell vehicle market introduction and penetration with assumptions for vehicle life and platinum recovery rates
- Assess the sufficiency of platinum resources. The primary platinum production over the period of the projection was integrated and compared with available resource projections

For the purposes of this study we assumed a 75 kW fuel cell power plant hybridized with batteries would be representative of a mid-size vehicle. Starting in 2005, we assumed that platinum requirements would decrease from 60 grams per vehicle to15 grams per vehicle in 2025 and then remain constant until 2050.

We based our vehicle projections on estimates of population growth and vehicles per capita in the five regions. In the mature automotive markets in the United States, Western Europe, and Japan, we assumed high per capita vehicle populations (i.e., 0.7 to 0.84) in 2050. For China and India, with values on the order of 0.01 vehicles per capita today, we considered future scenarios ranging from 0.1 to as high as 0.25 vehicles per capita. With these assumptions, the world vehicle fleet was projected to approximately double by 2050 driven by markets in the U.S., India, and China. In 2050, our assumptions led to annual vehicle sales of 72 million for the five regions. For comparison, in 2000, 41 million vehicles were sold worldwide with the five regions representing 75% of this value.

The next step in projecting platinum demand was the definition of fuel cell vehicle market penetration scenarios. Two scenarios were defined with market penetrations of 50% and 80% by 2050. For the 50% scenario, the production of vehicles for the selected regions was projected to be 72 million in 2050. In the Developed Countries, fuel cell production volumes were projected to be 20 million per year in 2050 for this scenario with annual increases of 1 million vehicles per year during the ramp up to 50% market penetration.

Based on the 50% scenario, we then integrated the cumulative primary platinum production over the time of the projection for all applications. The cumulative primary production (20,000 Mg) was less than the platinum resource base of 76,000 Mg projected by experts in the field.

Our conclusion that prices will return to historic mean prices depends on demand staying in balance with supply. Recycling will be critical to limiting the increases in primary platinum production.

Thank you, Mr. Chairman, for the opportunity to discuss this important subject. This concludes my testimony. I would be happy to answer any questions you may have.

Exhibit 1 Historic price behavior indicates that as long as supply and demand remains in balance, the long-term real price of platinum will be stable.

Exhibit 2 Growth in the world vehicle fleet will be driven by markets in the U.S., India and China.

Exhibit 3 We used two market penetration curves to estimate the impact of fuel cell vehicles on platinum demand.

Exhibit 4 Introduction of fuel cell vehicles would require increased rates of annual production. Discussions with the platinum industry suggested that production growth rates needed for the 80% scenario could not be met.

Exhibit 5 The complex interplay between recycling, fuel cell vehicle market penetration, and Developing Country market dynamics leads to steep increases in platinum demand in China and India after demand peaks in the developed countries. The latter due to recycling.

Exhibit 6 The projected demand of 20,000 Mg would be less than the currently estimated resource of 76,000 Mg.