X.12 Assessment of Platinum Leasing Strategies for Fuel-Cell Vehicles and Platinum Availability Update

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Contract Number: DE-AD36-06GO26044

Project Start Date: October 1, 2007
Project End Date: October 1, 2008

Objectives

- Assess constraints on platinum availability under high fuel cell vehicle (FCV) penetration scenarios. (Updates a 2003 TIAX study for DOE [1]).
- Quantify the benefits of establishing a platinum leasing program to reduce the cost of FCVs.

Technical Barriers

This project addresses the following technical barrier from the Fuel Cell section of the Hydrogen, Fuel Cells and Infrastructure Technologies Program Multi-Year Research, Development and Demonstration Plan:

(B) Cost

In addition, it addresses the following barrier from the Systems Analysis section:

(A) Future Market Conditions

Contribution to Achievement of DOE Systems Analysis Milestones

This project will contribute to achievement of the following DOE milestones from the Fuel Cells section of the Hydrogen, Fuel Cells and Infrastructure Technologies Program Multi-Year Research, Development and Demonstration Plan:

- **Milestone 72:** Generate transportation fuel cell system cost projections based on achievement of 2010 and 2015 technical targets.

It also contributes to achievement of the following milestones from the Systems Analysis section:

- **Milestone 1:** Complete evaluation of the factors (geographic, resource availability, existing infrastructure) that most impact hydrogen fuel and vehicles.

Accomplishments

- Completed platinum availability analysis for several different FCV penetration scenarios and presented results to DOE contacts.
- Completed analysis of several different platinum leasing scenarios, which demonstrate that under favorable conditions, leasing could offer cost reductions of between $1 and $15/kW, and that such a program is most beneficial during early stages of technology adoption.
- Reviewed results with and solicited feedback from industry stakeholders.
- Completed draft paper on platinum leasing portion of the study for submission to a peer-reviewed journal.

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Introduction

This project addresses two key questions relevant to successful commercialization of FCVs. The first portion evaluates the long-term impact of high FCV penetration on the worldwide platinum resource and supply infrastructure. A platinum catalyst is critical to proton exchange membrane fuel cell performance, and at present, there are no production-ready substitutes. As such, in a high FCV penetration scenario, the demand for platinum could strain the worldwide platinum resource and/or supply infrastructure. The platinum availability analysis addresses this question by comparing geological estimates of platinum reserves and analysis of mining capacity to global platinum demand estimates under different FCV penetration scenarios.

The second part of this project evaluates whether the cost of platinum in FCVs may be reduced by leasing, rather than selling, the platinum in the fuel cell stack to customers. Current fuel cell cost estimates treat the platinum content in a fuel cell as a sunk cost; in reality, the platinum is likely to maintain a large fraction of its residual value throughout the life of the vehicle. By leasing the platinum to a downstream borrower and recovering the platinum at the end of the vehicle's life, a commercial or government lender could potentially reduce the purchase price of a FCV while turning a profit. Our work focuses on how such a leasing program could be structured, whether there is a viable business case to a lender, and what the potential for cost-savings under a platinum leasing program could be.

Approach

Our platinum availability analysis compares current estimates of platinum supply and supply infrastructure to projections for platinum demand under two FCV penetration scenarios (50% and 80%). The FCV platinum demand projections are calculated from estimates of vehicle demand, based on population growth and motorization projections, and from FCV platinum requirements, based on US DOE targets. Platinum demand for other sectors is estimated based on historical trends. Supply estimates are derived from a survey of available geological resources, and from discussions with industry stakeholders.

Our evaluation of a platinum leasing program focuses on quantifying the potential cost savings and on detailing the logistics of how such a program could be structured. Cost estimates are based on high and low cases for platinum price and platinum loading, and are used to bracket the potential savings offered by a leasing program. Because there are not currently any leasing arrangements that are directly analogous to an FCV platinum leasing program, our evaluation of the industry structure and costs are based on research into lending practices and trends in the precious metals industry and in the automotive industry. Using preliminary results based on literature review, we engaged in discussions with stakeholders from the metals industry, the automotive industry, and the petroleum industry to solicit feedback on the strengths and weaknesses of different approaches.

Results

Our analysis of the global platinum resource and supply infrastructure models is based on two different FCV penetration scenarios: one in which FCVs achieve 80% market penetration by 2050, and one in which FCVs achieve 50% market penetration by 2050. For both scenarios, the results indicate that platinum reserves – estimated at about 76,000 Mg – are sufficient to support expected demand from FCVs, which is projected to range from 13,000 (in the 50% scenario) to 17,000 Mg (in the 80% scenario).

However, it is less certain that the industry's mining capacity can expand rapidly enough to meet the expected demand. As shown in Figure 1, for both scenarios, projected platinum demand rises sharply from 2025 to 2040, but levels off considerably after 2040 as older vehicles retire and the recycled supply of platinum becomes significant. During the period of peak growth, the platinum supply capacity must expand at a rate of approximately 12 Mg/yr in the 50% scenario and at a rate of 23 Mg/yr in the 80% scenario. Discussions with industry suggest that the rate of growth required by the 50% scenario is challenging but feasible, while that required by the 80% scenario is infeasible [1]. In addition, the majority of platinum reserves – over 80% – are located in South Africa. This lack of geographic diversity in the platinum supply could add a further element of risk.

The assessment of a platinum leasing program focused on structuring scenarios and evaluating the potential for each scenario to reduce the cost of a FCV. We identified two basic lending scenarios in addition to the base case. The base case describes a situation where there is no leasing program – the consumer purchases the FCV just as they would any standard vehicle. In this case, the consumer pays the full price of platinum at the time of purchase, but may recover its residual value at the end of vehicle life. In the first lending scenario ("Upstream Lender"), the government or a bank is the owner of the platinum and it is leased to the vehicle manufacturer (OEM, original equipment manufacturer) throughout the life of the FCV (e.g., 10 to 15 years). In the second lending scenario ("Downstream Lender"), the government or an automotive finance company is the owner of the platinum, which is leased to the owner of the FCV over the life of the vehicle.

The lending scenarios differ in a number of ways – most notably, in terms of the lender's cost of capital, the borrower's discount rate, and the logistics associated with end-of-life metal recovery. However,

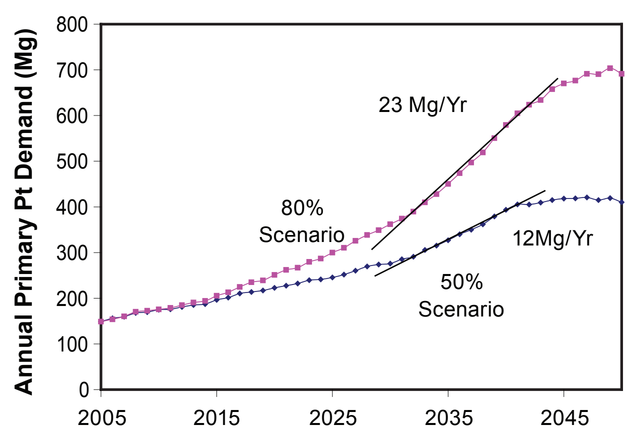

FIGURE 1. Annual Primary Platinum Demand

both scenarios incur similar types of cost to the lender, which must be internalized in the lease rate seen by the borrower. A summary of these lease cost components is given in Table 1. The results of this analysis suggest that the lender's cost of capital is the largest and most variable component of the lease rate, with governments being able to operate at the lower end of the range and commercial lenders operating at the higher end. In addition, both the lender's ability to efficiently recover platinum at the end of vehicle life ("Recovery Costs") and to minimize lending risks ("Price Risk" and "Ownership Risk") can have a determinative effect on the profitability of a leasing program.

Figure 2 provides a graphical description of the relative benefits of a leasing program, as described in the two scenarios. The figure considers factors including: 1) Relative Pt Value (with 1.00 representing the Base Case condition to the consumer – not including the end-of-life value of the platinum); 2) Platinum Lease Rate; and 3) Lessee Discount Rate. The estimated range of lease cost and discount rate for different lender/borrower combinations are superimposed on this figure; the uncertainty represents variance in the borrower discount rate, the lender's cost of capital, and the extent to which lending risks are minimized. These results indicate that the "OEM to Consumer" scenario is likely to be unfavorable due largely to the expected high lease rate. Both scenarios could be beneficial to the consumer when the government is the holder of the lease. The case where an upstream bank leases platinum to an OEM could have marginal benefits. It should also be noted that these results assume a ten year lease duration; a longer lease duration would make leasing less attractive for the consumer; for example, extending the lease duration to 15 years increases the relative cost of platinum to the consumer by 12% compared to that shown in Figure 2.

TABLE 1. Factors that Dictate Platinum Lease Rate

Lease Rate Component	Annual Lease	Description
Lender's Cost of Capital	5%-12%	Lender's cost of borrowing money; estimated from typical commercial & gov't borrowing rates
Price Risk	1%-2%	Hedging cost imposed by price volatility; estimated from metal futures market
Ownership Risk	2%-6%	Costs incurred through the life of the vehicle due to lease default, loss, damage, etc; estimated from risk costs of automobile leases
Recovery Costs	1%-5%	Costs associated with retrieving spent catalyst, returning it to the catalyst refiner, and reprocessing the spent catalyst; estimated from catalytic converter recycling costs and reprocessing costs of industrial catalyst
Total	**9%-25%**	

The benefits offered by a leasing program are also highly dependent on the value of the platinum contained in an FCV. Depending on platinum loading and platinum cost assumptions, the cost of platinum in an FCV to the consumer value may range from $500 (at target loadings of 0.2 g/kW and platinum price of $500/Troy oz) to $5,000 (at target loadings of 0.6 g/kW and platinum price of $2,000/Troy oz)[1]. Figure 3 shows the range of savings offered by these different platinum price assumptions under the favorable lease conditions denoted by the letter "A" in Figure 2. The left axis shows the savings in absolute terms, while the right axis shows the savings on a per-kW basis. As shown, the savings offered by such favorable lease conditions range from $1 to $15 per kW, depending on platinum loading and price. Including applicable supply chain markups and catalyst preparation costs, this corresponds to savings of between $150 and $1,800 for a vehicle with an 80 kW fuel cell stack.

[1] Both cases assume a 10% catalyst preparation cost, and that the retail price seen by the consumer is 1.5 times the cost of the platinum catalyst.

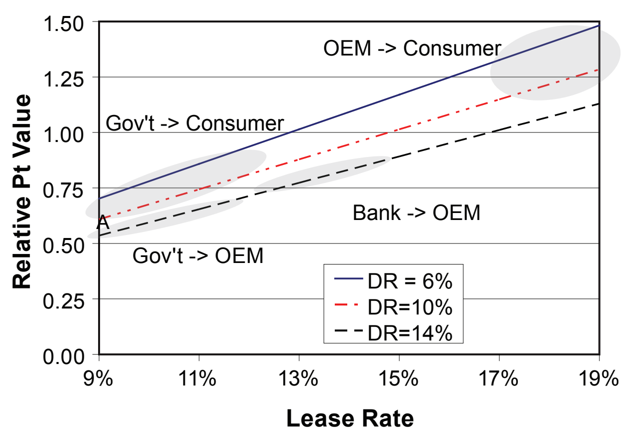

FIGURE 2. Cost of Platinum to the Consumer, Relative to the Base Case

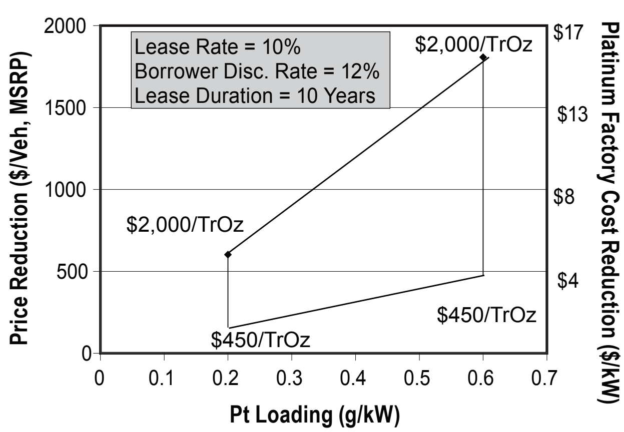

FIGURE 3. Savings Under Favorable Lease Conditions as a Function of Loading and Platinum Price

In addition to these quantitative results, several broad themes emerged from our ongoing conversations with stakeholders:

- Platinum manufacturers and refiners are typically uninterested in owning metal. At present, banks or other financers act as a middleman in metal leasing transactions. As such, a dedicated lending institution could have interest in the OEM-based leasing program, but would require a high rate of return on their investment.
- A government-financed program was viewed as most promising, but several experts suggested that low-cost loans could accomplish the same end.
- There is a general consensus among industry experts that a leasing program, if attempted, should start small and leverage an early-adopter strategy. Several stakeholders indicated that a fuel cell *stack* or *vehicle* leasing program could help to jumpstart early-stage market penetration of FCVs because the low number of participant vehicles limits risk. By leasing the whole vehicle, OEMs could leverage institutional knowledge about vehicle financing.
- Most stakeholders felt that in the long run, such a program would offer only marginal benefits to the consumer, and that reducing platinum loading is the top priority.

Conclusions and Future Directions

Key conclusions for the platinum availability analysis are as follows:

- **Platinum Resources:** The projected cumulative primary platinum demand (2005 to 2050) assuming high FCV penetration is 17% to 23% of the global platinum resource (i.e., 76,000 Mg). Most of this resource will come from South African and Russian suppliers.
- **Primary Platinum Supply:** The two scenarios project a growth rate of primary platinum demand of 12 Mg/year, which is potentially achievable, and 23 Mg/year, which is beyond reasonable growth expectations.

Hence, although the global resource is sufficient to meet projected demand, the combination of rapid growth required by mines and geographic concentration of where these mines are located could pose a significant barrier to rapid penetration of FCVs.

Key conclusions from the platinum leasing portion of the study are as follows:

- Under favorable lease conditions, leasing platinum can reduce the upfront cost of the platinum in an FCV by approximately 30%. Depending on the price of platinum and the platinum loading, this corresponds to a cost reduction of between $1 and $15 per kW, or $150 and $1,800 per vehicle. The benefits of leasing are strongly linked to the difference between the lease rate charged by the owner of the platinum and the buyer's cost of borrowing money.
- A large-scale platinum leasing program is regarded as a very high risk endeavor. Without any real world experience, none of the stakeholders would know how to accurately price the risk factors. Minimizing the risk to the lender entails establishing efficient end-of-life platinum recovery operations and a legal structure to protect the lessor's ownership rights.
- Due to its access to low-cost capital and its ability to develop efficient platinum recovery loops, federal support is critical to the success of a large-scale platinum leasing program.
- A platinum or fuel cell stack leasing program is most promising as a means to facilitate adoption of FCVs during initial market introduction.

No additional analysis is currently planned for this study. Pending review of our draft by DOE sponsors, during the next several months, we intend to submit a draft manuscript to a peer-reviewed journal for publication.

FY 2008 Publications/Presentations

1. Kromer, M. "Update on Platinum Availability and Assessment of Platinum Leasing Strategies for Fuel Cell Vehicles". 2008 DOE Annual Merit Review. June 13, 2008.

2. Rhodes, T and Kromer, M. "DRAFT Update on Platinum Availability and Assessment of Platinum Leasing Strategies for Fuel Cell Vehicles". Presentation to Fuels Pathway Integration Tech Team. January 31, 2008.

References

1. Carlson, E et al. "Platinum Availability and Economics for PEMFC Commercialization". December 2003. TIAX LLC, Prepared for US DOE, Contract # DE-FC04-01AL67601.