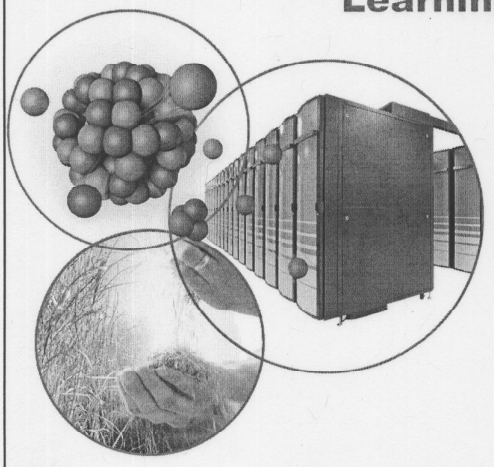
David L. Greene
08-3-5

Bringing Down Hydrogen Fuel Cell Vehicle Costs: Observations on Scale, Learning and Cost-Sharing From an Analysis for the US DOE



Dr. David L. Greene

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A presentation to the California Air Resources Board

Sacramento, California

March 27, 2008

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Our analysis is conditional on several key assumptions.

- **DOE R&D program goals met on schedule.**
- **Hydrogen costs based on DOE's H2A production and delivery models.**
- **2006 EIA AEO Hi Oil price base case: $72/bbl in 2015**
- Three scenarios through 2025, then simulate market response.

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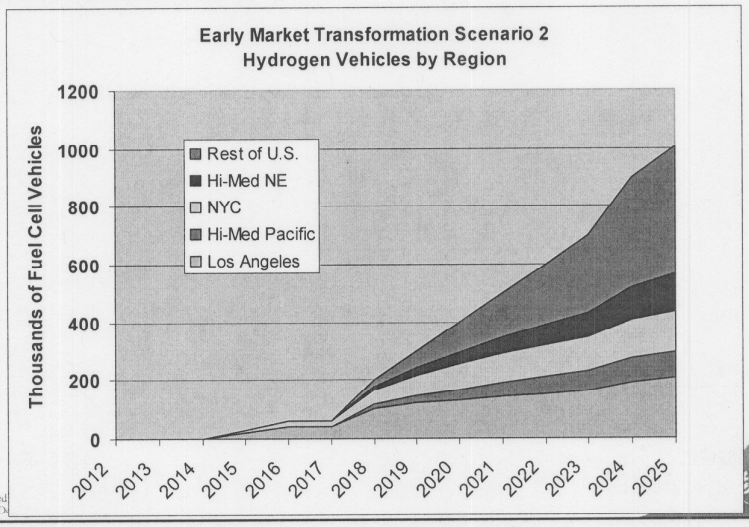
Hydrogen fuel cell vehicles are initially concentrated in a few regions. National annual FCV production in 2017 reaches 60,000 units in scenarios 2 and 3.



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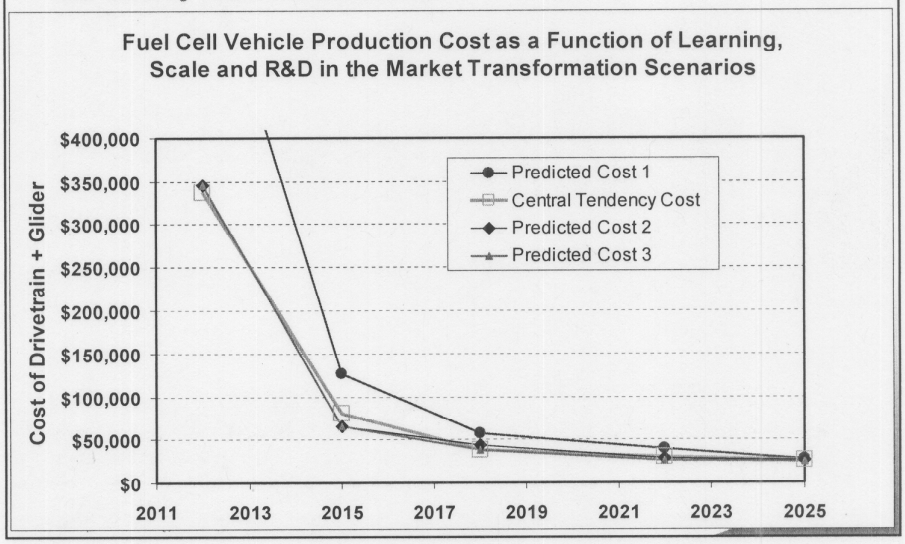
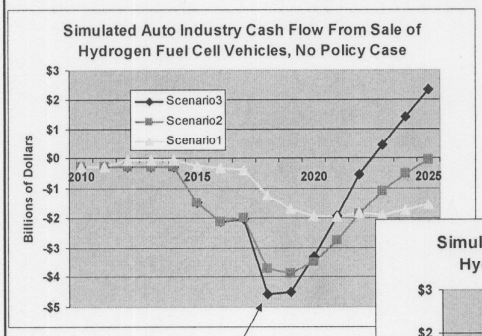
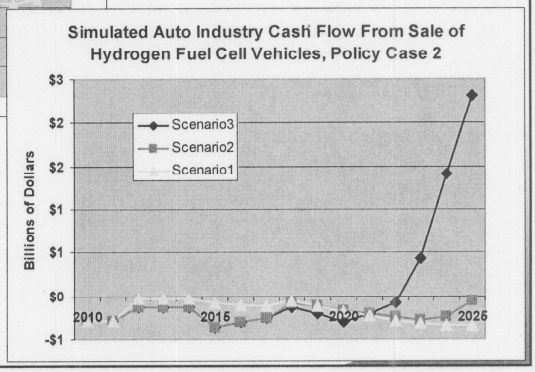
FCV costs depend on technology status, annual production volume and learning-by-doing (cumulative production). Scale elasticity (-0.28) and progress ratio (~0.9) calibrated using proprietary cost estimates supplied by 3 OEMs, cost paths reviewed and OK'd by those manufacturers.



Without government cost sharing a transition to hydrogen vehicles would be costly to the auto industry and prolonged.

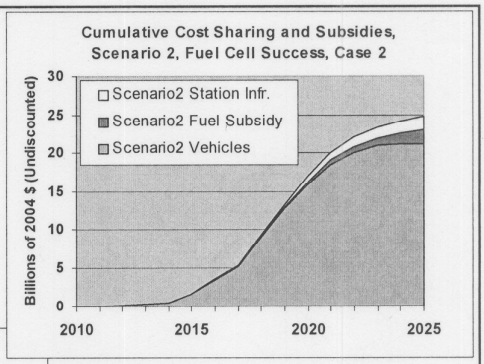


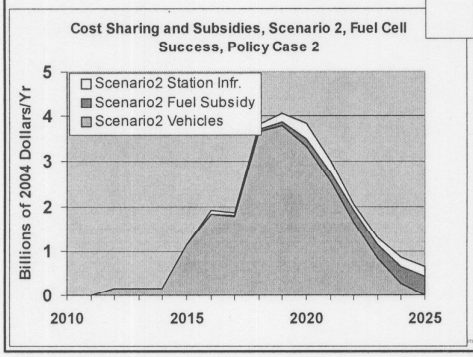
- Fuel availability
- Make/model diversity
- Cost hurdles
  - Scale
  - Learning-by-doing



"Valley of Death" (without government cost-sharing policy)

From a national perspective, the costs of transition appear to be practicable. In scenario 2, annual national costs peak at $4B, cumulative costs reach $25B.





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While our analysis is dependent on many key assumptions, there are some useful insights.

- Driving down costs via scale economies and learning-by-doing is essential to reaching competitive cost targets.
- Meeting technology goals is also very important, but some deviation is probably acceptable.
- Government cost sharing is likely to be essential in the early transition to overcome inherent barriers of
  - Fuel availability
  - Make and model availability
  - Scale and learning-by-doing

THANK YOU.

D.L. Greene and P.N. Leiby, 2007. *Integrated Analysis of Market Transformation Scenarios with HyTrans*, ORNL/TM-2007/094 Oak Ridge National Laboratory, Oak Ridge, Tennessee.

D.L. Greene, et al., 2008. *Analysis of the Transition to Hydrogen Fuel Cell Vehicles & the Potential Hydrogen Energy Infrastructure Requirements*, ORNL/TM-2008/30, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Available on line at:
http://cta.ornl.gov/cta/Publications_Index.shtml

Deployment of Hydrogen Fuel Cell Vehicles by Scenario (thousands)

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Scenario 1	0.0	0.0	0.0	3.0	4.8	7.2	50	100	150	200	250	300	400	500
Scenario 1 Cumulative	0.0	0.0	0.0	3.0	7.8	15.0	65	165	315	515	765	1,065	1,465	1,965
Scenario 2	0.5	1.0	1.0	30.0	60.0	60.0	200	300	400	500	600	700	900	1,000
Scenario 2 Cumulative	0.5	1.5	2.5	32.5	92.5	152.5	353	653	1,053	1,553	2,153	2,853	3,753	4,753
Scenario 3	0.5	1.0	1.0	30.0	60.0	60.0	300	500	750	1,000	1,200	1,500	2,000	2,500
Scenario 3 Cumulative	0.5	1.5	2.5	32.5	92.5	152.5	453	953	1,703	2,703	3,903	5,403	7,403	9,903

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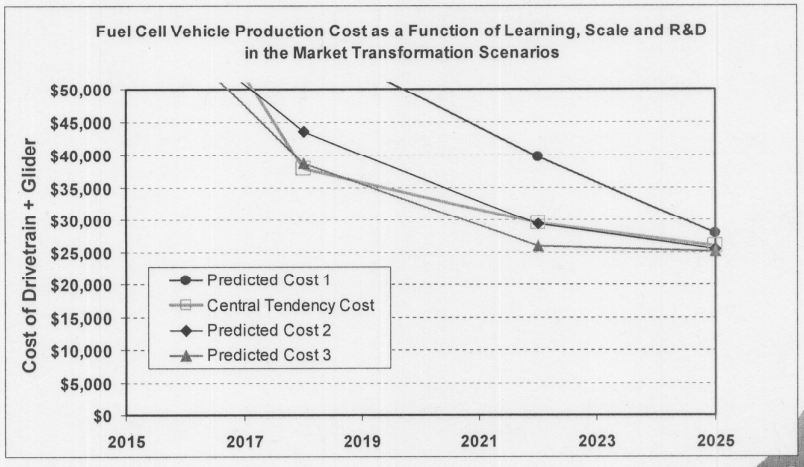
Magnification of scale and learning effects, 2015 to 2025.



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Policy Case 2 – Government cost shares vehicle costs 50/50 to 2017 and provides tax credits after 2018 to cover incremental costs.

- "Fuel Cell Success"
- FCV vehicle production costs (RPE vs HEV) shared
  - 50% total vehicle cost through and including 2017
  - Tax credit covers 100% of incremental cost 2018 to 2025
- Station capital cost starts at $3.3 million, declining to $2.0 million
  - Cost share $1.3 million/station, 2012-2017
  - Cost share $0.7 million/station, 2018-2021
  - Cost share $0.3 or 0.2 million/station, 2022-2025
- H2 fuel Subsidy
  - $0.50/kg through 2018
  - Declines to $0.30/kg by 2025

Details of policy case assumptions.

		2012-2017	2018-2021	2022-2025
Vehicle Cost Sharing	Case 1:	50/50 incremental cost share	50/50 incremental cost share	50/50 incremental cost share
	Case 2:	50% total vehicle	None	None
	Case 3:	50% total vehicle cost share	None	None
Vehicle Tax Credits	Case 1:	None	None	None
	Case 2:	None	100% of incremental cost	100% of incremental cost
	Case 3:	None	100% of incremental cost plus $2,000/vehicle	100% of incremental cost plus $2,000/vehicle
Station Cost Sharing (SMR Production at Station)	All three Cases:	$1.3 Million/Station	$0.7 Million/Station	$0.3 Million/Station
H_2 Fuel Subsidy	All three Cases:	$0.50/kg	$0.30/kg	$0.30/kg