Will there be enough platinum?

Fuel cell systems currently require platinum catalysts to produce sufficient electricity to propel an electric vehicle. Automobiles already account for 41% of global platinum consumption for use in catalytic converters (along with palladium, another precious metal) to remove some of the nasty constituents of gasoline engine exhaust gases. Fuel cell electric vehicles will not require catalytic converters, since the only exhaust from a fuel cell is water, so FCEVs trade one platinum use for another. But today's FCEVs use more than ten times the platinum required in catalytic converters, bringing up the question of whether there is enough platinum to support FCEVs.

Some have noted (correctly) that if all cars were converted to FCEVs overnight, then FCEVs would consume the entire world annual platinum production. But that is not the appropriate calculation. Like any new technology, FCEVs will enter the marketplace gradually over many years if not decades. The proper question is whether the mining industry can gradually ramp up production to meet the growing demand for FCEVs, assuming that there is enough platinum in the ground to support that growth.

There are several factors that will shape the use of platinum for FCEVs in the years ahead:

- The growth rate of FCEV sales
- The potential for gradually increasing the mining industry production rate
- The declining use of platinum per vehicle over time as fuel cell companies devise new methods to minimize precious metal loading (including significant research into non-platinum catalysts that would render this calculation mute.)
- The degree of platinum recycling undertaken by fuel cell suppliers to reduce costs (Recycling can recover 98% of the platinum in catalytic converters, and experts believe recycling fuel cell platinum should be less difficult than recycling catalytic converters[1].)
- The ability of non-fuel cell platinum users to substitute other precious metals such as palladium for platinum (which already happens for catalytic converters[2] driven by relative supply and hence prices for these platinum group metals [PGM])

Platinum loading in fuel cells has been dropping rapidly with continuing R&D. Here is the expected trajectory for platinum use per FCEV (80 kW net stacks):

- FCEVs on the road today (with three- or four-year old technology) use something like 65 grams (2.3 oz) of platinum
- Fuel cells based on 2008 demonstrated technology[3]: 39 grams (1.4 oz)

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[1] See UK Department for Transport publication at http://www.dft.gov.uk/pgr/roads/environment/research/cqvcf/platinumandhydrogenforfuelce3838?page=3

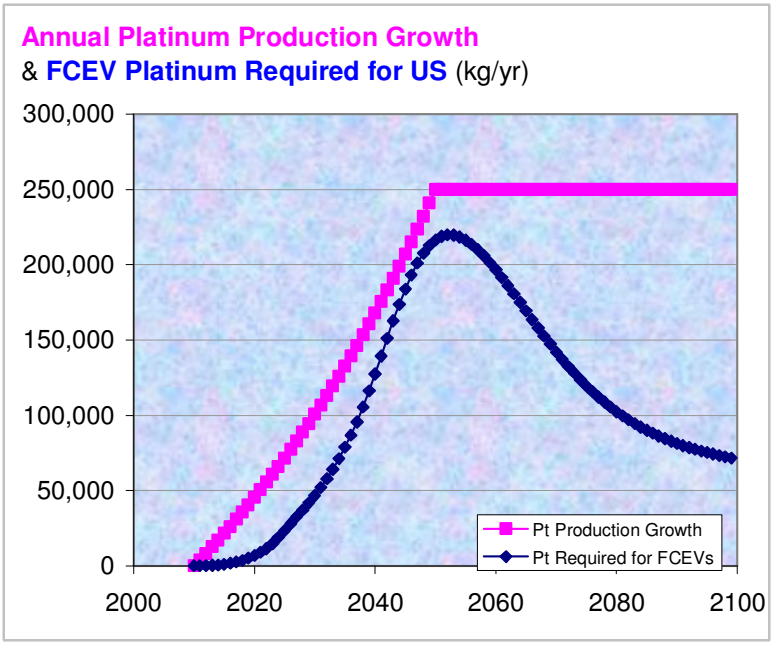
[2] Palladium has been successfully used to replace platinum in gasoline engine catalytic converters, but not for diesel engine exhaust systems which currently use only platinum. Since 50% or more cars sold in Europe run on diesel fuel, more platinum is required in the EU.

[3] See B. D. James and J. A. Kalinoski, "Mass production cost estimation for direct hydrogen PEM fuel cell systems for automotive applications: 2008 update," March 26, 2009 http://www1.eere.energy.gov/hydrogenandfuelcells/pdfs/mass_production_cost_estimation_report.pdf

- Projected 2010 technology: 24 grams (0.85 oz)
- Projected 2015 technology: 16 grams (0.6 oz)

Johnson Matthey has estimated based on their research that fuel cells will eventually reach the 5.7 grams/FCEV range (0.2 oz)[4], but we will not assume these low levels here. Furthermore, we assume that the 2010 goal (24 grams/FCEV) is not achieved until 2015, and the 2015 goal is not achieved until 2020.

The world platinum production reached 207,000 kg in 2007, compared to an estimated world reserve of 80 million kg of economically recoverable platinum[5]. If we assume that 80% of fuel cell platinum is recycled (compared to 98% demonstrated) and a 2%/year platinum production growth rate between now and 2050, then there will be enough platinum to supply the US demand for FCEVs postulated in the NHA's "Energy Evolution" computer simulation[6]:



Platinum Annual Production Growth Rate	2.00% (%/year)
Platinum Required per FCEV in 2010	39 grams
Platinum Required per FCEV in 2020	16 grams
Platinum Recycle Rate	80%

Story Economics.XLS; Tab 'Platinum'; T 29 10/24 /2009

With these assumptions, the US would consume approximately 35% of today's known world platinum reserves by the end of the century. If we take into account FCEVs deployed in the rest of the world with these assumptions, then the platinum supply as we know it today might be stressed under these conditions. However, as with most minerals and fossil fuels, new mining technology always leads to new discoveries of reserves.

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[4] Ibid, UK Department of Transport.
[5] U.S. Geological Survey, http://minerals.usgs.gov/minerals/pubs/commodity/platinum/platimcs06.pdf
[6] See the National Hydrogen Association web page at: http://www.hydrogenassociation.org/general/evolution.asp or an International Journal of Hydrogen Energy article at: http://www.h2gen.com/Uploads/file/Battery_vs_FuelCell_EVs.pdf

However, we have assumed that platinum loading stays at 16 g/FCEV after 2020, while experts are projecting values as low as 5.7 g/FCEV and there are many R&D programs around the world developing fuel cells without any precious metal catalysts. If only 5.7 g/FCEV was sufficient, then a mining industry growth rate of less than 1%/year would be required. In addition, even the mining industry production ramp rate of 2%/year assumed here could be doubled according to the UK Department of Transport, which should be sufficient to cover FCEV introduction to the rest of the world.

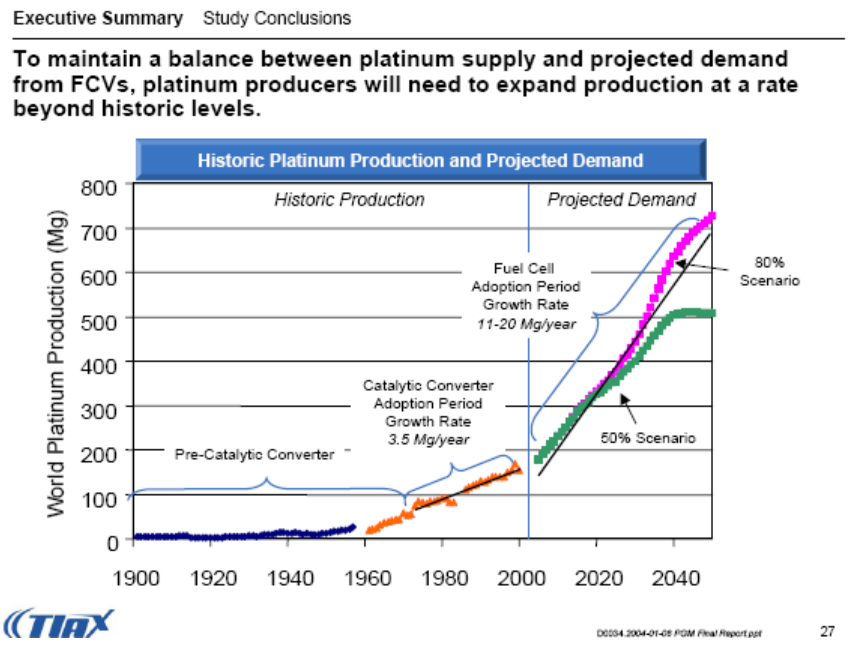
Tiax Analysis. One Department of Energy contractor, Tiax, completed a detailed study in 2003 of the platinum supply considering a world-wide deployment of FCEVs[7]. They considered the other sources for platinum such as jewelry and the expected population and vehicle growth rates in both developed and developing nations. They assumed that platinum use would decrease to 15 g/FCEV by 2025 with 95% recycling of fuel cell platinum.

Tiax considered two scenarios: one assuming that FCEV market share reached 50% by 2050, and the other 80%. For frame of reference, the NHA "Energy Evolution" model assumed 65% FCEV market share by 2050. By coincidence, the NHA assumption is midway between the two Tiax assumptions. Their detailed analysis concluded that these two scenarios for the global FCEV sales would consume between 22% to 26% of currently known platinum resources by 2050. The NHA model predicted that US FCEVs would consume 12% of platinum resources by 2050 (and 35% by 2100.)

Tiax concluded that the platinum mining industry would be able to comfortably supply the worldwide FCEV market at the lower 50% market share by 2050. However, they warned that the 80% FCEV market share by 2050 *"could exceed the expansion capabilities of the (mining) industry."*[8]

They noted that the mining industry did ramp up production in the 1960 to 2000 period to meet the increasing demand for catalytic converters. That expansion is compared with the projected increase in demand for FCEVs in the Tiax chart on the next page. Tiax compared these two periods in terms of absolute annual expansion: 3.5 million grams/year for to meet catalytic converter demand, compared to 11 Mg/yr (50% scenario) to 20 Mg/yr (80% scenario.) But note that the expansions to meet FCEV demand are starting from a much larger mining production base. In terms of *percentage expansion* of mining capacity, these two episodes match a 3%/year expansion as shown on the second figure on the next page.

[7] "Platinum availability and economics for PEMFC commercialization," Tiax LLC report D0034 to the US Department of Energy, Cambridge, Massachusetts, December 2003.
http://www1.eere.energy.gov/hydrogenandfuelcells/pdfs/tiax_platinum.pdf
[8] Ibid, slide 19.



In the following chart, the red squares represent sample points from the Tiax catalytic converter data (1960 to 2000) and the 80% FCEV market share scenario above from 2000 to 2050. The blue dashed line is a 3%/year annual expansion rate from the1960 time period, illustrating that an annual mining growth rate of 3%/year would be sufficient to supply the global platinum demand with the Tiax assumptions. Recall that Johnson Matthey postulated that the mining industry should be able to achieve up to 4%/year annual growth rates.