



2010 – 2025 Scenario and Infrastructure Analysis

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Energy Efficiency and Renewable Energy
U.S. Department of Energy**

Presented to

Hydrogen Technical Advisory Committee

January 9, 2007



Related NAS Recommendations and EPACT Provision

NAS Recommendation from 2004 Hydrogen Economy Report

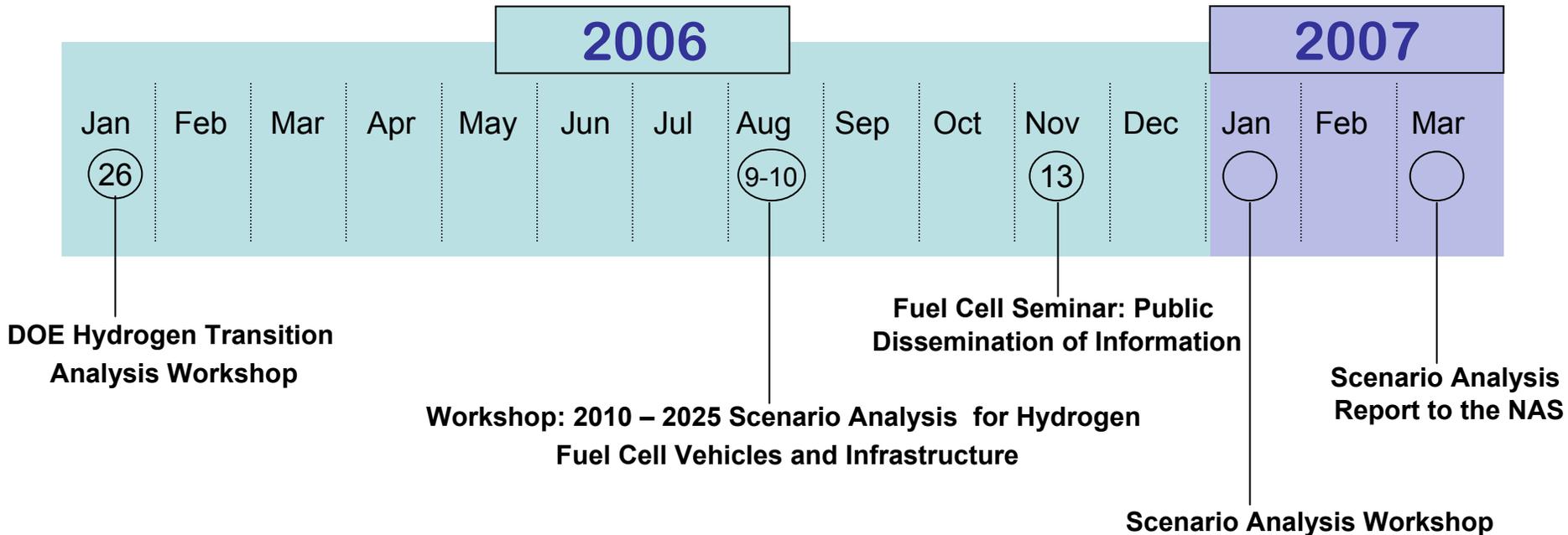
- “DOE should map out and evaluate a transition plan consistent with developing the infrastructure and hydrogen resources necessary to support the committee's hydrogen vehicle penetration scenario or another similar demand scenario.”
- “DOE's policy analysis should be strengthened with respect to the hydrogen economy, and the role of government in supporting and facilitating industry investments to bring a transition to the hydrogen economy needs to be better understood.”

EPACT Provision

- EPACT section 811 requires a report from the Secretary to Congress on measures to support the transition to a hydrogen economy, including those related to producing and deploying hydrogen fueled vehicles and infrastructure.



Responding to the National Academies' Recommendations



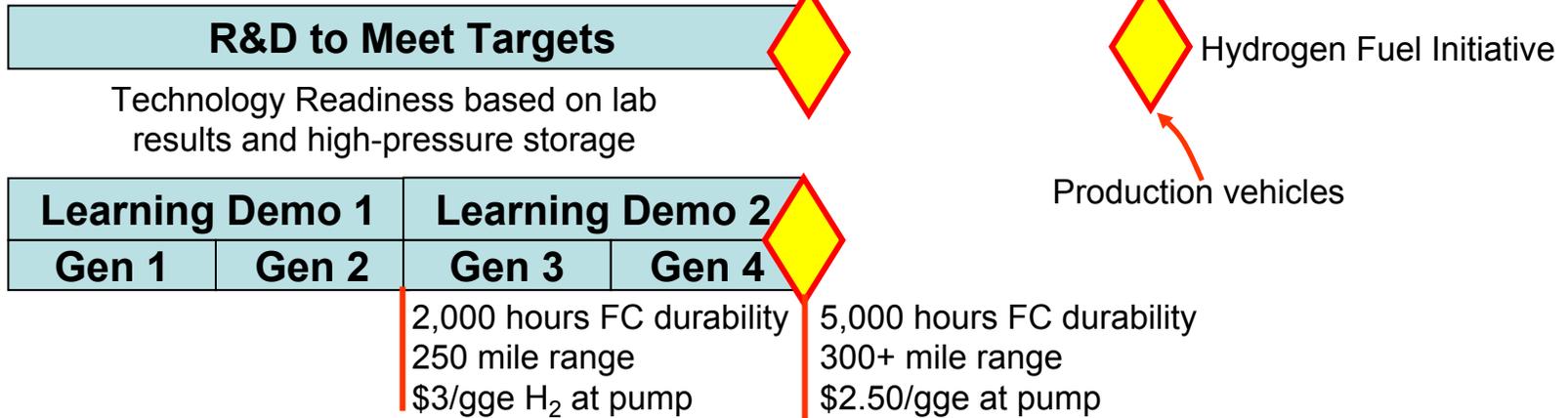
Over 60 participants from Energy and Automotive Industries, Federal and State Governments, National Laboratories and Academia at each meeting

2010-2025 Scenario Analyses



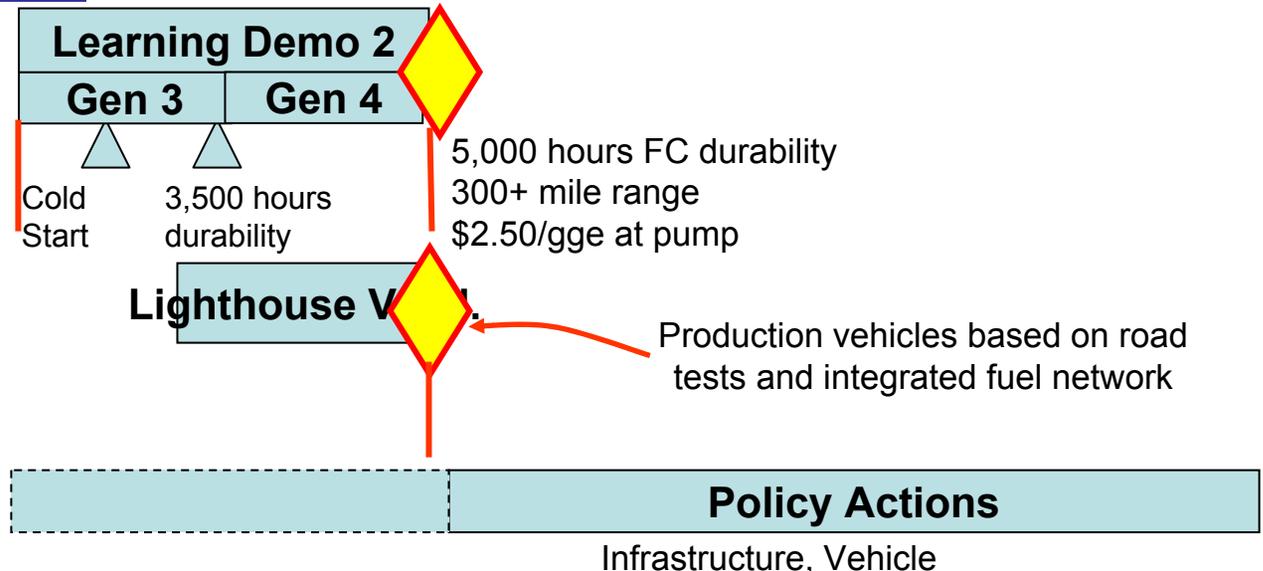
Hydrogen Fuel Initiative

Current DOE Program



Alternative Scenario

Proposed Future Options





Market Penetration Scenarios Considered in DOE Analyses

Transition Analysis Workshops addressed three scenarios – NAS (scenario 3) and two that are more conservative.

Scenario 1: *Hundreds to thousands* of vehicles per year by 2012 and by 2018 *tens of thousands* of vehicles per year. This option is expected to lead to a market penetration of 2.0 million FCVs by 2025.

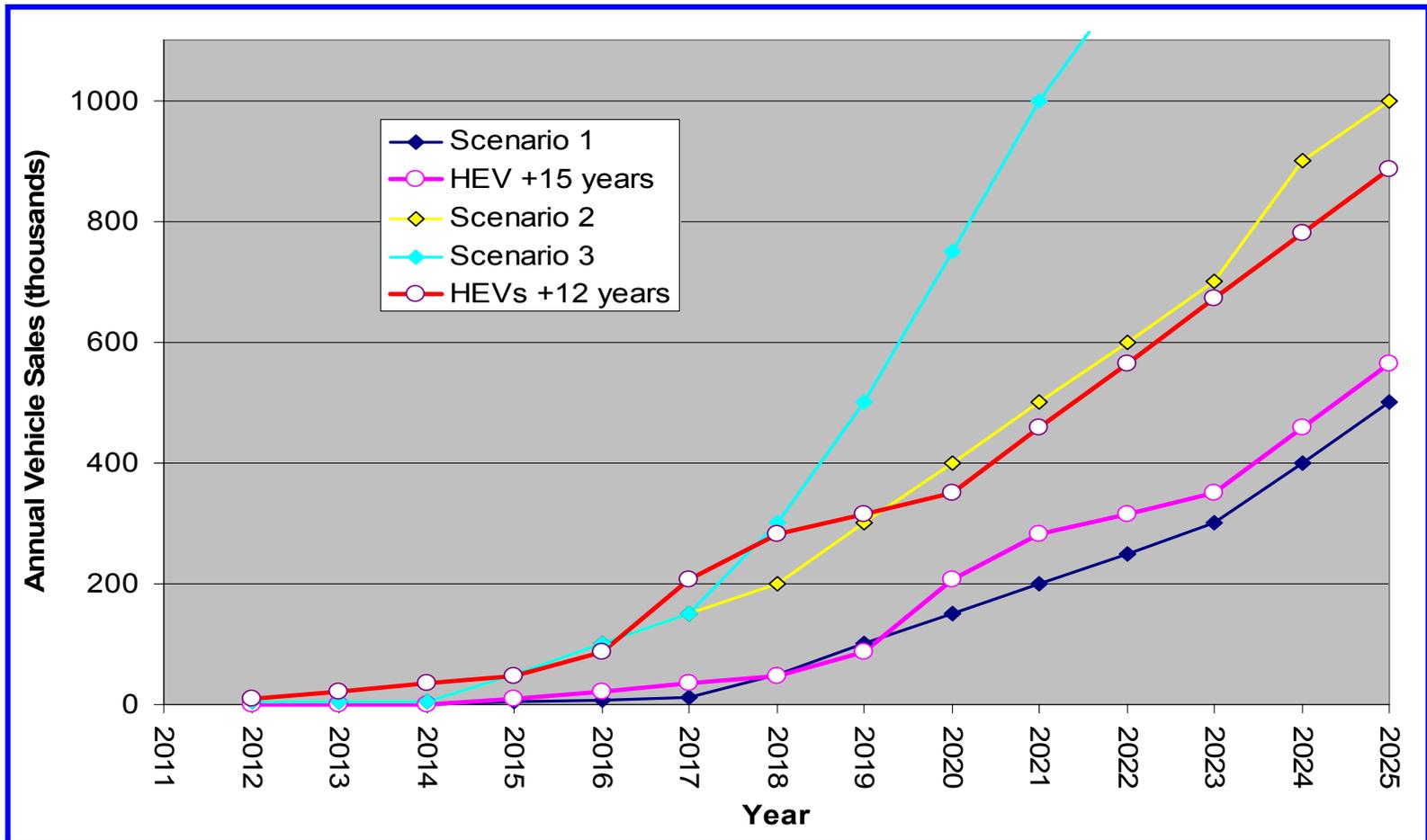
Scenario 2: *Thousands* of FCVs by 2012, *tens of thousands* by 2015 and *hundreds of thousands* by 2018. This option is expected to lead to a market penetration of 5.0 million FCVs by 2025.

Scenario 3: *Thousands* of FCVs by 2012, and *millions* by 2021 such that market penetration is 10 million by 2025. (NRC scenario)

These scenarios are provided for transition analyses as recommended by the National Research Council to evaluate the transition phase and do not represent any specific policy recommendation.

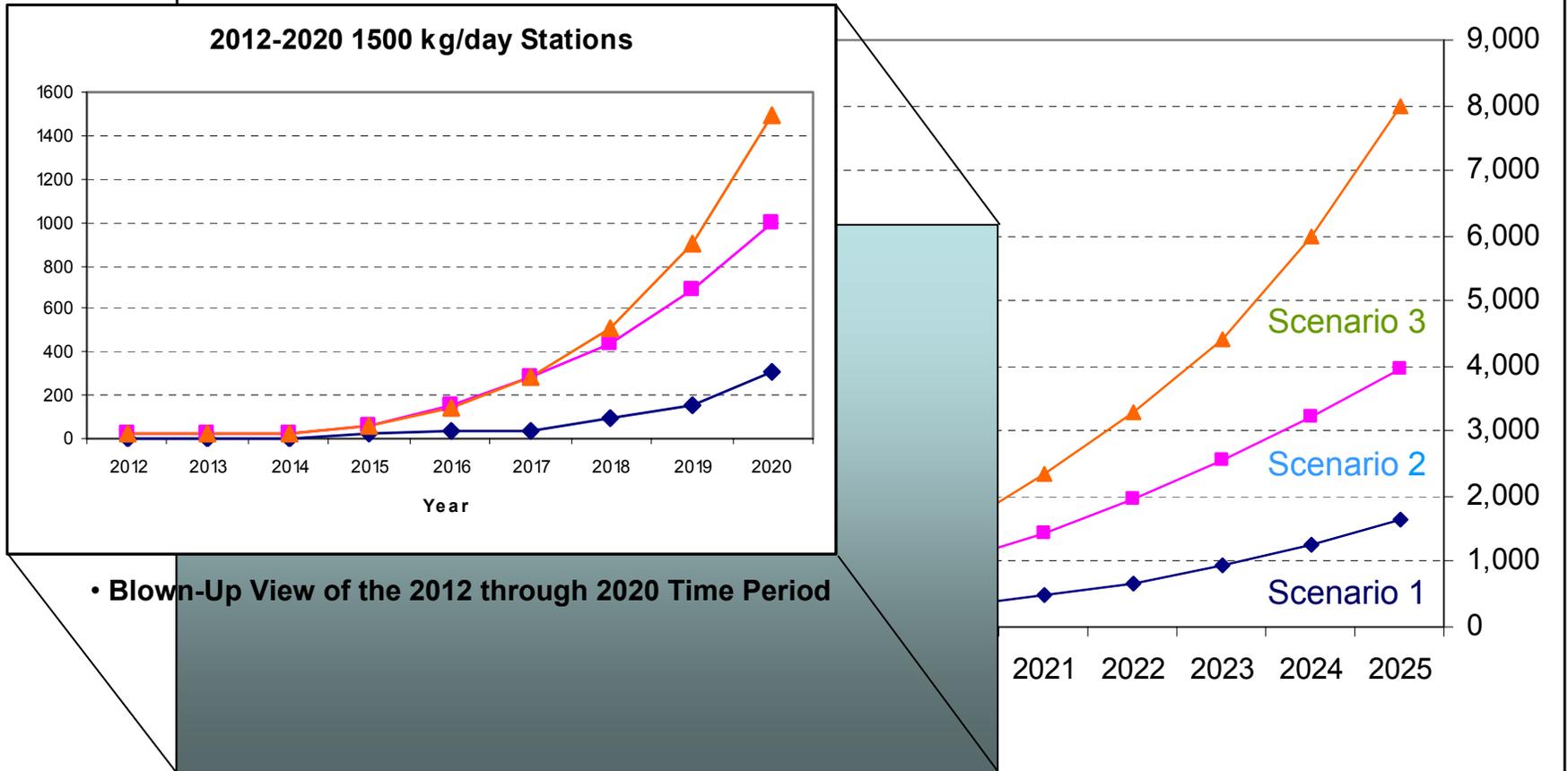
HEV Sales Compared to Scenarios for FCV Vehicle Market Penetration

Scenarios 1 and 2 are consistent with current and projected HEV penetration rates

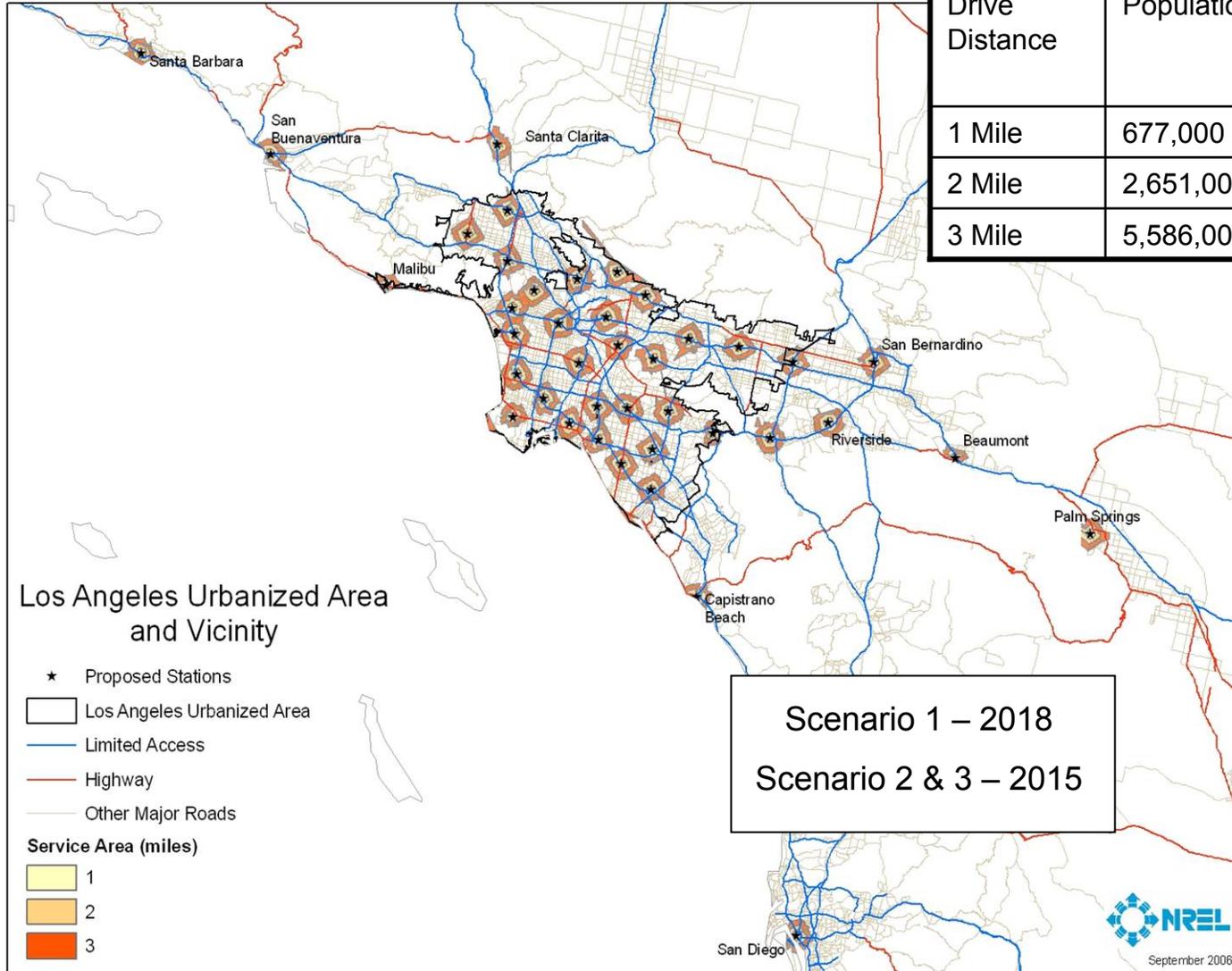


Hydrogen Demand

1500 kg/day Distributed Steam Methane Reforming Stations



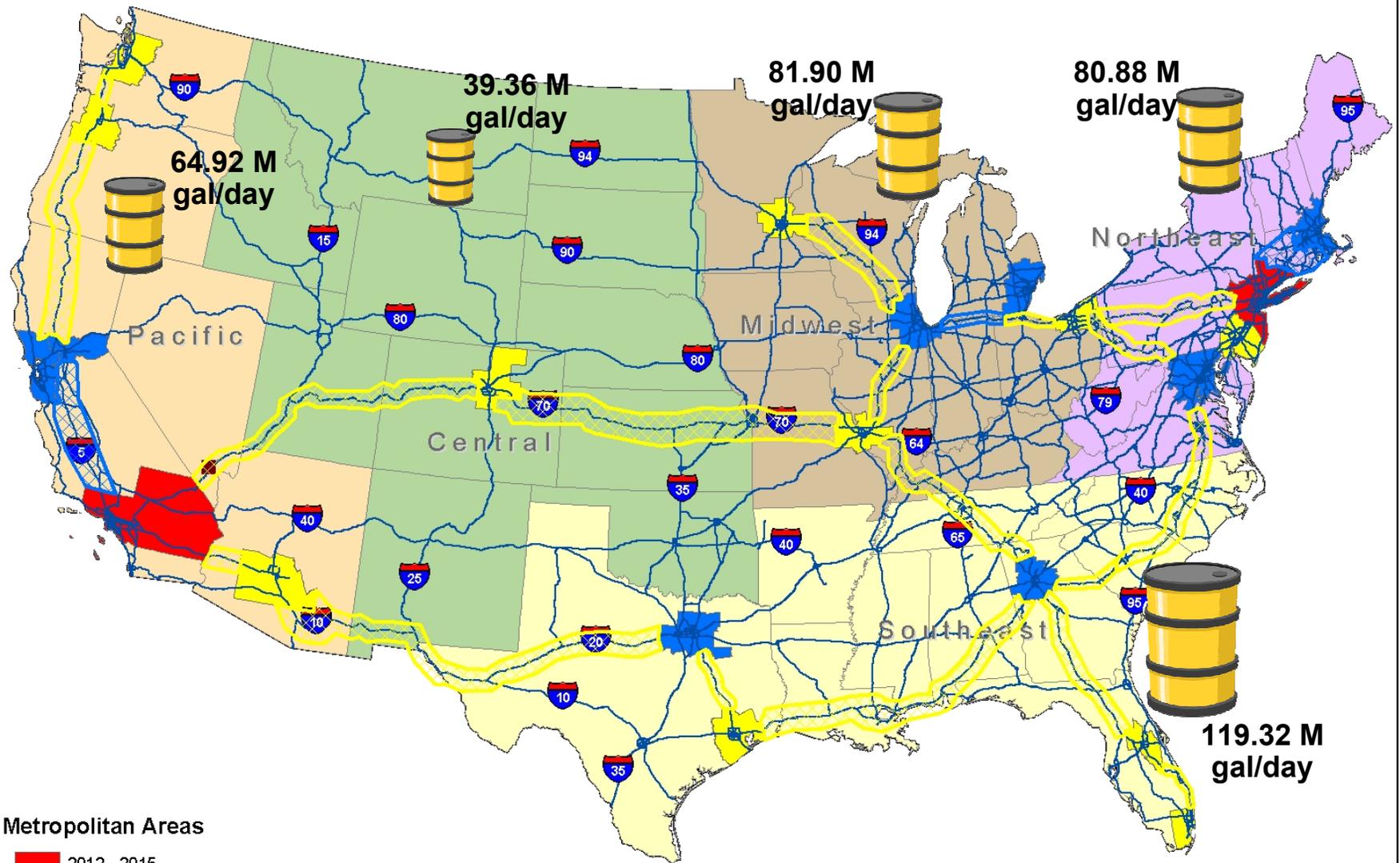
Recommendation from Scenario Analysis Meeting



Drive Distance	Population	% Population <small>(2000 Census LA Urbanized Area and Vicinity)</small>
1 Mile	677,000	4%
2 Mile	2,651,000	14%
3 Mile	5,586,000	30%

Scenario 1 – 2018
Scenario 2 & 3 – 2015

Representative City Deployment and Regional Infrastructure by 2025



Metropolitan Areas

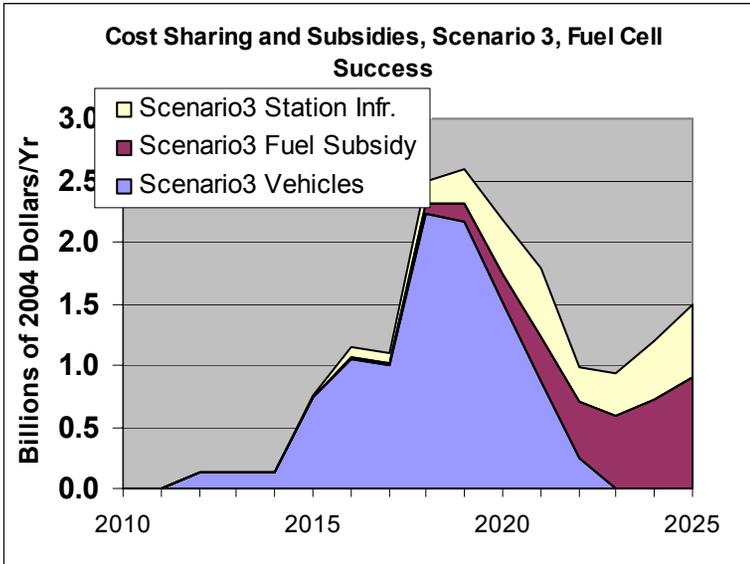
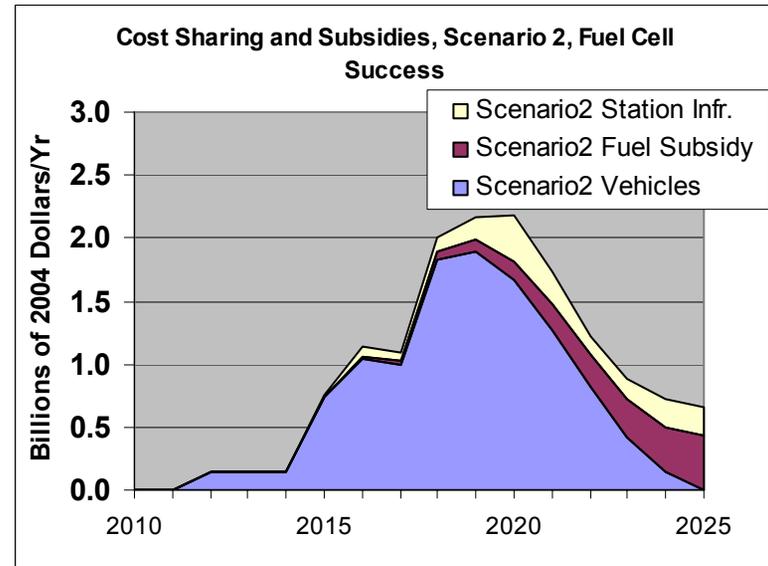
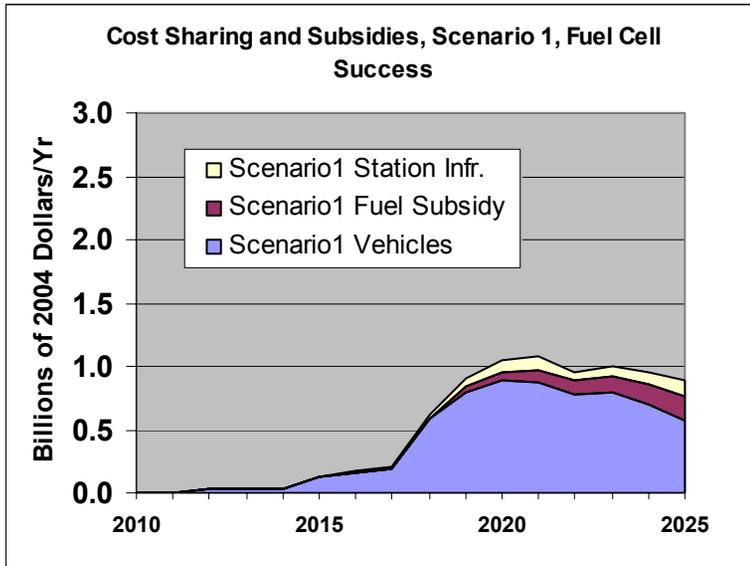
2012 - 2015

2016 - 2019

2020 - 2025

Freeway System

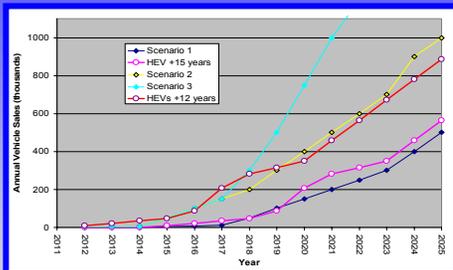
Annual Costs of Cost Sharing and Fuel Subsidy



- Prior Legislation**
- EPACT 2005 Section 805 - Programs- H2 Supply (50/50 cost share)
 - SAFETEA-LU (DOT) – Ethanol Tax Credit (\$0.50/gal.) provided for hydrogen
 - EPACT 2005 Section 808 – Demonstrations (50/50 cost share)

Infrastructure Analysis

Scenario Analysis



Infrastructure Impact Analysis

- Hydrogen supply/ demand
- Resource demand
- Infrastructure requirements
- Constraints and limitations
- Others (CO2 sequestration)

Hydrogen supply/ demand

- Regional demand assessment
- Hydrogen supply cost

Resource Demand (includes feedstocks and utilities)

- Supply/Cost Impact
- Resource availability
- Impact on hydrogen product cost

Infrastructure Requirements

- Pipelines
- Railroads
- Electrical systems
- Land availability
- Offsites (sewer systems, etc.)



Summary

- In response to the NRC recommendation, several scenarios have been proposed for analysis of the possible impact and cost. A report will be presented to the NRC in March 2007 for their further analysis and assessment in compliance with EPACT (section 1825).
- The analysis is meant to identify possible scenarios for establishing hydrogen infrastructure during the FCV market introduction.
- Industry involvement and feedback is an integral part in the development of an inclusive set of scenarios to be analyzed.

Market conditions/economics and policy actions will determine how the hydrogen market evolves.



Acknowledgements

- David Greene and Paul Leiby of Oak Ridge National Laboratory
- Margo Melendez and Anelia Milbrandt of National Renewable Energy Laboratory
- Brian James and Julie Perez of Directed Technologies, Inc.



Additional Information



TRANSITION STRATEGIES

Focus on near-term nascent hydrogen economy

Stage 1:

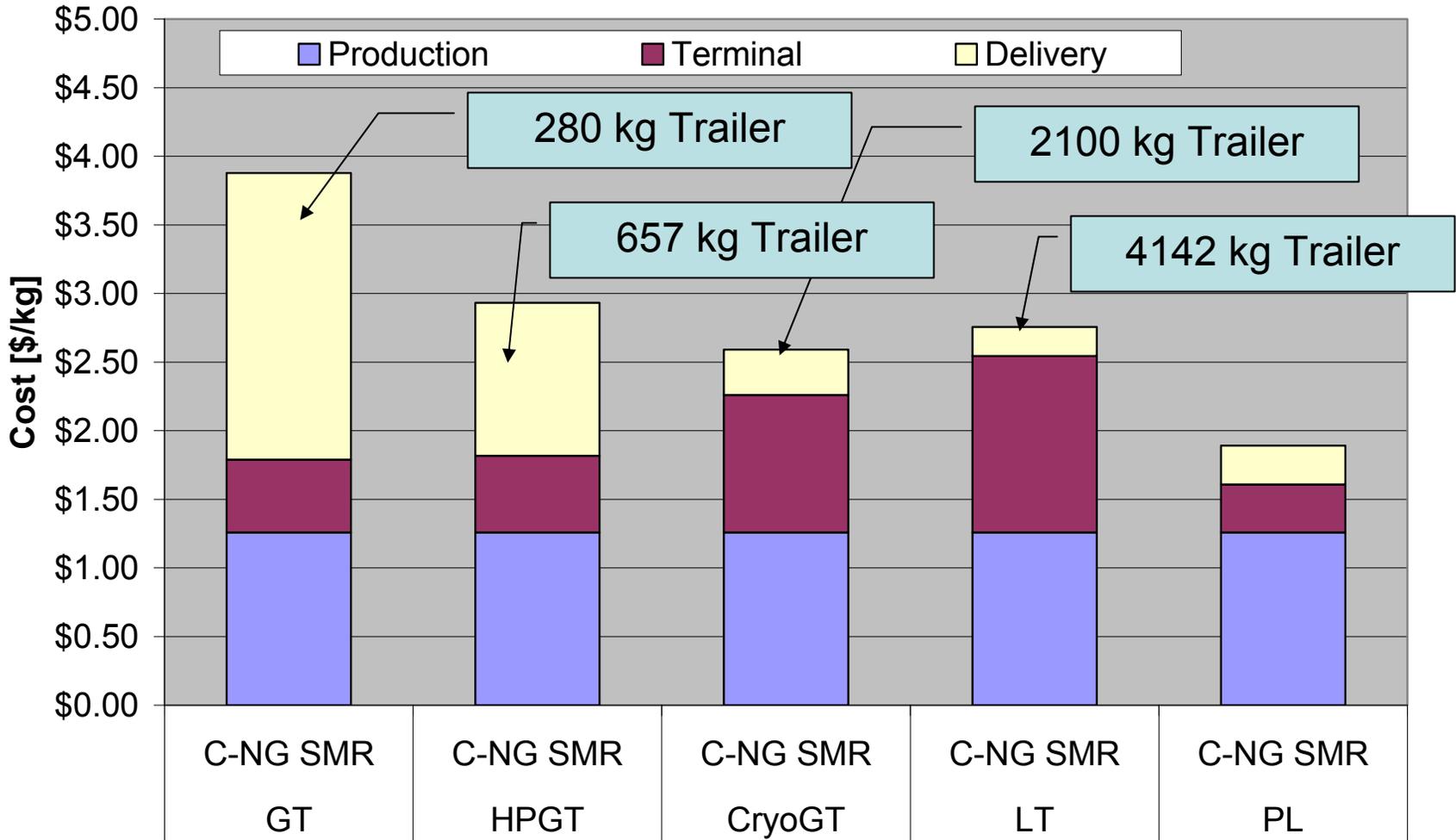
- Forecourt
- Cluster or network from mid-size plant
- Use existing infrastructure
- Investigate liquid delivery systems

Stage 2:

- Nascent interconnect system

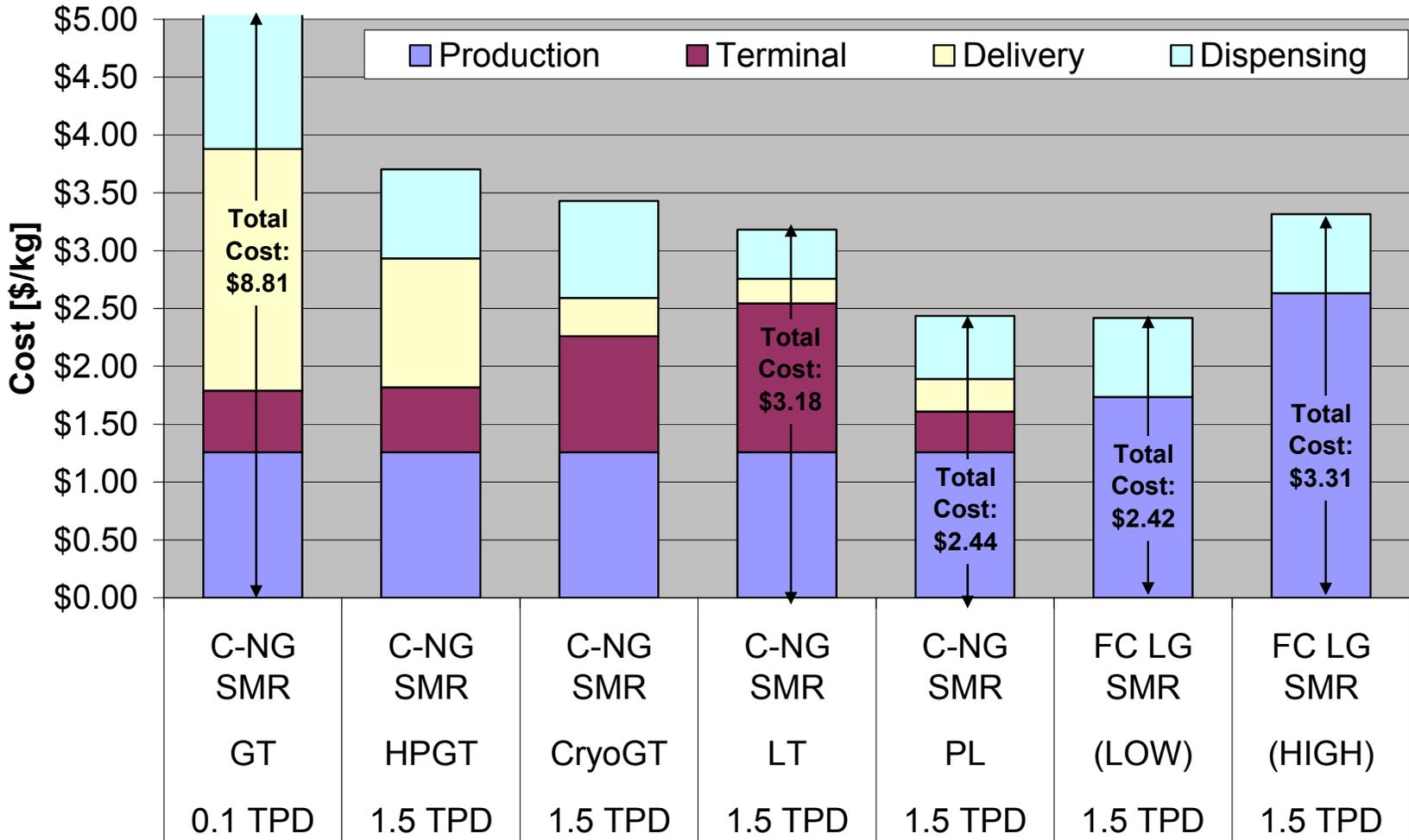
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Delivery Costs



30 miles beyond city edge

Total Pathway Costs

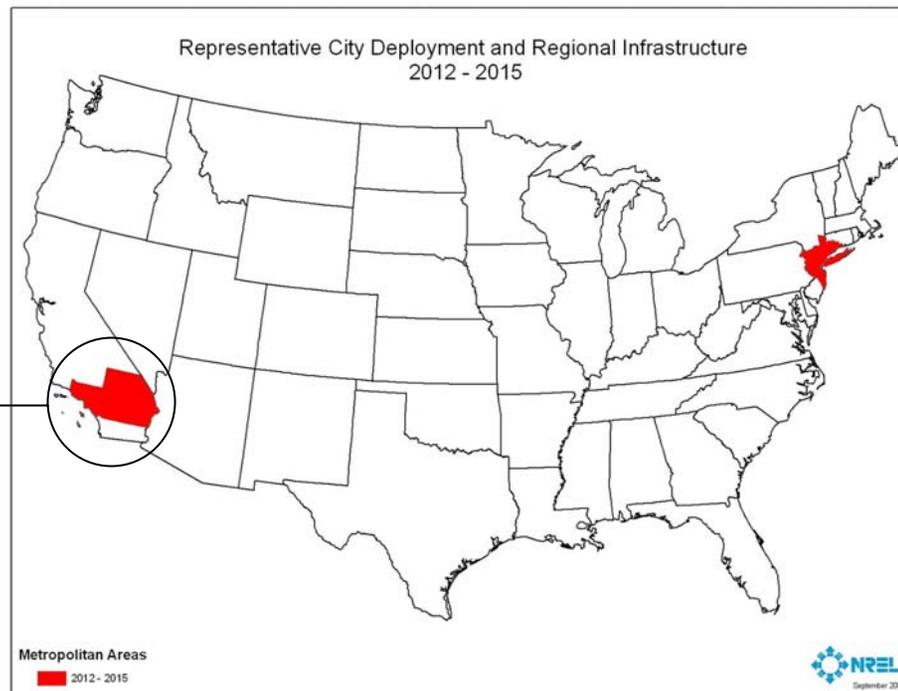


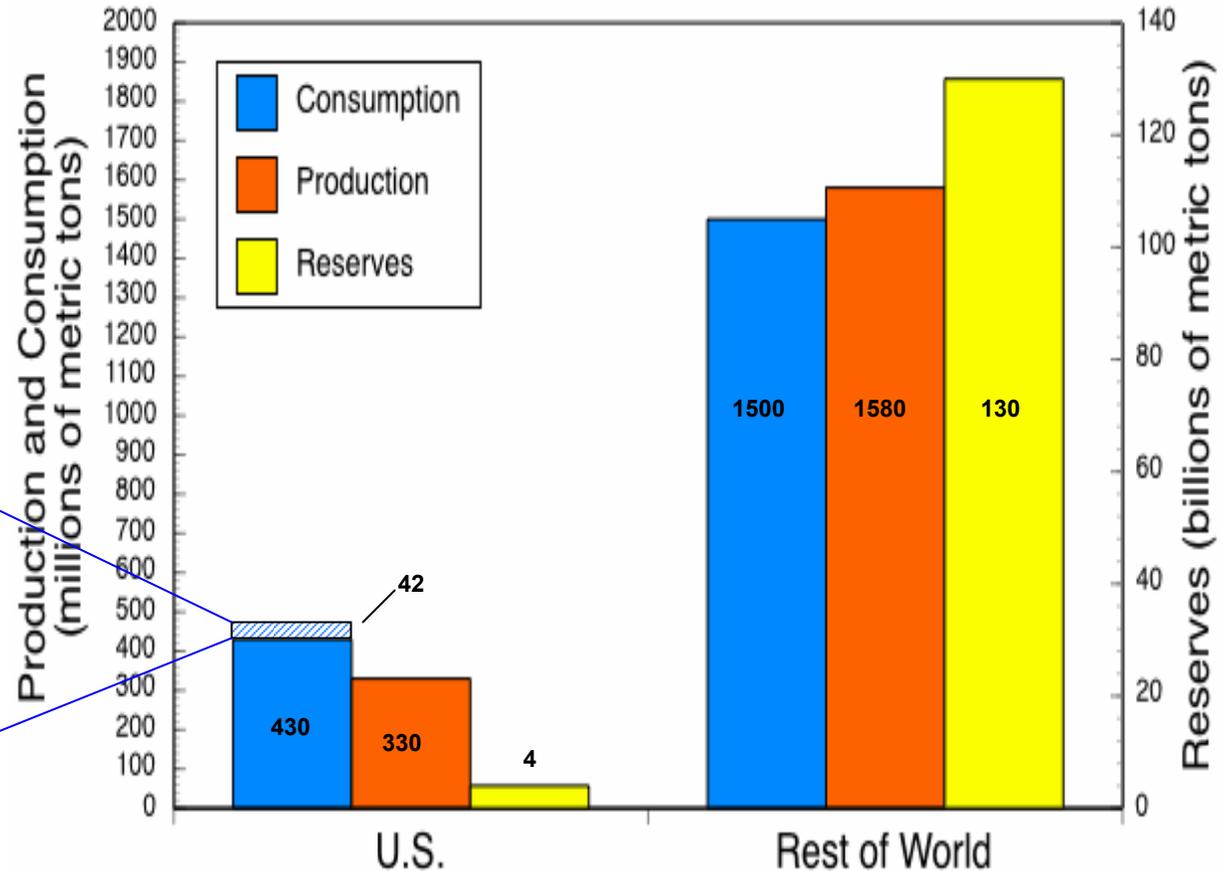
30 miles beyond city edge

Infrastructure Analysis for LA region

- 1,500 kg/day hydrogen refueling station requires about 255,000 cu. ft. per day of natural gas.
- Such a hydrogen refueling station would be considered a large gas load for a local gas distribution company – roughly equivalent to the ave. load of:
 - 1,200 homes, or
 - 150 commercial customers, or
 - One 1,800 kW power plant
- If a new service line is required to supply the natural gas to the distributed reformer, the hydrogen cost will increase by \$0.1 - \$0.2/gge.
- Land for distributed hydrogen facilities is scarce.

Possible Regional Deployment Strategy (NREL Analysis)





Natural gas (42 million metric tons per year) needed to produce 13 million metric tons of hydrogen to fuel 49 million vehicles

Notes:

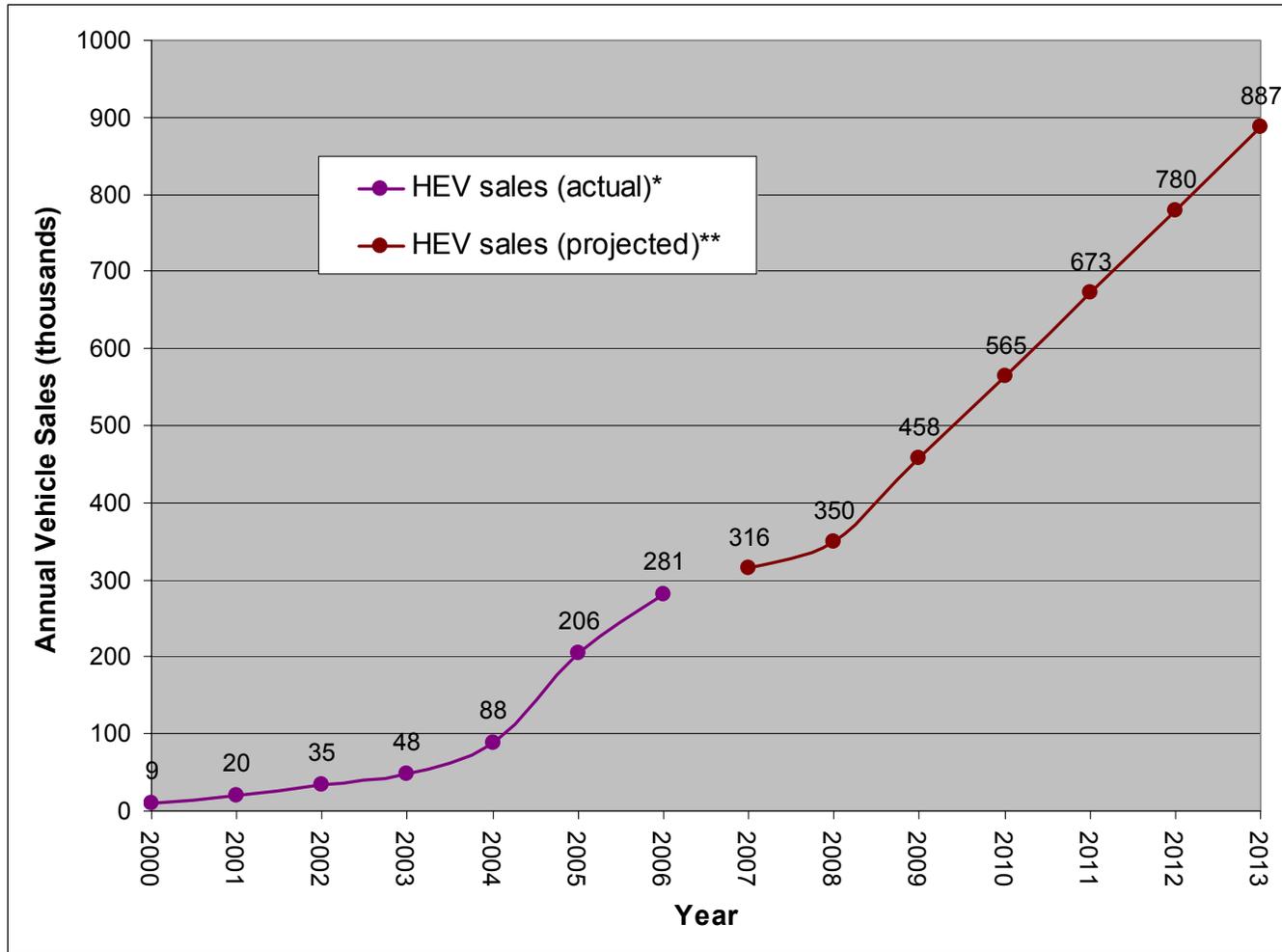
- Reserves as of January 1, 2005.
- Production and consumption data are expressed as dry gas.

Sources:

U.S. DOE, Energy Information Administration, *International Energy Annual 2004*.

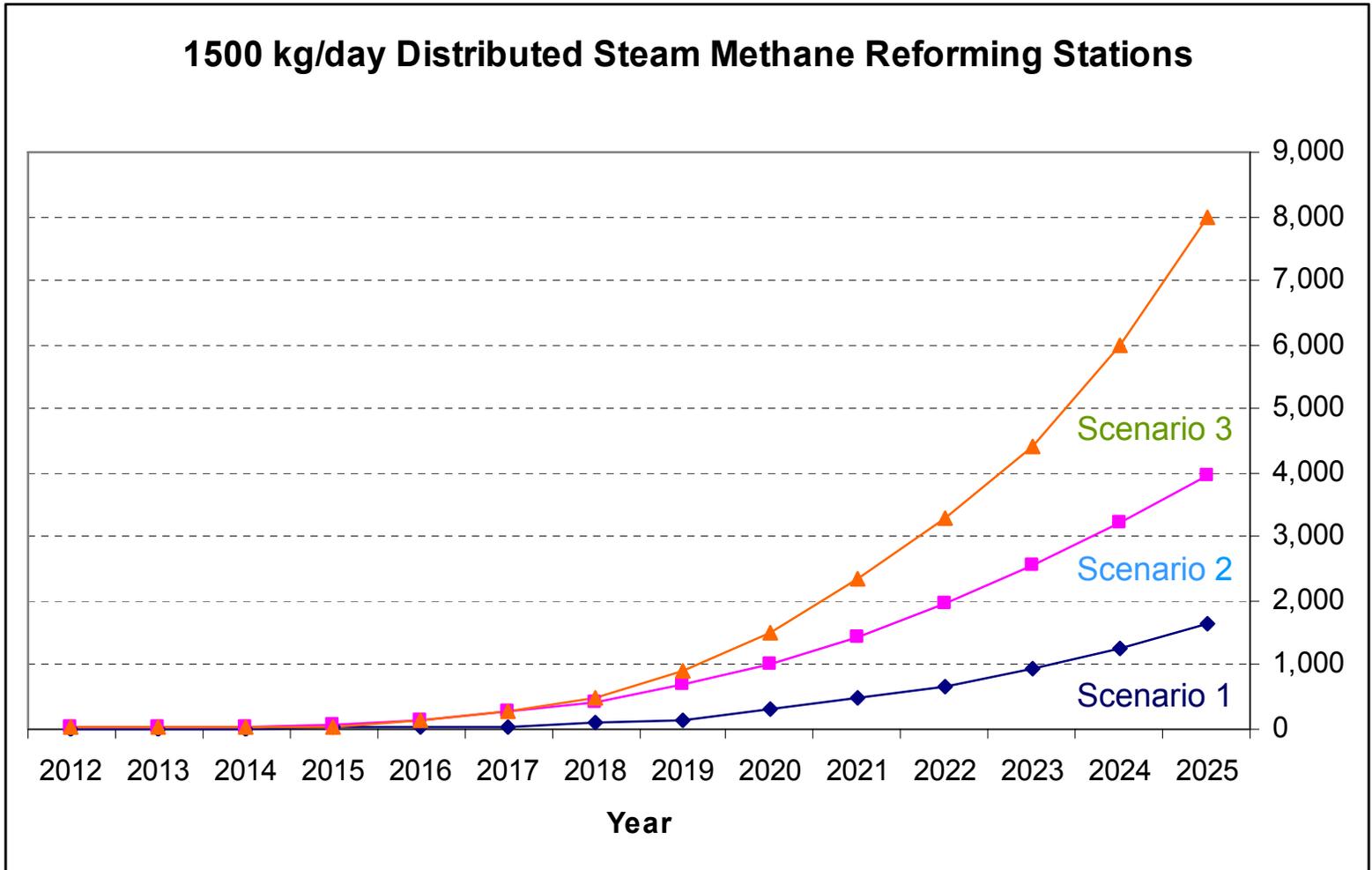


Actual and Projected U.S. HEV Sales



*Data through 2006 From hybridcars.com May 16, 2006

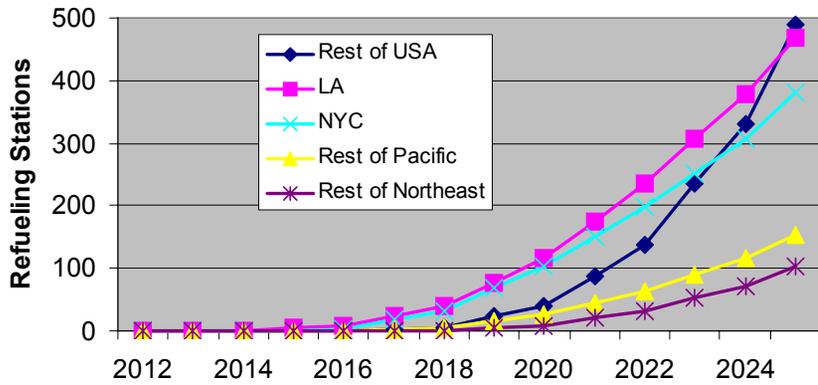
**Data beyond 2006 from JD Power and Associates HEV Outlook



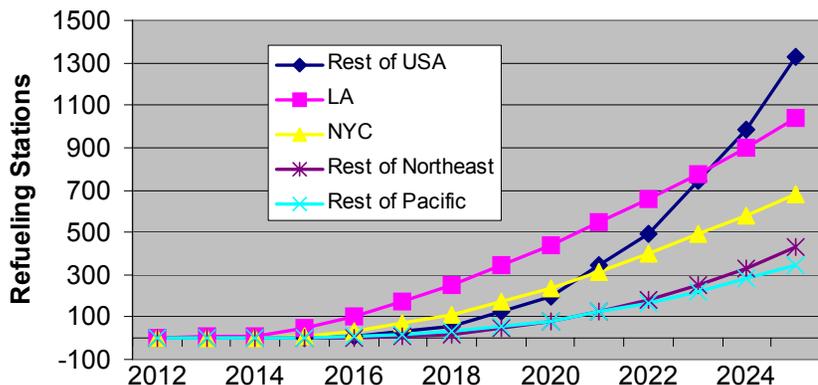


In addition to more stations overall, Scenario 3 gives a greater role to cities other than NY and LA.

Estimated Station Deployment, Scenario 1



Estimated Station Deployment, Scenario 2



Estimated Station Deployment, Scenario 3

