Update on Platinum Availability and Assessment of Platinum Leasing Strategies for Fuel Cell Vehicles

Project ID # AN12

Systems Analysis Session

DOE Merit Review
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Timeline

- Start date: Oct 2007
- End date: May 2008
- 95% Complete

Barriers

- Barriers addressed
  - B. Cost

Budget

- Total project funding
  - DOE share = $167K
  - No cost share
- FY08 = $167K

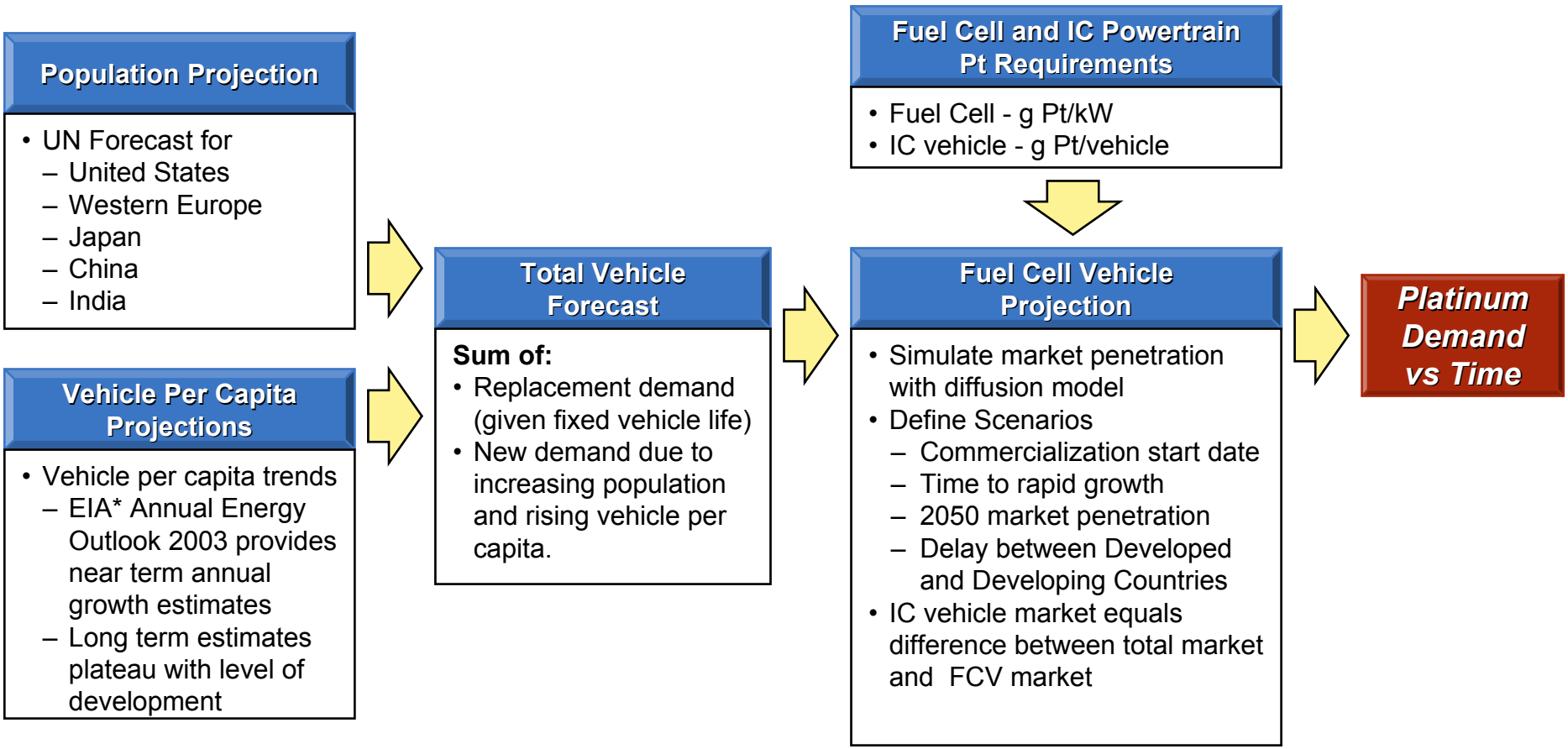
Collaboration

- Discussions with experts in finance, metal catalysts, and automotive OEMs
- Feedback from the Fuel Pathways Integration Technical Team

This project updates a 2003 TIAX study on platinum availability and assesses the benefits of a platinum leasing program to support FCV commercialization.

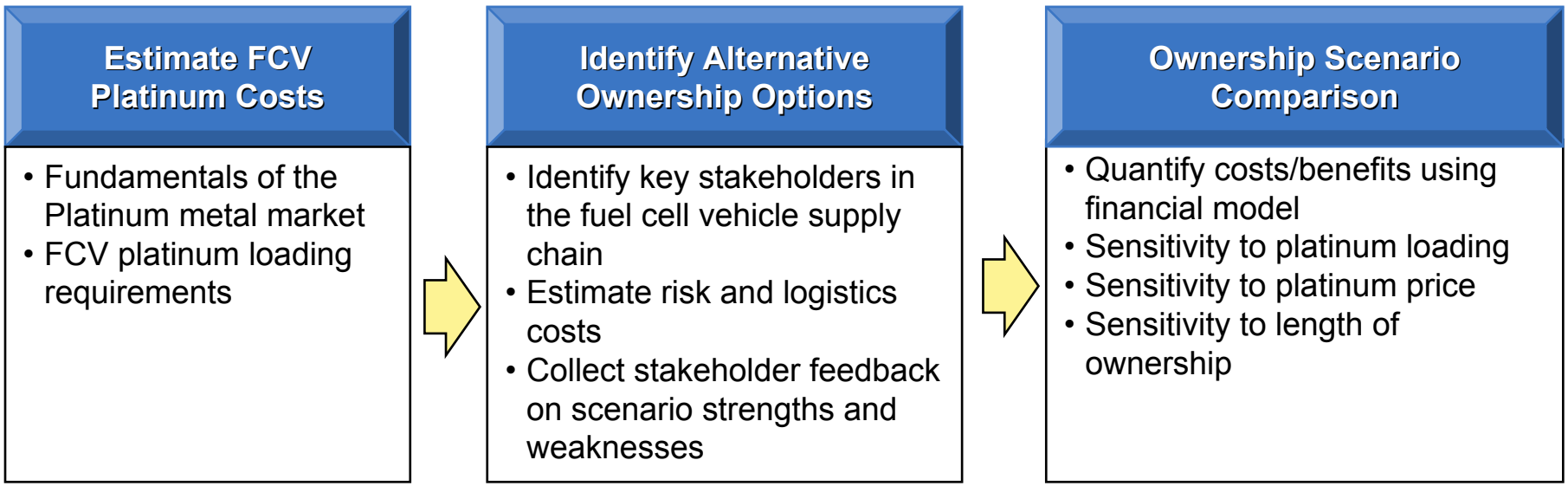
Objectives	1.) Assess constraints on platinum availability under high fuel cell vehicle (FCV) penetration scenarios. • Are worldwide platinum resources sufficient to support high market penetration of FCVs? • Can the platinum supply infrastructure meet the projected demand? 2.) Identify and quantify the benefits of alternative platinum ownership scenarios: • Can upstream suppliers offer significant cost savings by internalizing the residual end-of-life value of platinum in an FCV's upfront cost? • What are the risk factors and transaction costs associated with a leasing program? • Given likely FCV supply chains, how could such a leasing program be structured and deployed?

Platinum demand estimates are based on population projections, vehicle per capita scenarios, and projected FCV and ICEV platinum requirements. Supply was estimated from the literature and compared to these demand projections.

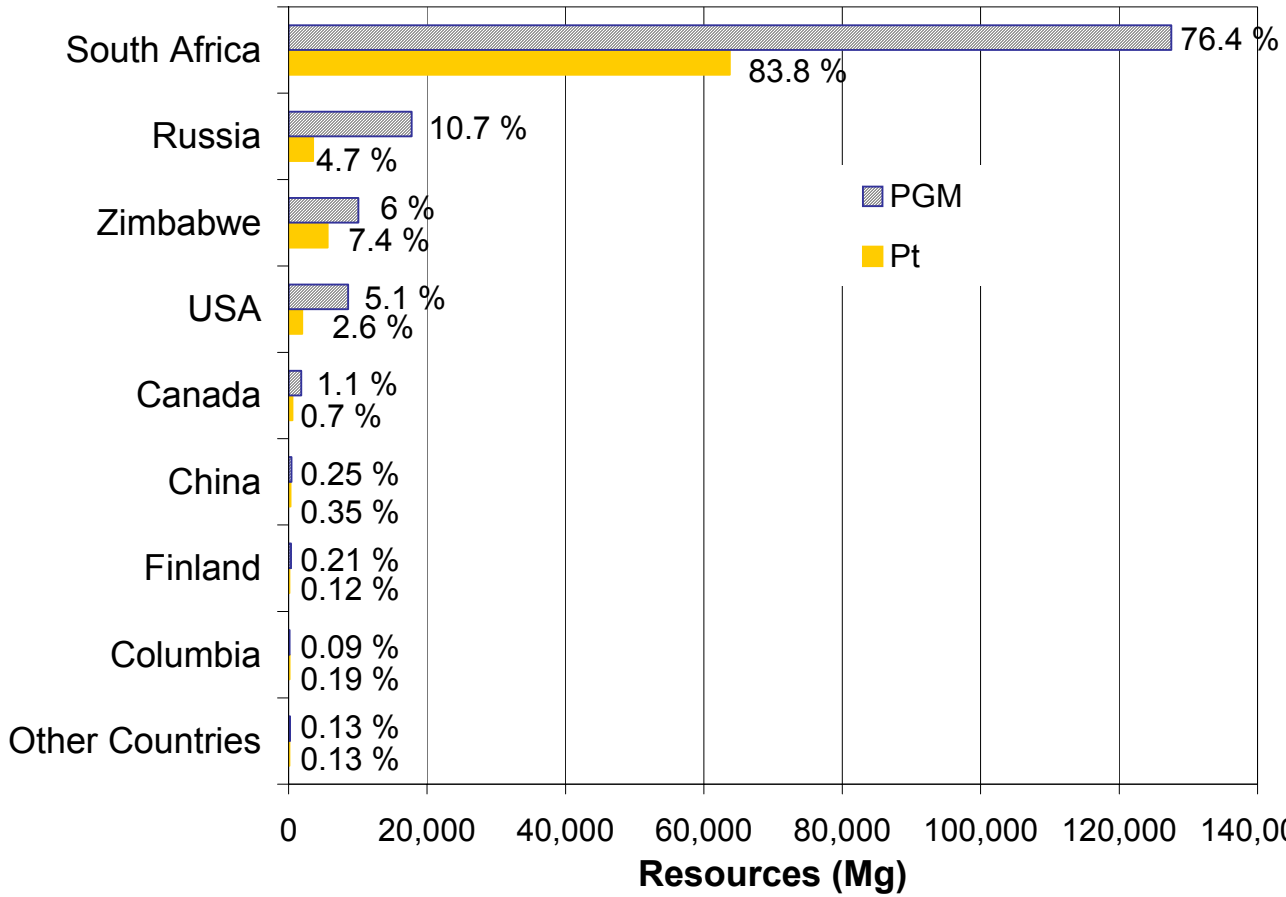


* *EIA: DOE Energy Information Administration*

Alternative platinum ownership scenarios were characterized based on analysis of automotive supply chains, the metal lending market, and the automotive finance industry.



TIAX projects that world resources for all PGMs are about 160,000 Mg, and that platinum resources alone are about 76,000 Mg.



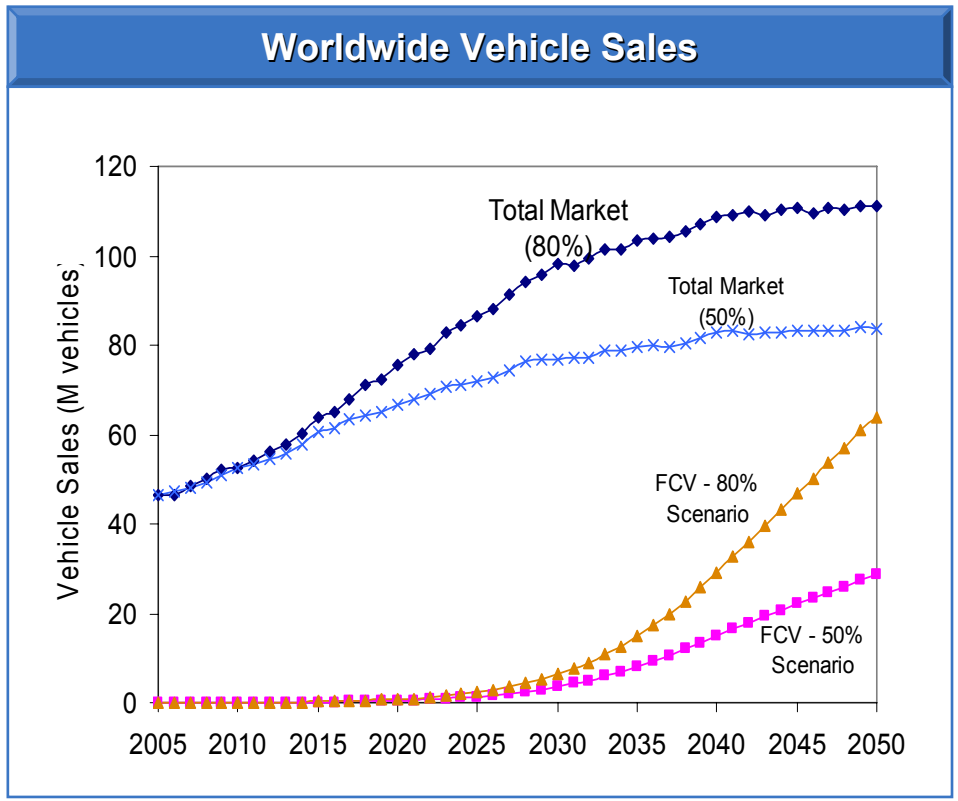
Source: Compiled from a variety of sources, including Cawthorn, Vermaak, Page, Mining Weekly, and Stribyn

Under high FCV penetration scenarios, the worldwide transportation sector will rely very heavily on South African and Russian platinum suppliers.

Based on population and motorization projections, we developed two FCV adoption scenarios on which to base our future platinum demand estimates.

FCV Adoption Scenario Assumptions

Factor	50% Scenario	80% Scenario
Market Penetration in 2050 (% New Vehicle Sales)	50%	80%
FCV Market Entry[1] (Developed Countries)	2020	2020
Lag time in FCV adoption by developing countries	15	10
Vehicles per capita growth	11% max (for ~4 years)	12% max (for ~8 years)
Fuel Cell Rated Pwr	80 kW	80 kW
FCV Pt Loading	16 g/Veh	16 g/Veh
ICE Pt Loading[2]	3 g/Veh	3 g/Veh
Eff, FCV Pt Recycling	95%	95%

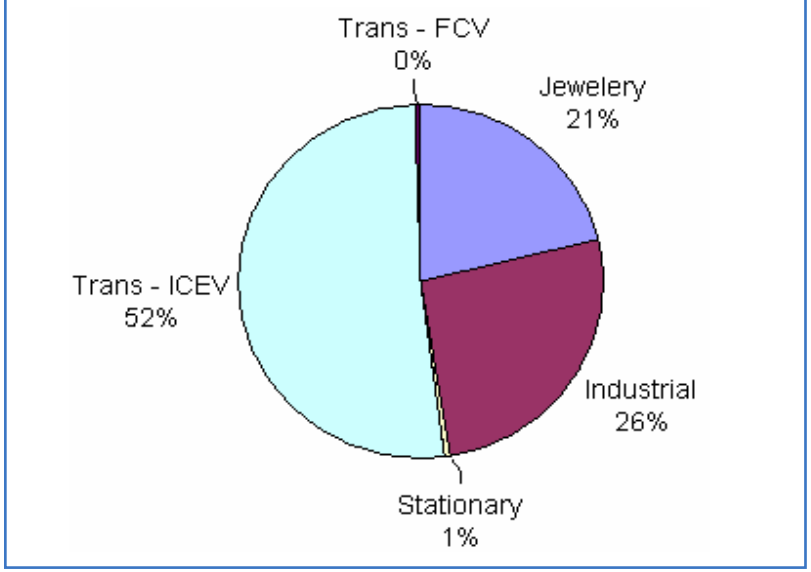


[1] Defined as the first year to have >1% market share

[2] Value is calculated as "platinum equivalence" to account for substitution with palladium for cost effective manufacturing. A 4:1 equivalence ratio between palladium and platinum is assumed to account for the palladium's lower effectiveness.

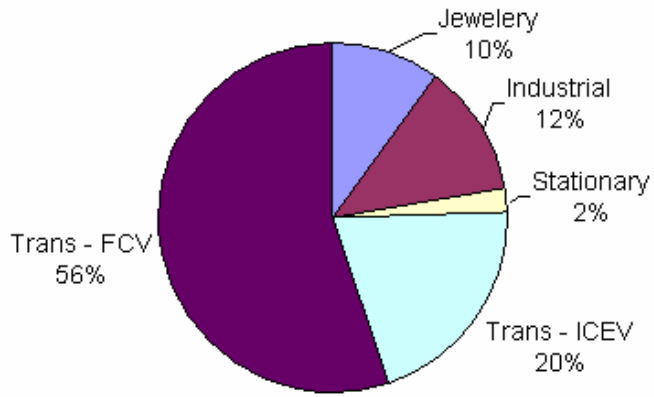
Commercialization of FCVs will make transportation the dominant application for platinum with about 75 to 85 percent of the total market in 2050.

2007: Platinum Demand by Application

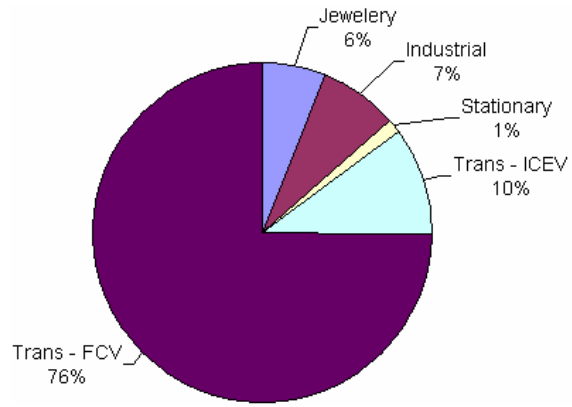


Source: Johnson Matthey, 2007.

50% Scenario
2050: Platinum Demand by Application*

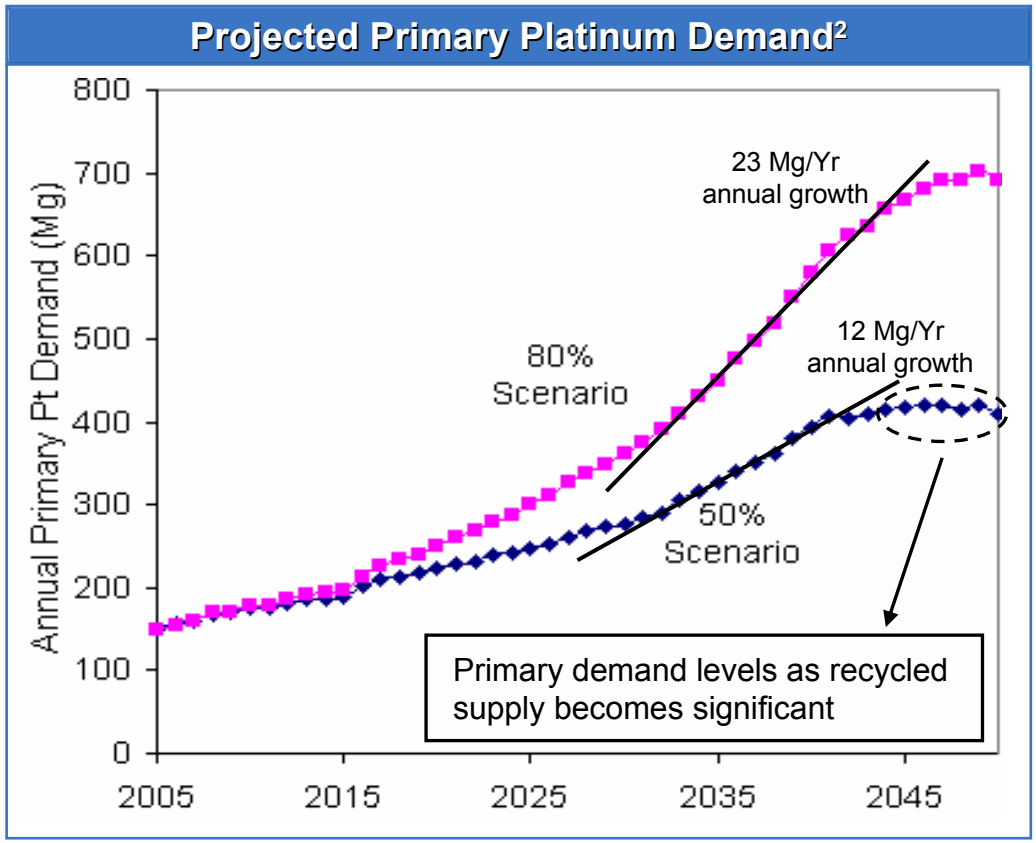


80% Scenario
2050: Platinum Demand by Application*



* TIAX Projections

High penetration of FCVs will place considerable strain on mining capacity during the first several decades of market penetration.



- Industry experts suggest that rates on the order of 12 Mg/Yr are feasible[1]: hence, the 50% scenario is plausible, while the 80% penetration scenario may be constrained by supply infrastructure.
- For reference, supply has grown at a rate of ~6 Mg/Yr over the last 5 years.

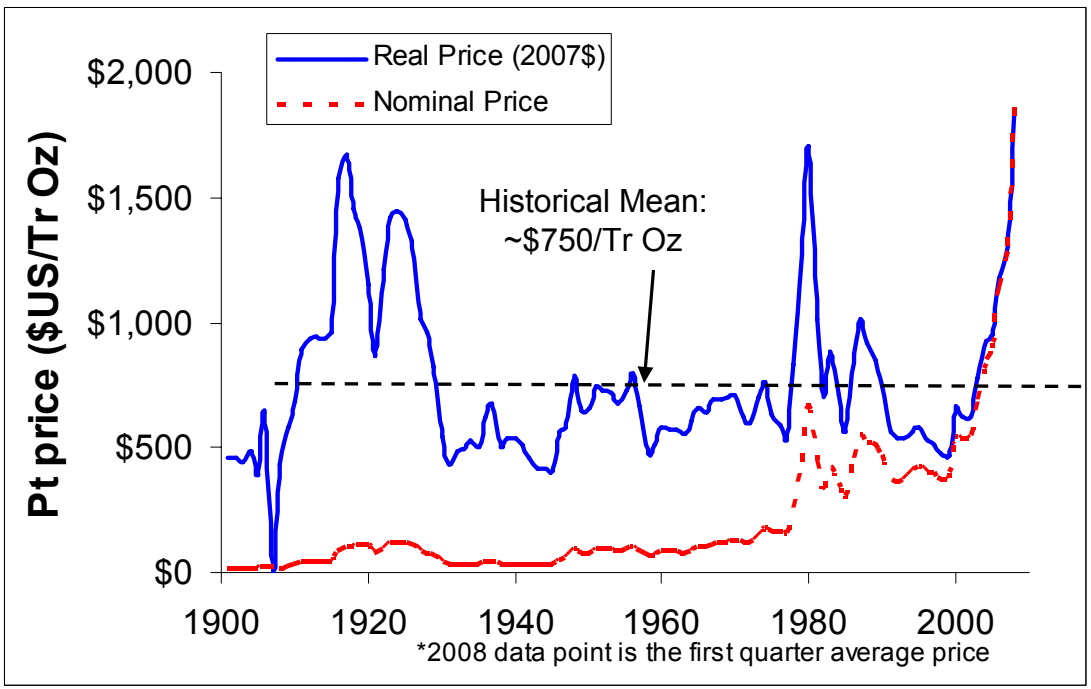
[1]Memorandum from Johnson Matthey to TIAX, (10/2003). More recent estimates (12/2003) were for 10 Mg/yearannual growth.

[2]Assumptions are based on Pt loadings of 0.2 g/kW

However, the platinum resource is sufficient to meet this demand: the projected cumulative demand (13,000 Mg to 17,000 Mg) accounts for 17% to 23% of the projected global platinum resource (i.e., 76,000 Mg).

Although platinum prices have risen sharply in the last decade, market fundamentals suggest that they should revert to a level close to their historic mean.

Historical Platinum Prices

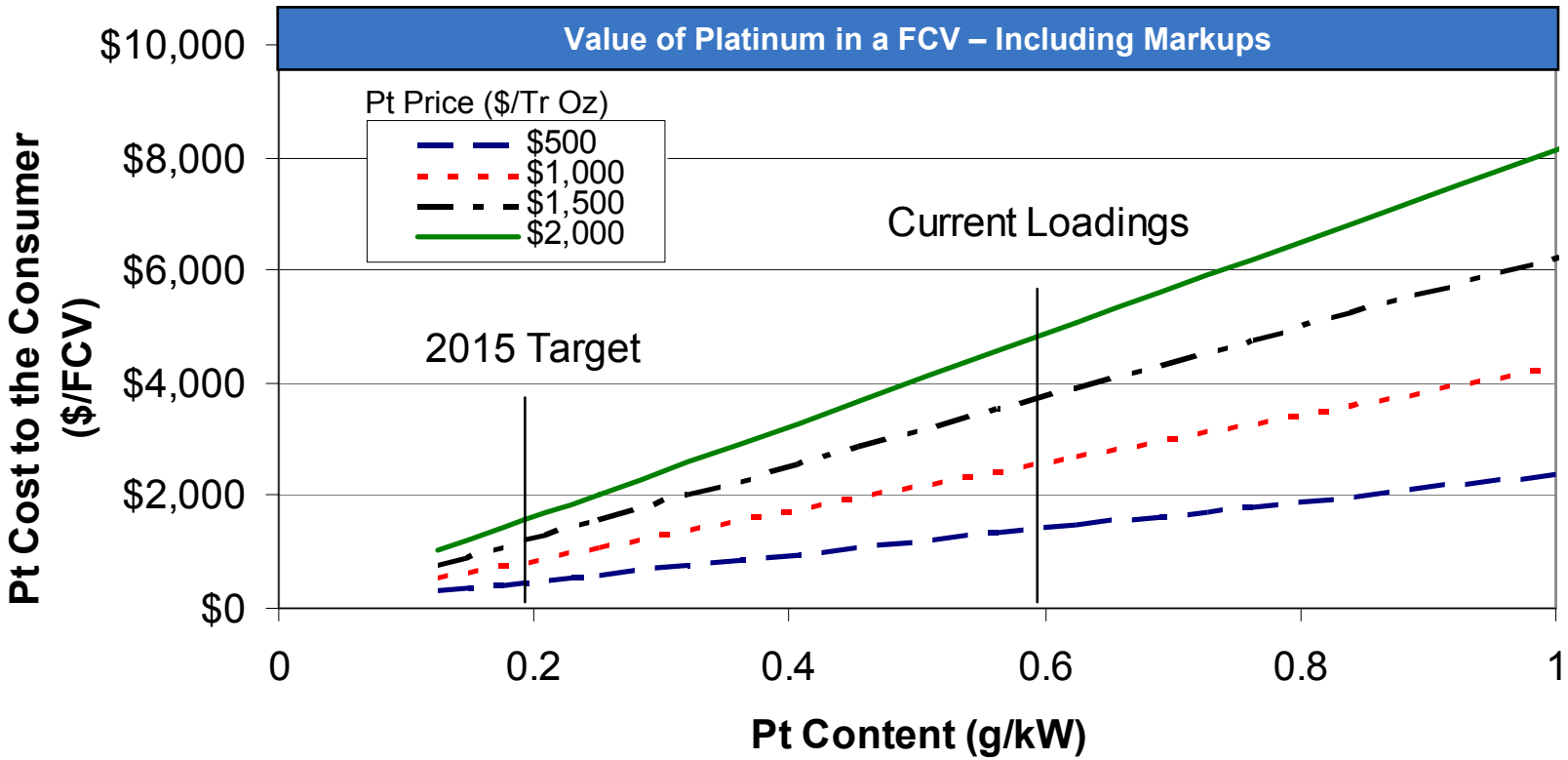


Source: Johnson Matthey, Platinum 2007.

- The recent increase is a function of rising demand due to increasing motorization and dieselization, and limited expansion of supply by the mines.
- Substitutes exist in key platinum markets, so long-term growth of the platinum market requires that industry expand its capacity to meet demand.
- Expanded capacity would likely cause prices to decline from current levels.

If capacity is not increased, platinum markets may switch to other metals.

We estimate that the platinum value in a FCV could range from about $500 at low loadings, up to $5,000 in a high-loading, high-price scenario.



While there is considerable uncertainty with respect to both platinum price and loadings, these calculations suggest a "window" of platinum cost for which a leasing program could be justified.

To characterize the potential benefits of leasing platinum, we evaluated a base case with no lending and two different platinum lease scenarios.

Scenario		Platinum is Owned By:	Platinum is Leased To:	End-of-Life Recovery:
0	**Base Case**	Consumer	No lease	Open market
1	**Upstream Lender**	Government or Bank	OEM	OEM returns Pt to Catalyst Manufacturer
2	**Downstream Lender**	Government or Automotive Finance	Consumer	Lender collects Pt

- The two leasing scenarios incur similar risks. They vary primarily based on differences in the cost of capital / discount rate for different lenders and borrowers.
- Efficient end-of-life platinum recovery loops must be established regardless of the lender. The structure of these loops will vary depending on who owns the platinum.

Depending on the lender's cost of capital and how well risks are managed, the platinum lease rate for FCVs is estimated to range from 9% to 25%.

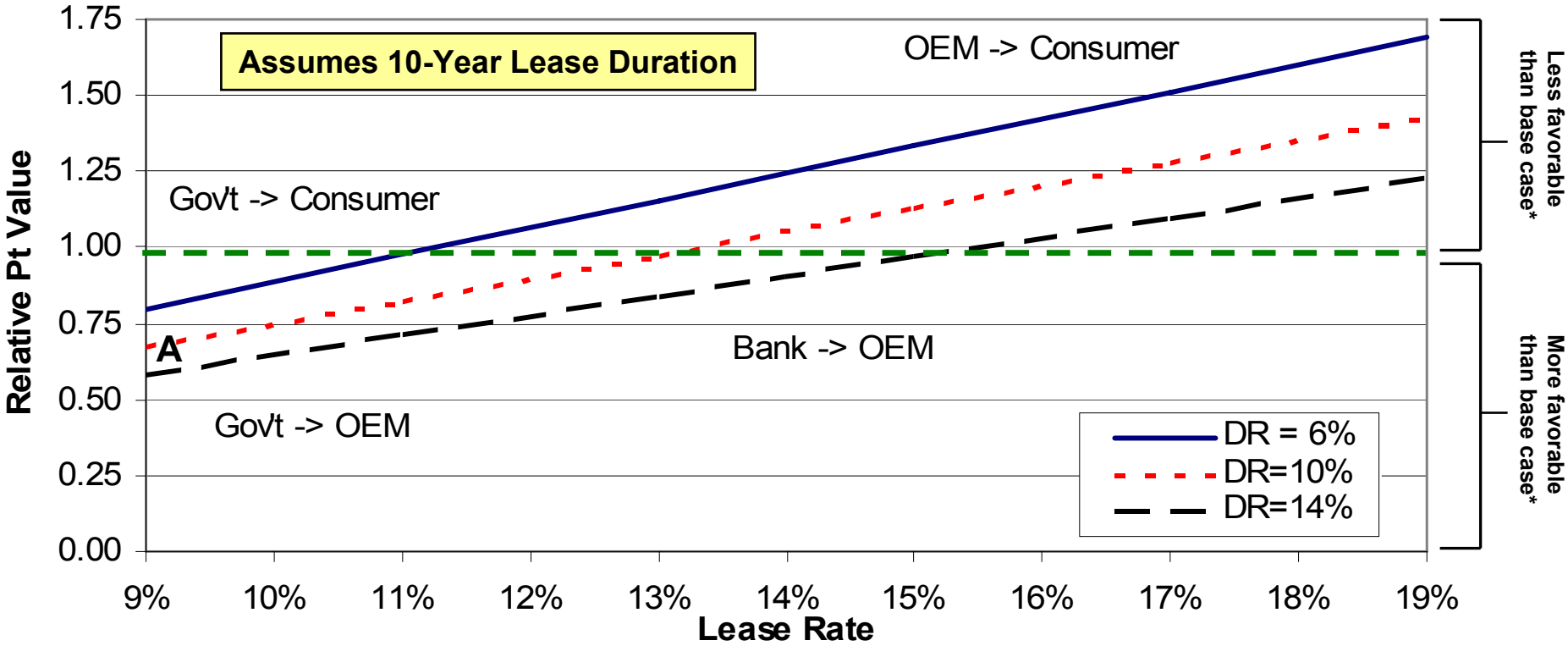
Lease Rate Components	Annual Lease	Description	Estimated from…
Lender's Cost of Capital	5% - 12%	Lender's cost of borrowing money	Typical commercial and government borrowing rates
Price Risk	1% - 2%	Hedging cost imposed by the volatility of metal markets	Metal futures market
Ownership risk	2% - 6%	Costs incurred through the life of the vehicle due to lease defaults, loss, damage, theft, etc.	Risk cost associated with automobile leases.
Recovery Costs	1% - 5%	Costs associated with retrieving spent catalyst, returning it to the catalyst refiner, and reprocessing the spent catalyst.	Catalytic converter recycling costs and reprocessing costs of industrial catalyst
Total	**9% - 25%**		

Our two leasing scenarios differ as to the borrower's discount rate and operational characteristics related to platinum recovery and ownership risk.

Factor	Scenario 1: Upstream Lender	Scenario 2: Downstream Lender
Lender Cost-of-Capital	5%-9% (Gov't to Bank)	5%-12% (Gov't to Auto Finance)
Lender Lease Rate	9%-15% (Gov't to Bank)	9%-20% (Gov't to Auto Finance)
Borrower Discount Rate	10%-12% (OEM)	5%-10% (Consumer)
Ownership Risk	- May require pre-paid lease - Recovery is an issue	- Similar to, but potentially higher, than auto lease rates - Change of ownership is problematic
End-of-Life Recovery	- Indirect lending / dual title makes end-of-life recovery problematic	- Straightforward end-of-life recovery
Price Risk	Determined by platinum price volatility	

The "Discount Rate" is defined as the borrower's weighted average cost of capital; it represents their time-value of money.

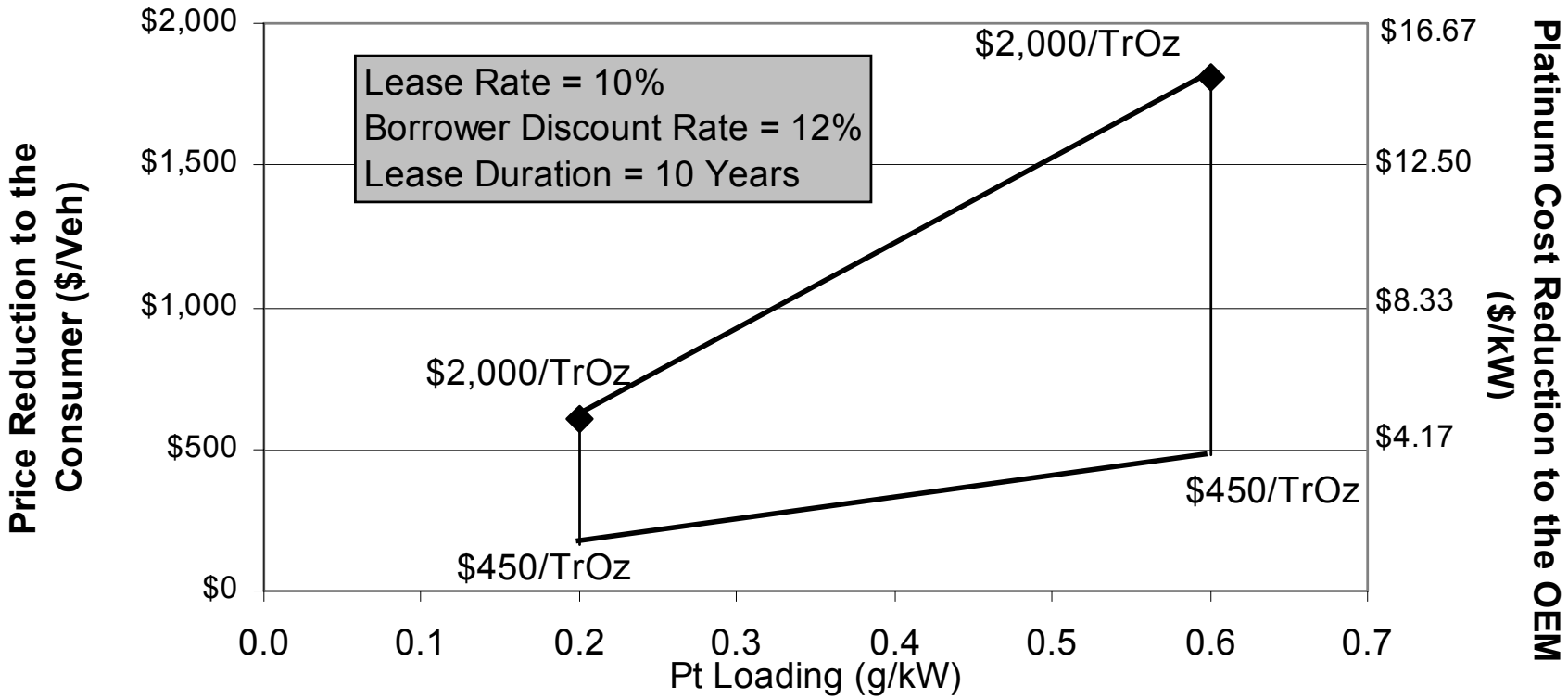
The most promising scenario takes advantage of low government lease rates and a high OEM discount rate, but would require very efficient management of lease risks.



Under low-risk lease conditions (9%) and with a high borrower discount rate (14%), a lease may reduce the upfront cost of platinum in an FCV by 40% (A).

***A "Relative Pt Value" of 1.00 is comparable to the value paid by consumers in the base case. It does not include the future value of end-of-life platinum.**

Under low-risk lease terms, platinum leasing could reduce the cost of a fuel cell system to an OEM by between $1 and $15 per kW.



These savings would result in a vehicle price reduction of between $160 and $1,800 to the consumer, including likely supply chain markups.

Summary

While platinum resources are sufficient to meet projected future FCV demand, growth could be constrained by primary supply capacity. Leasing may provide some cost reductions, but would likely need low interest government financing.

- *Cost of Platinum in FCVs:* Platinum is a major component of fuel cell cost, accounting for almost half (~$3,200) of projected fuel cell system factory cost for an 80kW vehicle. This cost could vary from $500 to $5,000 depending on platinum cost and loading assumptions[1].
- *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 considered 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.
- *Leasing Scenarios:* 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.

1) Based on 2006 projections.

There is a general consensus among industry experts that a leasing program, if attempted, should start small and leverage an early-adopter strategy.

- 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.
- 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.
- Manufacturers are typically uninterested in owning metal. A bank or other financer could have interest, 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.

In addition, most felt that such a program offers only marginal benefits to the consumer, and that reducing platinum loading is the top priority.