HyTrans Model: Analyzing the Potential for Stationary Fuel Cells to Augment Hydrogen Availability in the Transition to Hydrogen Vehicles

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AN004

Overview

Timeline

- Start: 2007
- Complete: 2015
- 50% complete

Budget

- Total project funding
  - $1.7M
  - DOE 100%
- FY09: $500,000
- FY 2010: $200,000

Barriers

- Future market behavior
- Stove-piped/siloed analytical capability
- Suite of models and tools

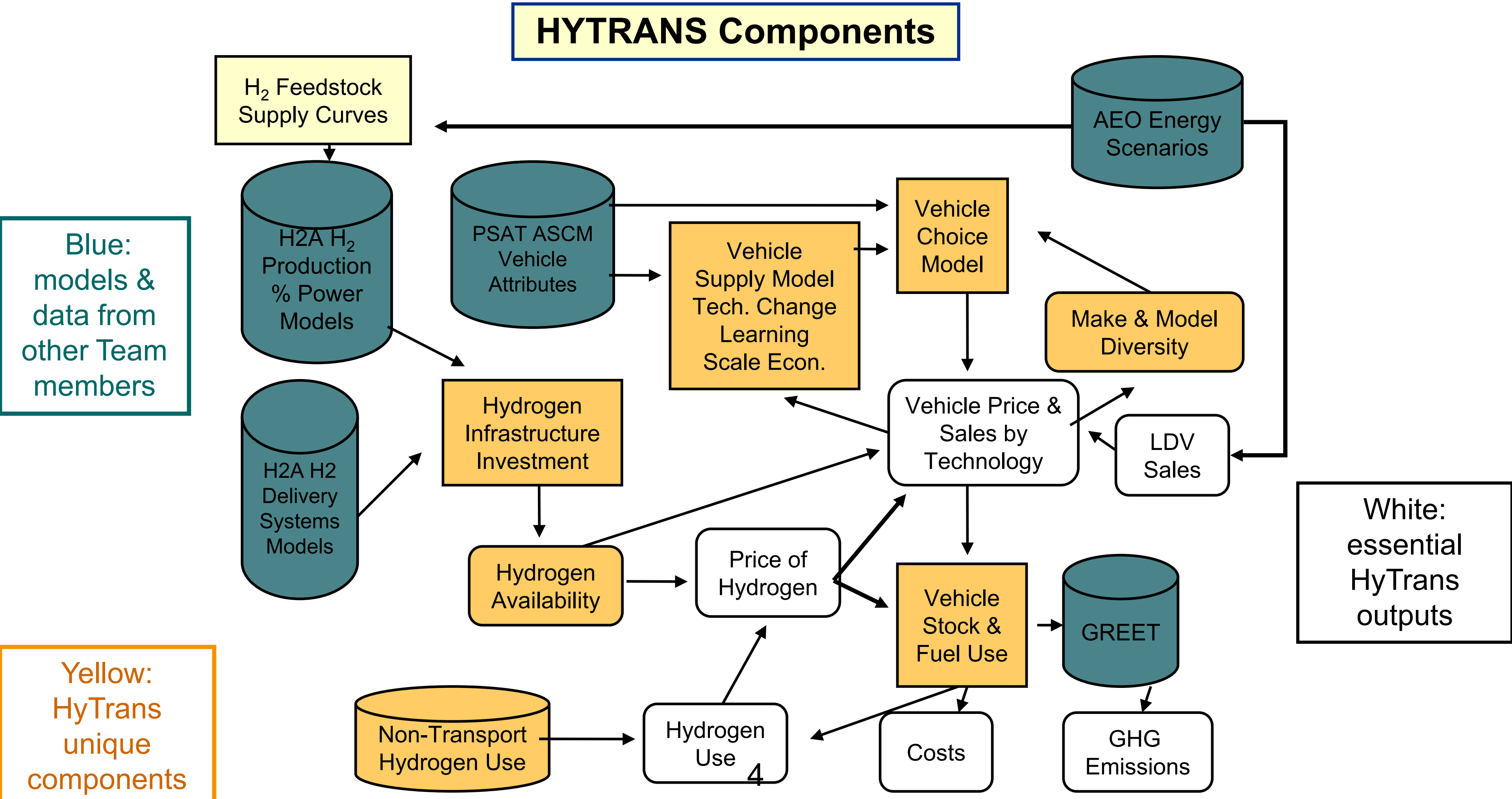
Partners

- NREL
- Econotech
- University of Tennessee
- HyTrans model development: many others

HyTrans contributes to the Hydrogen Program Systems Analysis goals through integrated analysis of the dynamic evolution of hydrogen vehicles and infrastructure.

- Objectives: HyTrans simulates the dynamic market transition from petroleum to hydrogen-powered vehicles to 2050.
- FY 2009-2010 research focused on inclusion of ICE and Hydrogen PHEVs and on analyzing the role that Combined Heat and Hydrogen Power (CHHP) could play in increasing hydrogen refueling availability during the transition.
- The CHHP analysis contributes to understanding potential synergies between stationary and mobile hydrogen fuel cell applications.

Approach: HyTrans simultaneously represents the 3 key agents: 1) fuel supply, 2) vehicle manufacture, 3) consumer choice, in a market simulation using dynamic, non-linear optimization.



Three national CHHP deployment scenarios were developed based on scenarios created for California by the California Energy Commission and EPRI.

- The CEC-EPRI report projects the FC CHP installed capacity in California under several scenarios. CHHP capacity by census division is projected based on residential and commercial electricity demand relative to California.
- High-R&D + Incentives Case extends the California Self-Generation Incentive Program (SGIP) nationwide + 3-year faster progress in FC technology than the Base Case. High Deployment Case accelerates R&D 2 more years and assumes a more favorable market.
- Three representative CHHP sizes: 150kW, 250kW, 1MW
  - 150 kW producing 56 kg H_2 per day.
  - 250 kW producing 93 kg/d
  - 1 MW producing 340 kg/d
- Two methods of delivery are represented:
  - H2A Power: short pipeline to nearby refueling station
  - HDSAM v 2.0 & NRC (2004): tube trailer to retail site within 5 miles

In the CEC-EPRI High-Deployment Case, federal and state incentives for those willing to provide hydrogen from a CHP installation (CHHP) are very substantial, and technological progress is faster.

Scenario	Onsite CHP MW	Export CHP MW	Total Market Penetration MW	Description
Base Case	1,966	0	1,966	Expected future conditions with existing incentives
No Incentives	1,141	0	1,141	Remove SGIP, CHP incentive gas price, and CHP CRS exemptions)
Moderate Market Access	1,966	2,410	4,376	Facilitate wholesale generation export
Aggressive Market Access	2,479	2,869	5,348	$40/kW year T&D capacity payments for projects under 20 MW, global warming incentive, and wholesale export
Increased (Alternative) Incentives	2,942	0	2,942	Extended SGIP (incentives on first 5 MW for projects less than 20 MW, $0.01/kWh CHP production tax credit
Streamlining	2,489	0	2,489	Customer behavior changes: higher response to payback levels and greater share of market that will consider CHP
High R&D on Base Case	2,764	0	2,764	Rate of technology improvement accelerated 5 years
High Deployment Case	4,471	2,869	7,340	Accelerated technology improvement with aggressive market access and streamlining to improve customer attitudes and response

Base

- A: Federal Business Tax Credit
  - 30% of expenditure or $3000/kW whichever is smaller
- B: Federal Tax credit for alternative fuel vehicle refueling property
  - The lesser of 30% of equipment cost or $30k
- C: CHP Tax Credit
  - 10% of expenditures
- Either B or C but not both can be taken

HiR&D+SGIP

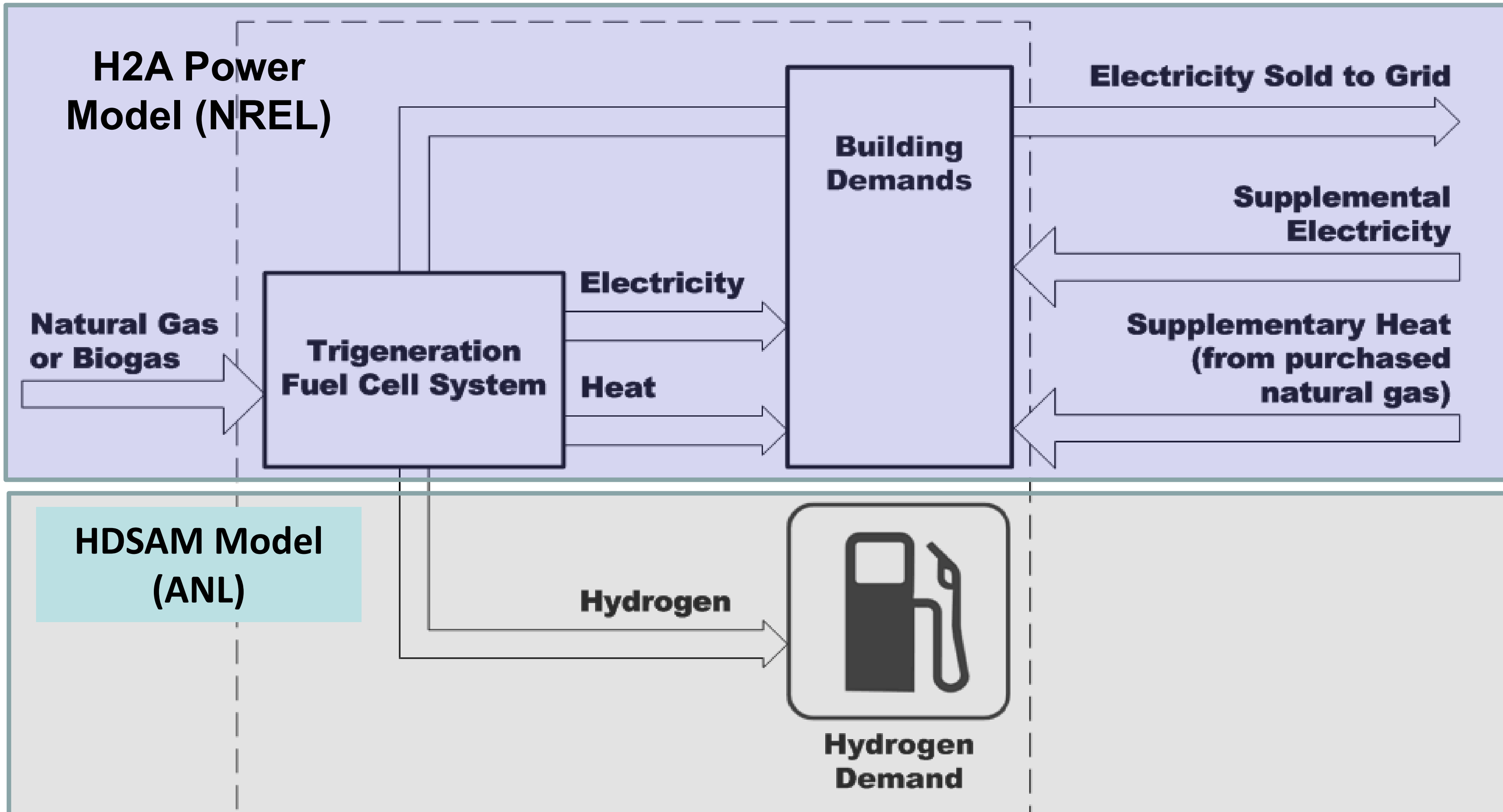
- optimistic technology improvement
- CA SGIP incentive available to all states

High Deployment

- more optimistic technology improvement
- The California SGIP incentive is assumed for all states, $2500/kW for up to 1MW
- optimistic market acceptance

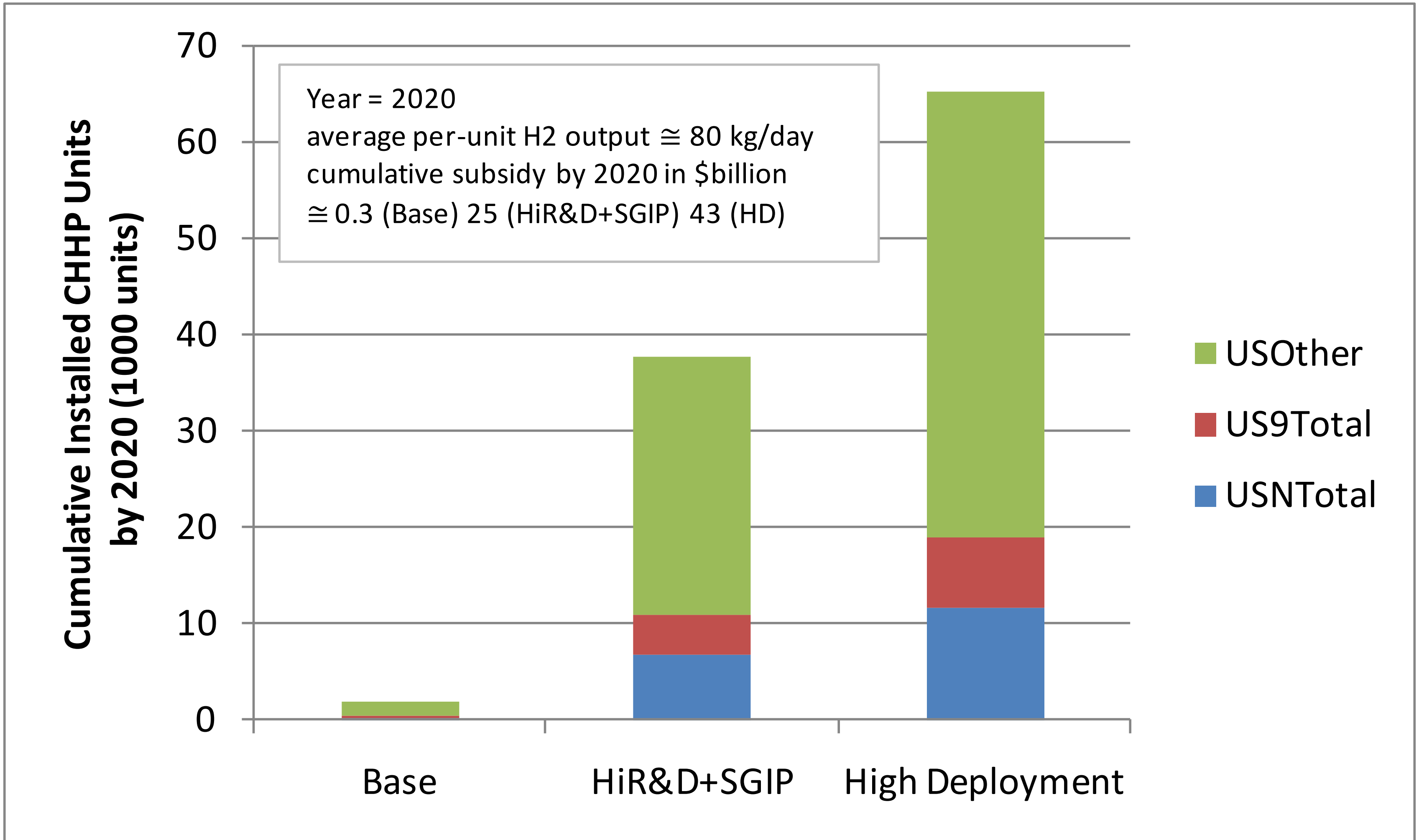
Source: Assessment of California CHP Market and Policy Options for Increased Penetration, EPRI, Palo; Alto, CA, California Energy Commission, Sacramento, CA: 2005

Two delivery cases: High-cost connecting CHHP unit to retail delivery by a short pipeline based on H2A Power Model ; Low-cost utilizing tube trailer delivery to the retail site (based on HDSAM v 2.0 & 2004 NRC study).

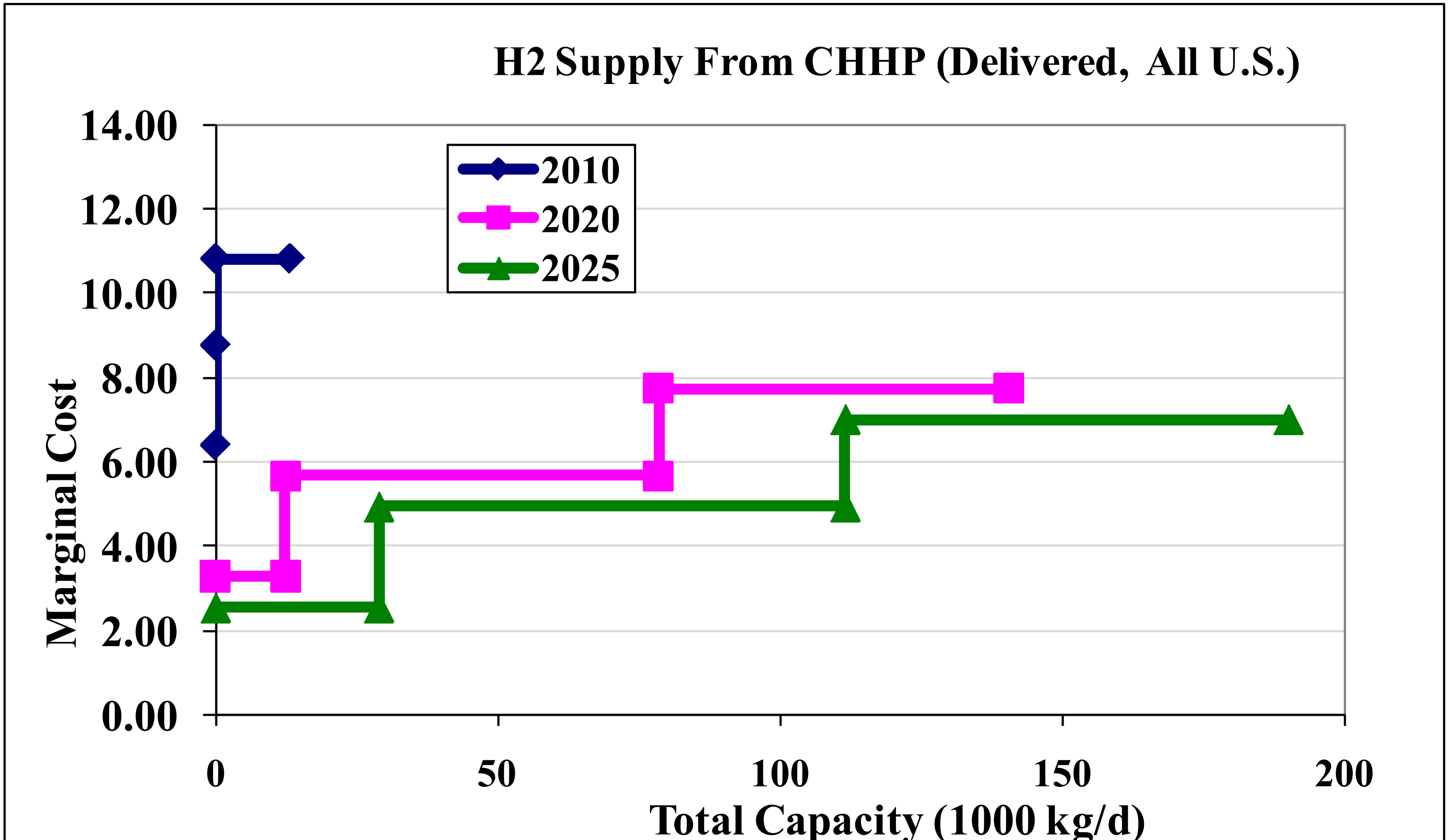


Darlene Steward, Mike Penev. H2A Power Model: Molten Carbonate Fuel Cell Case Study. NREL
Amgad Elgowainy, Marianne Mintz, and Jerry Gillette. HDSAM V2.0. ANL

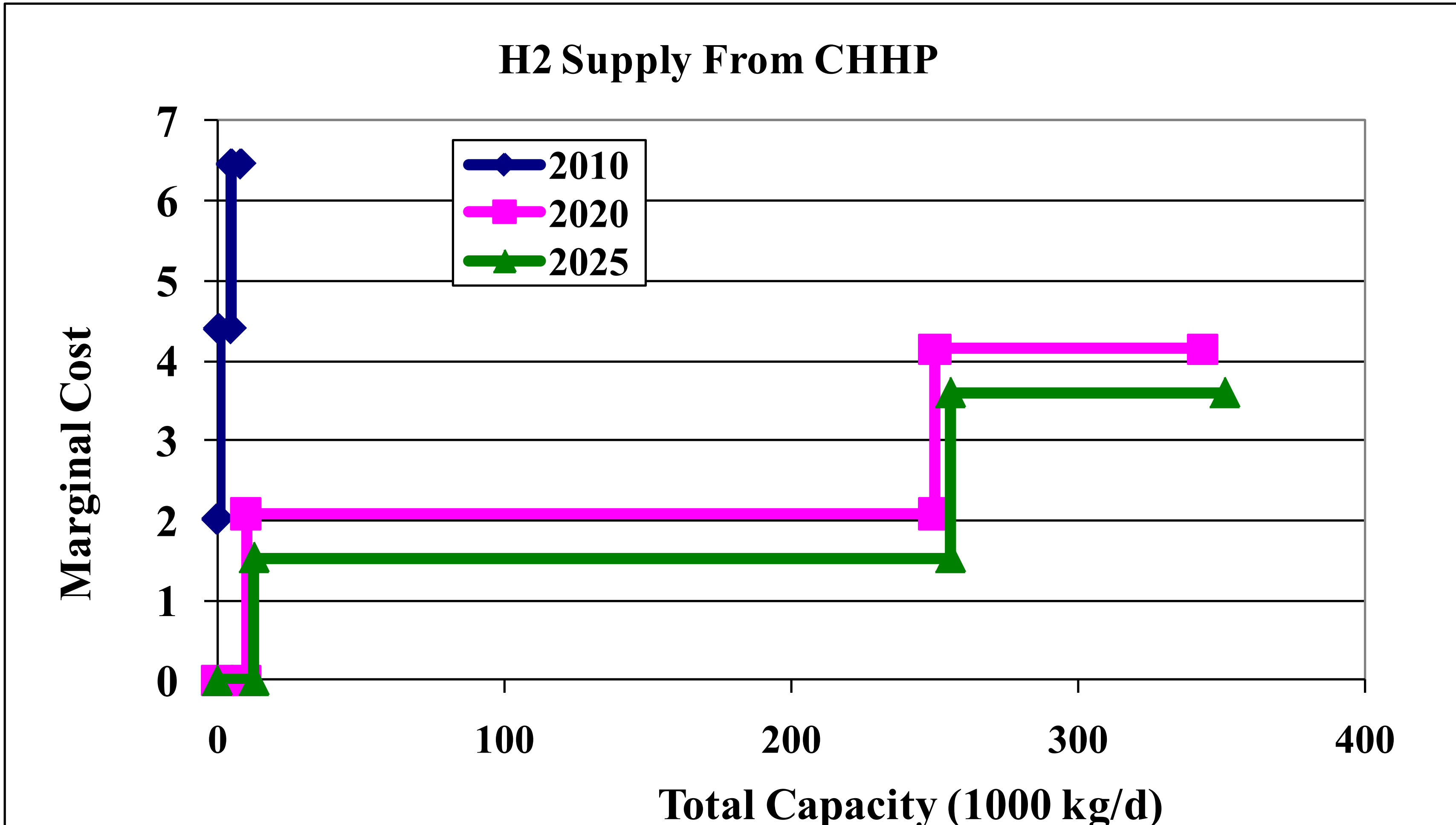
With the kind of strong incentives for CHHP offered by national and California policies, up to 60,000 CHHP sites are potentially active by 2020.



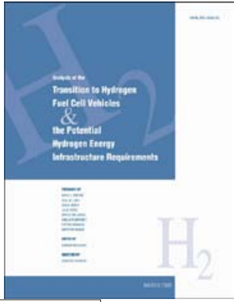
Base CHHP deployment case: incentives limited, technological progress slower. Assuming the higher cost delivery option, CHHP H_2 costs are substantially higher than distributed SMR.

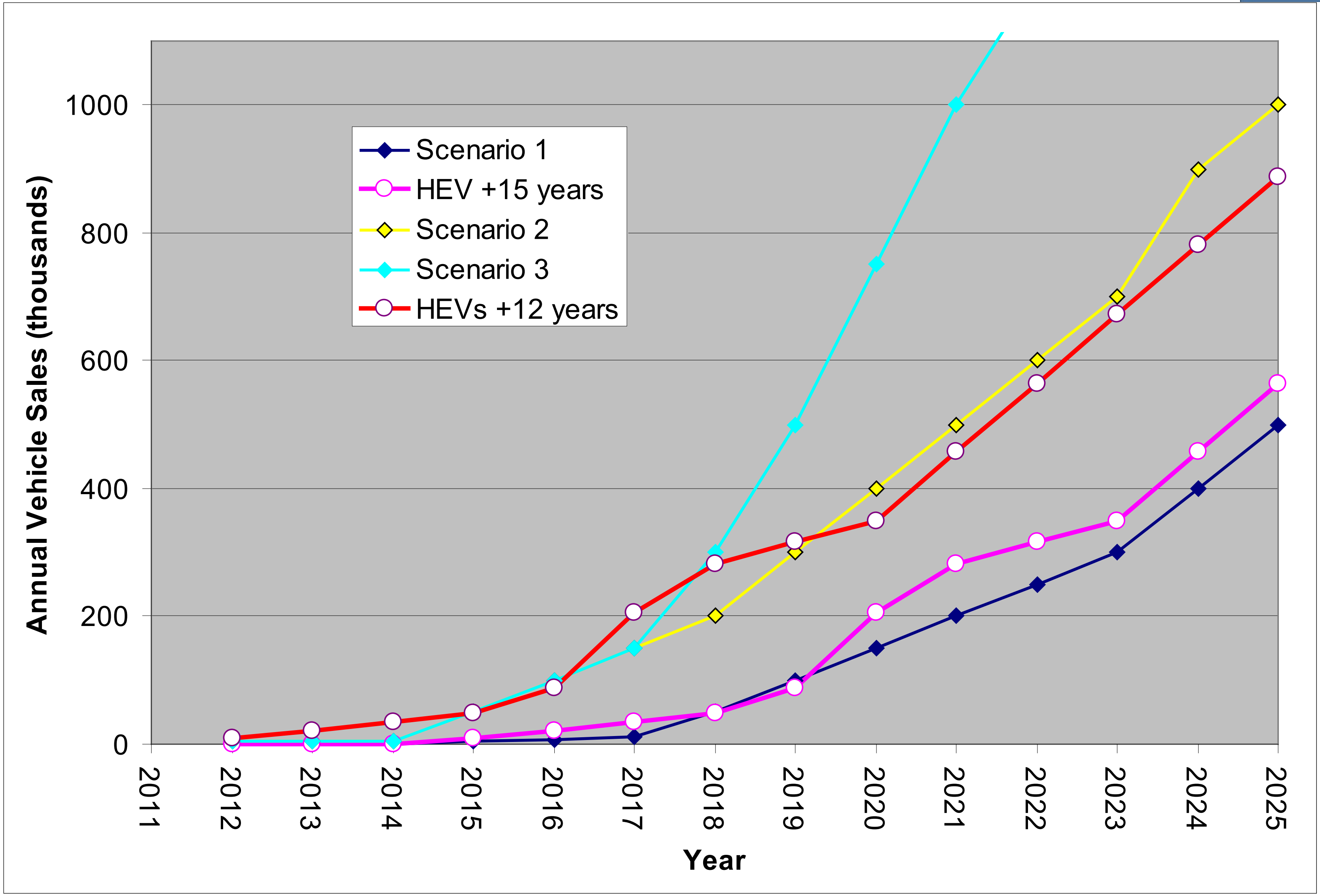


The combination of additional incentives and more rapid technological progress makes hydrogen from CHHP very competitive in the HiR&D+SGIP case even with high delivery costs

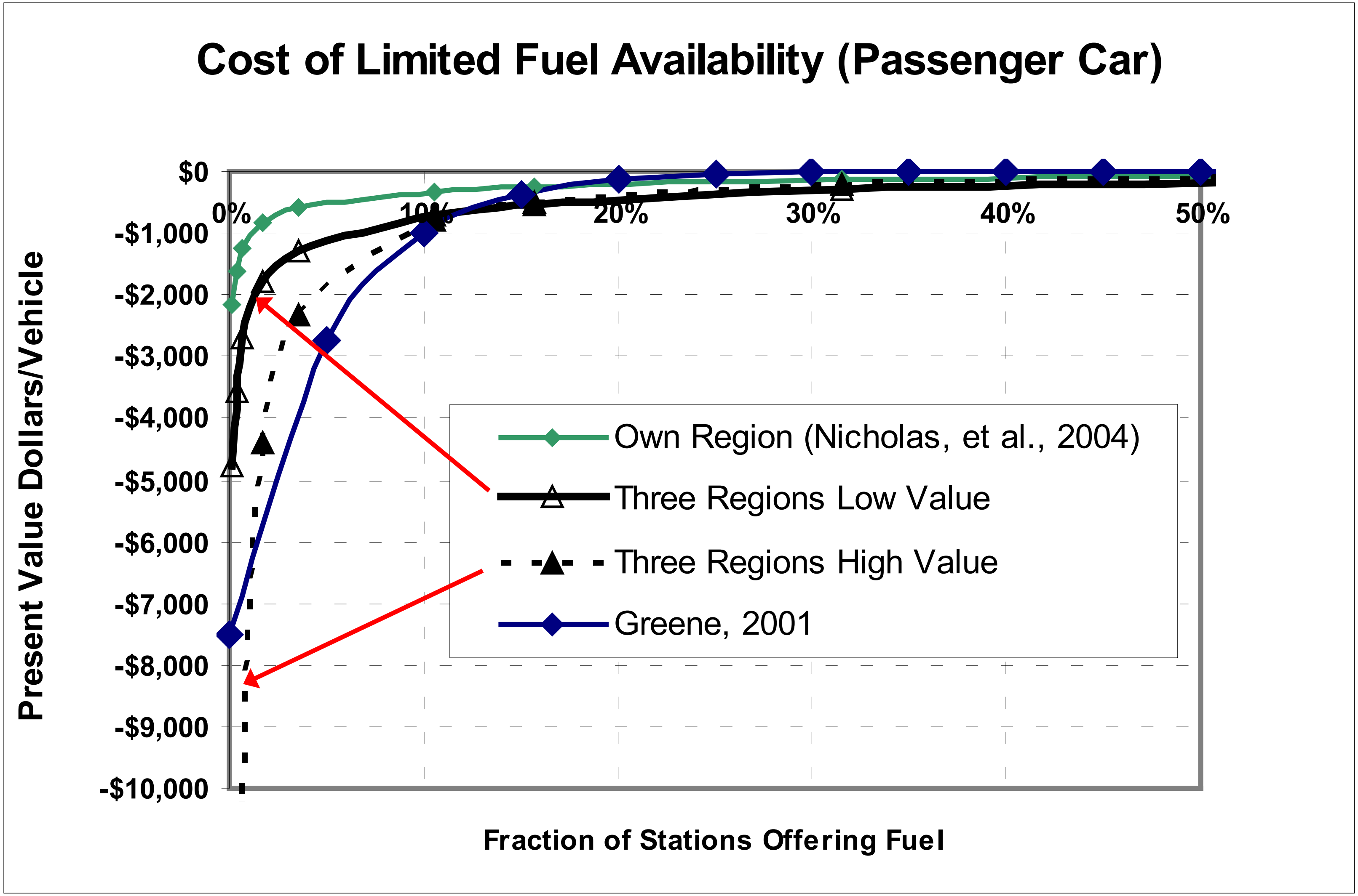


The impact of CHHP on fuel availability was examined in the context of DOE's three 2008 transition scenarios. The results presented below focus on Scenario 2.

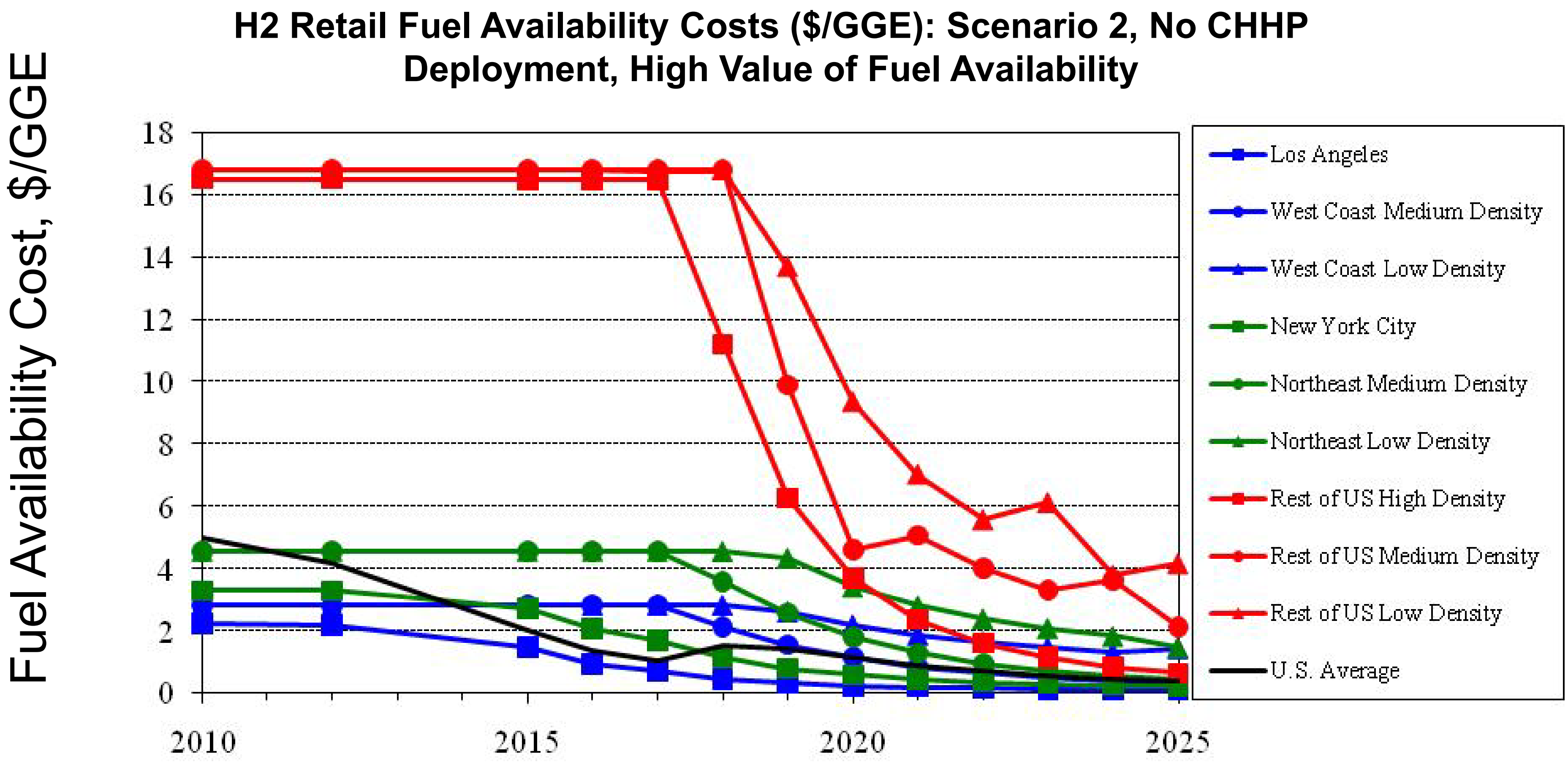




The cost of limited fuel availability at very low station densities has not been measured precisely but is a key determinant of the value of the CHHP option. The Low availability case reflects only the value of the extra time to access stations. The High case is intended to reflect “range anxiety” as well.

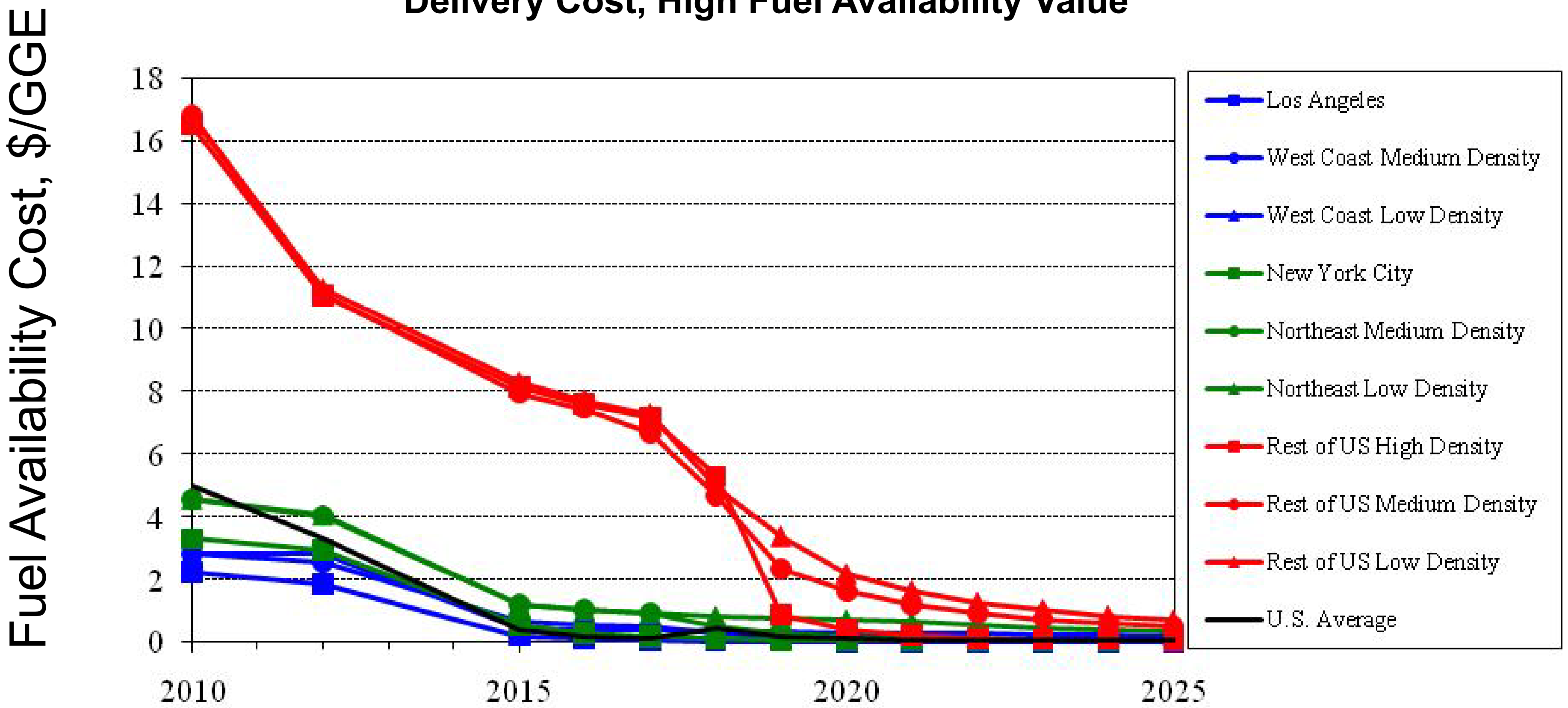


Lack of fuel availability can be a major additional perceived cost for hydrogen fuel cell vehicles during the early transition, especially outside the lighthouse regions.



With better incentives and better technology for CHHP, more CHHPs become sources of H2 supply. This significantly improves fuel availability when coupled with hydrogen retail outlets.

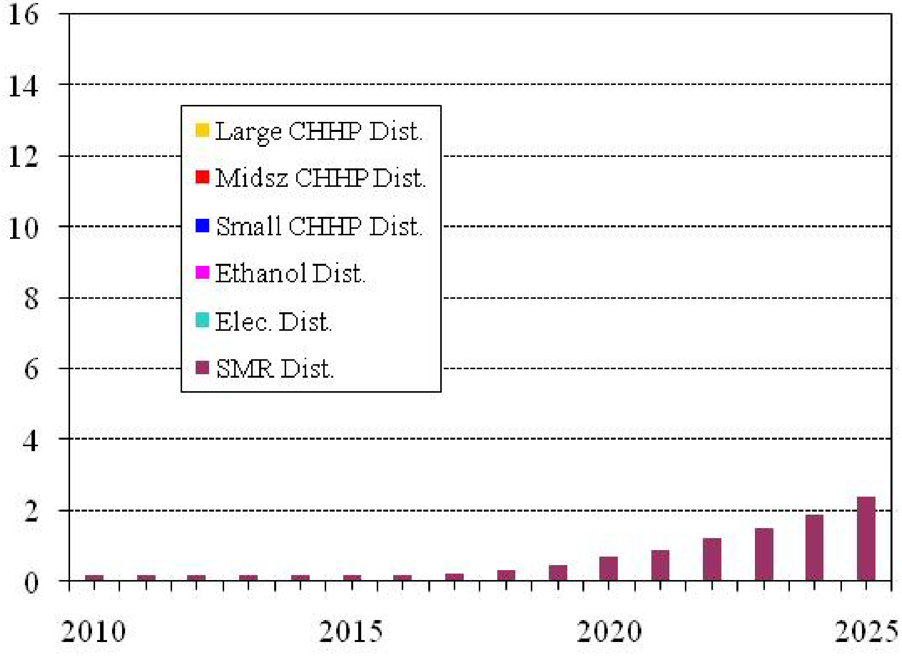
Retail Fuel Availability Costs by Region ($/GGE), HiR&D+SGIP, High Delivery Cost, High Fuel Availability Value



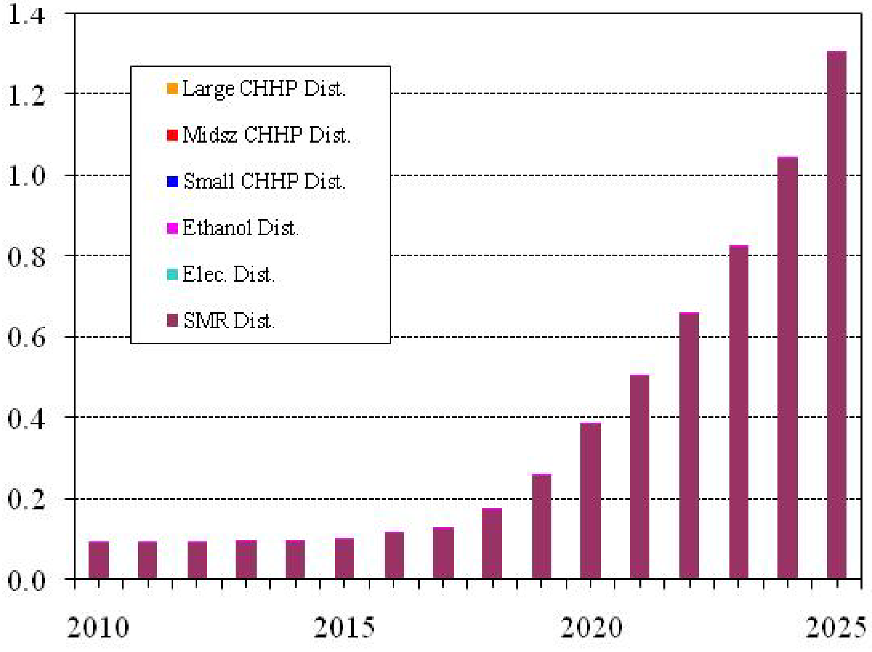
Without CHHP, almost 100% of H_2 supply for vehicles and 100% of retail outlets in the early transition period are 1500 kg/day SMR installations.

Scenario 2, No CHHP Deployment, High Value of Fuel Availability

Thousands of Distributed Retail Stations



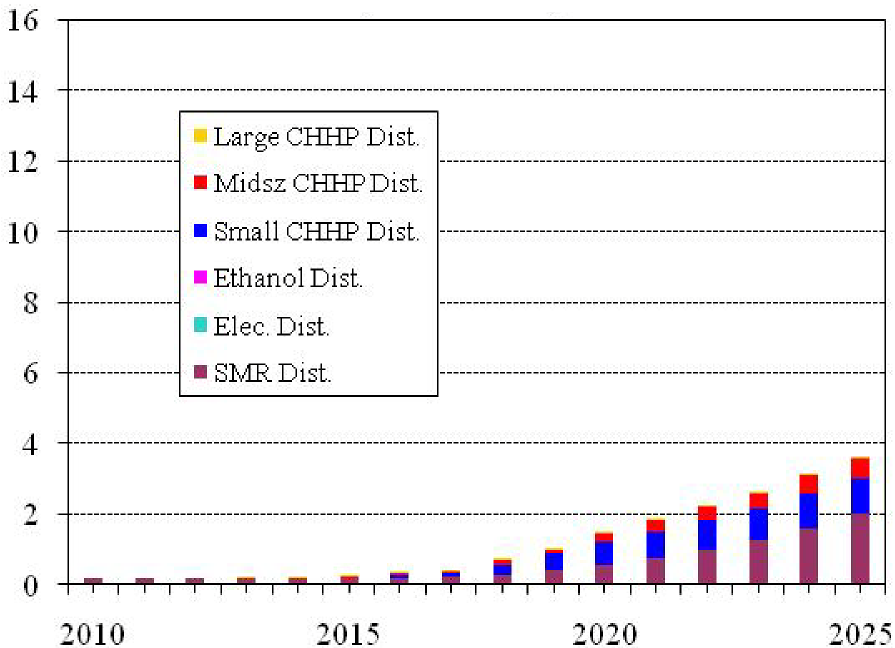
Hydrogen Production in Billion kg/year



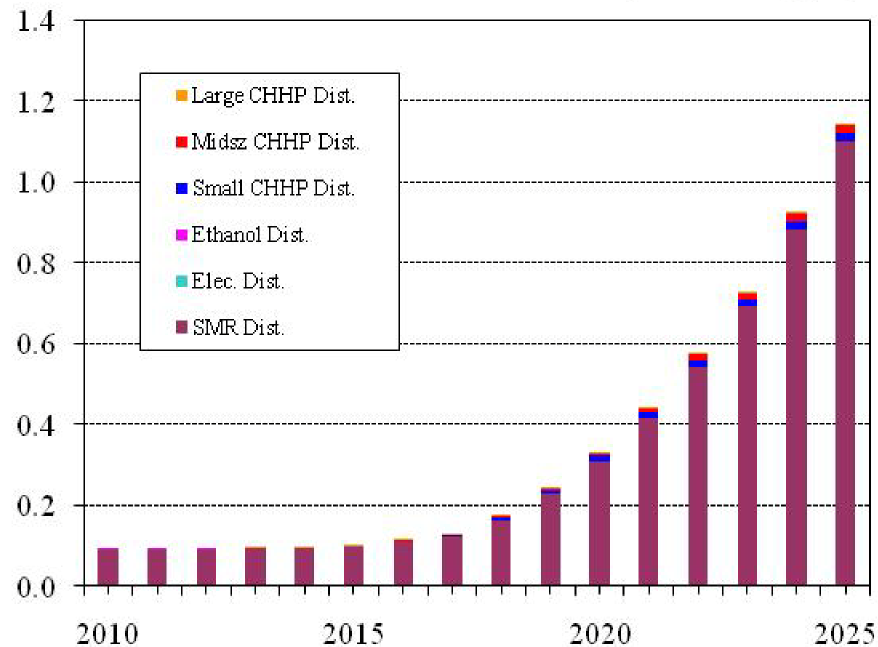
With CHHP, some SMR stations would be replaced by CHHP stations, resulting in more hydrogen stations, smaller average station size and better fuel availability

Scenario 2, Base CHHP Deployment, High Value of Fuel Availability

Thousands of Distributed Retail Stations



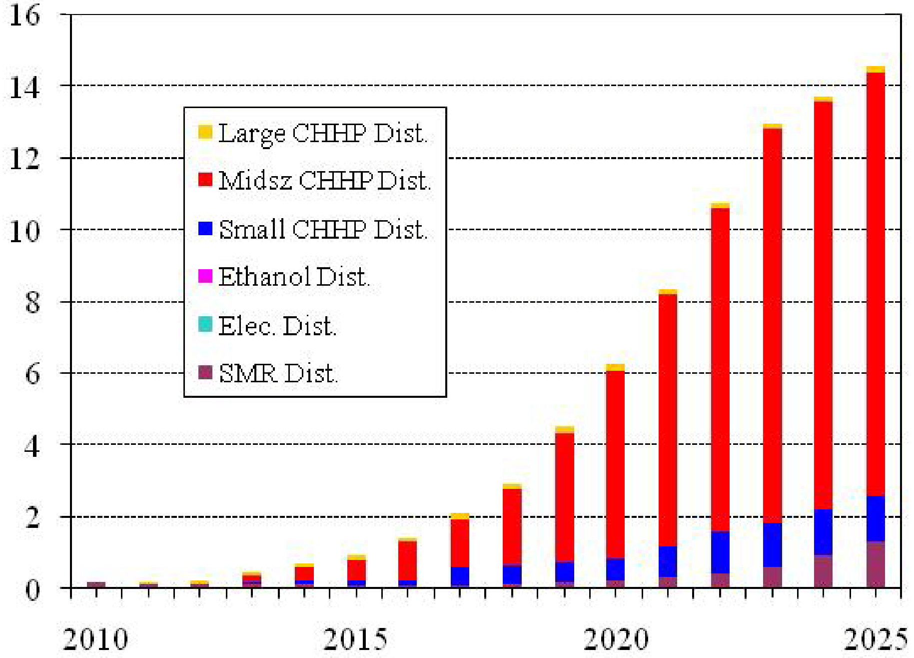
Hydrogen Production in Billion kg/year



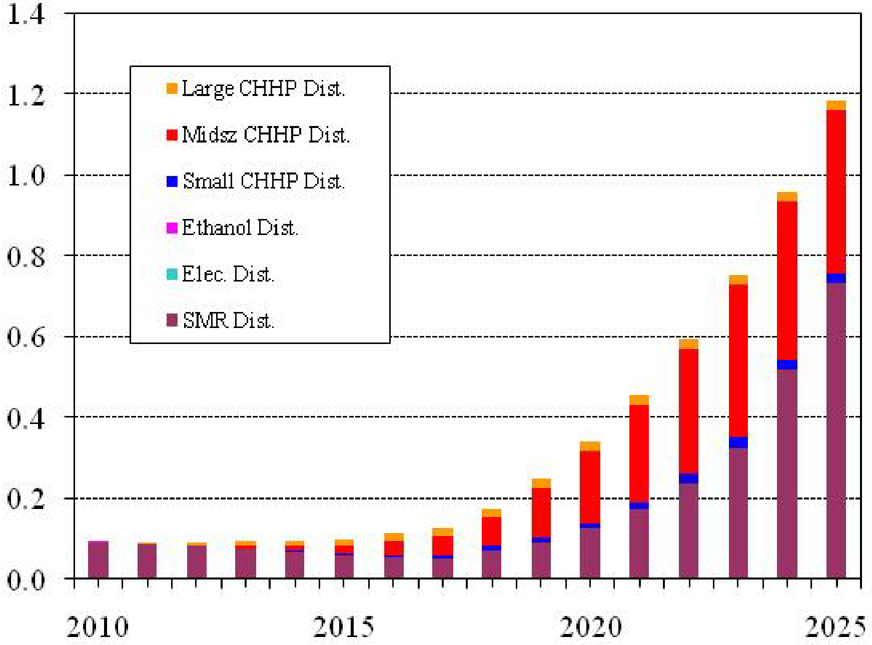
With better technology progress and CA incentives available to all states, by 2025, hydrogen is mostly provided by SMR while fuel availability is mostly provided by CHHP

Scenario 2. HiR&D+SGIP Scenario, High Delivery Cost, High Value of Fuel Availability

Thousands of Distributed Retail Stations



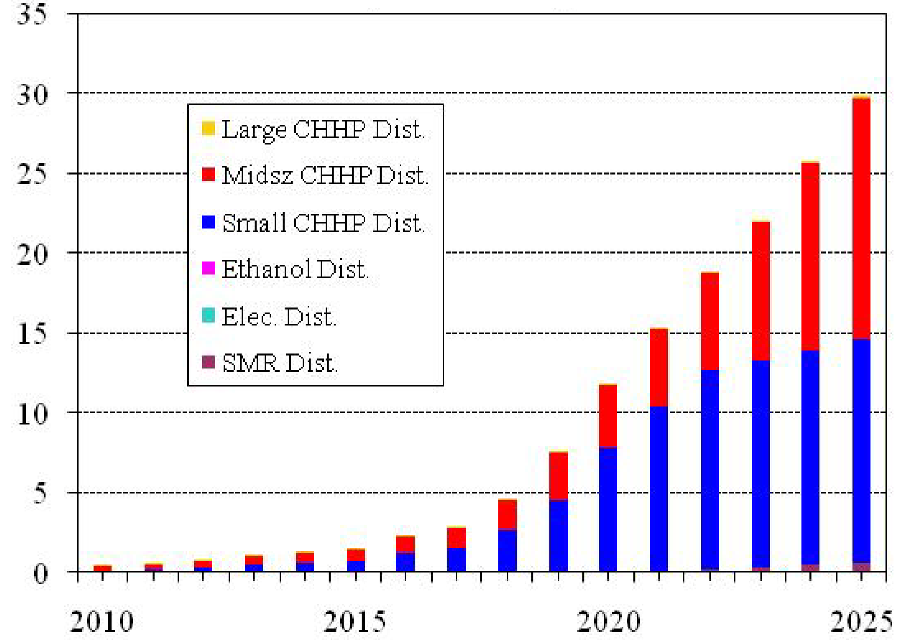
Hydrogen Production in Billion kg/year



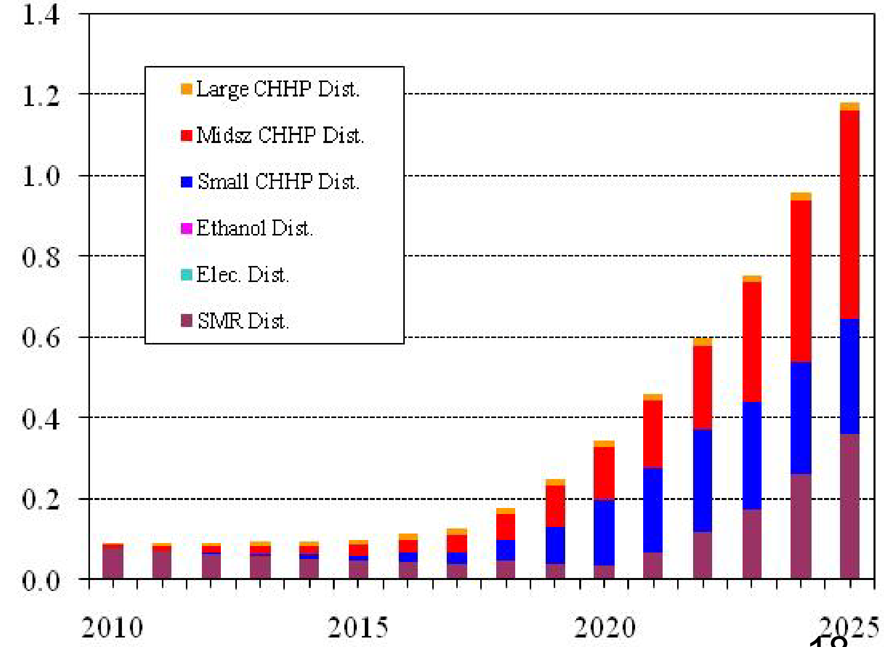
With the full CHHP market potential realized and even faster CHHP technology progress, hydrogen refueling network can be greatly expanded with CHHP stations providing nearly all geographic coverage and a few SMR stations providing high volume service in high density areas

Scenario 2. High Deployment Scenario, Low Delivery Cost, High Value of Fuel Availability

Thousands of Distributed Retail Stations



Hydrogen Production in Billion kg/year



This analysis has revealed potentially important synergies between stationary and mobile fuel cell applications that could aid a transition to hydrogen.

- Widespread deployment of CHHP could greatly reduce the problem of hydrogen availability in the early stage (e.g., 2015-2025) of a transition to fuel cell vehicles.
- Rapid technological progress supported by substantial subsidies is likely to be necessary.
- The HyTrans model has been successfully enhanced to analyze a potentially important synergy between stationary and mobile fuel cell markets.

In our view, the greatest need at this time is to develop and test an integrated policy framework for the transition to hydrogen.

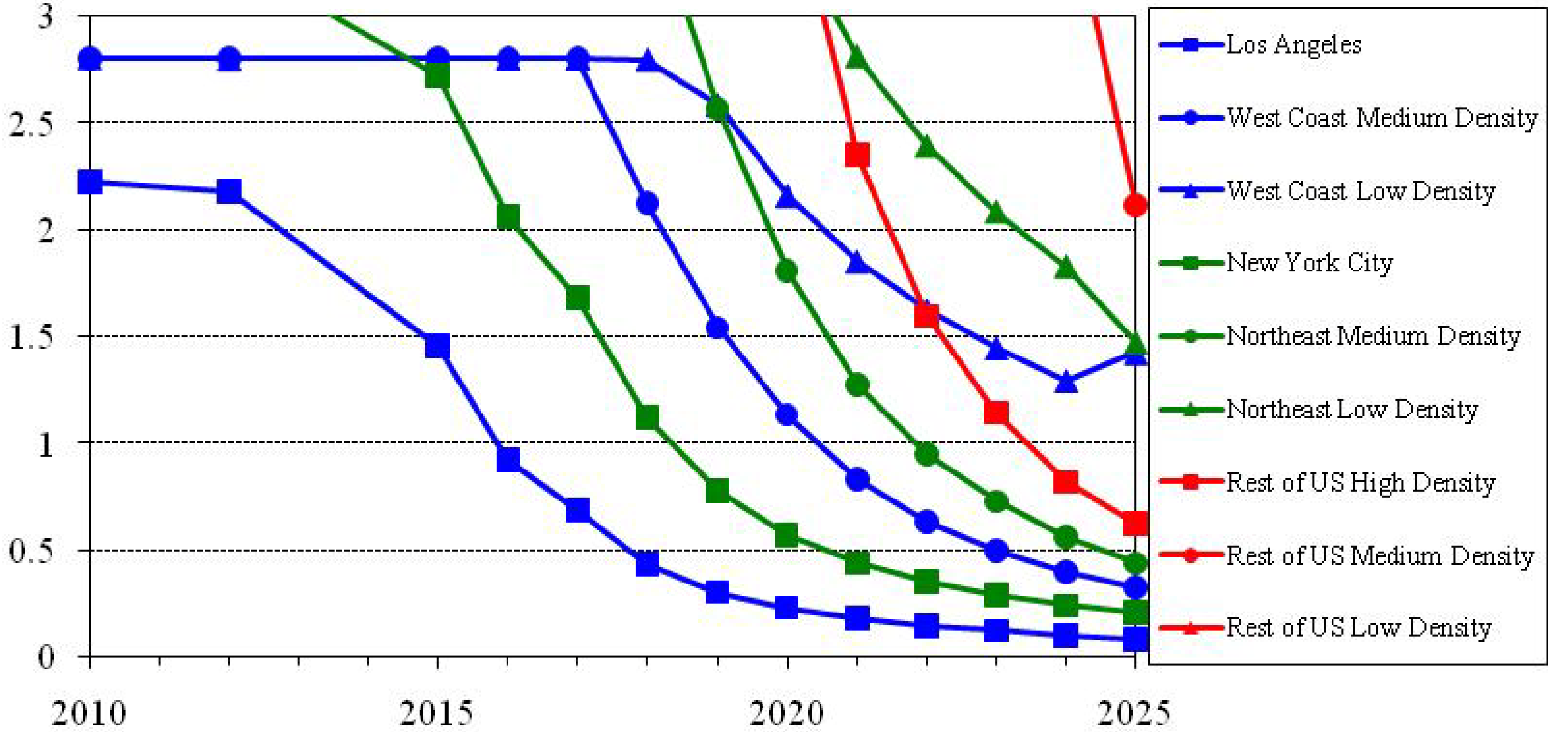
- A transportation energy transition to achieve public goods (climate protection, energy security and sustainability) is unprecedented.
- In past work we have quantified natural economic barriers to transition that create a “valley of death”. We and others have also quantified the potential benefits.
- Early adopters, early vehicle manufacturers and early fuel providers also produce positive network externalities that can be quantified and may serve as a basis for determining efficient subsidies or mandates.
- Uncertainty of technological success both for hydrogen and competing technologies must also be included.
- Our objective for FY 2010 is to develop and implement such a framework in the HyTrans model.
- In FY 2011 our goal is to test the framework analytically, in the context of alternative scenarios and to document and publish the results in refereed journals and other reports.

Thank you.

Supplemental Slides

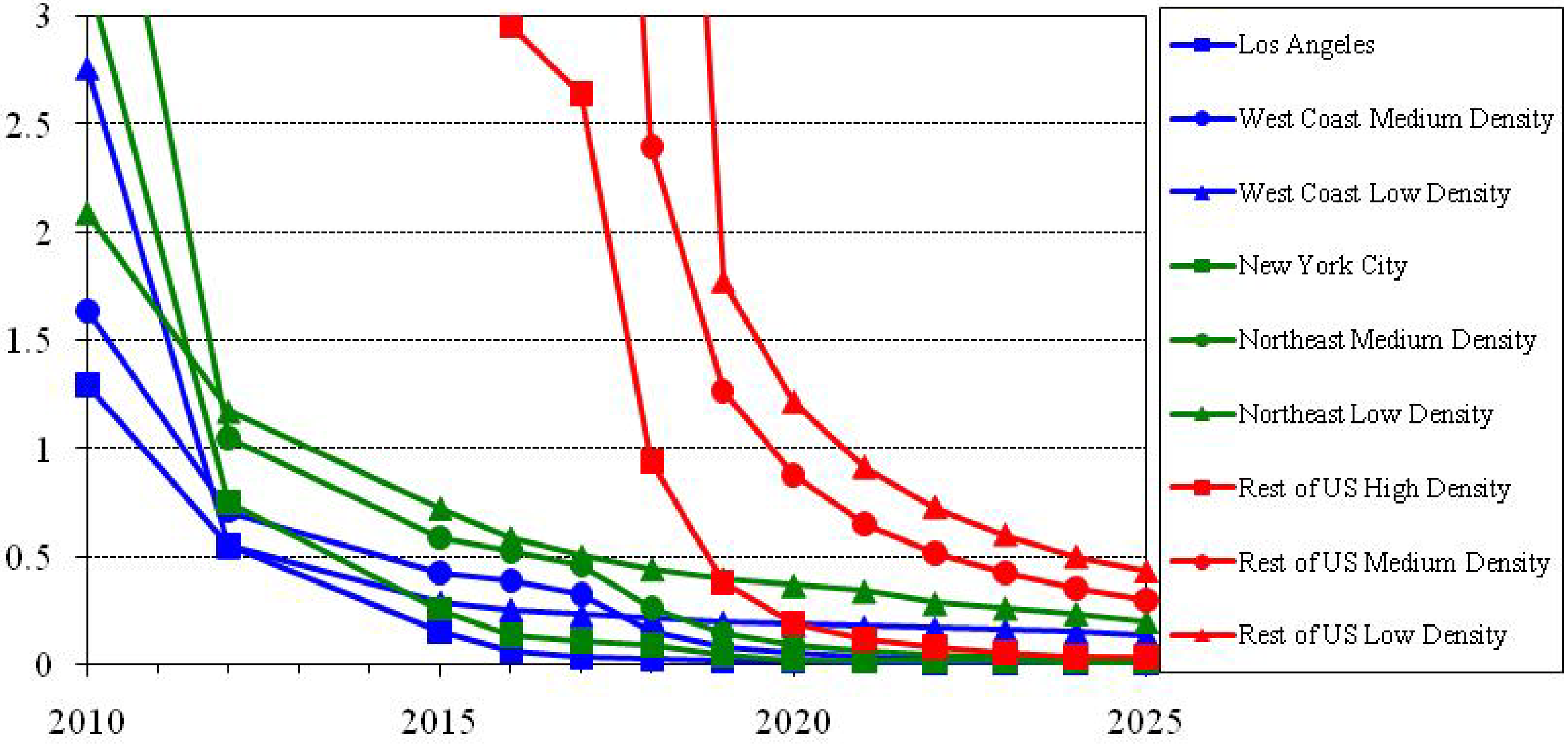
w/o CHHP, availability costs stay higher longer. In the lighthouse regions costs are >$1/kg until almost 2020. Rest of US costs are very high.

H2 Retail Fuel Availability Costs ($/GGE): Scenario 2. No CHHP Scenario, High Delivery Cost, High Value of Fuel Availability



With incentives and tech progress, CHHP brings availability costs in the lighthouse regions to essentially zero by 2020 and greatly reduces availability costs elsewhere.

H2 Retail Fuel Availability Costs ($/GGE): Scenario 2. HiR&D+SGIP Scenario, High Delivery Cost, High Value of Fuel Availability



As an integrating market simulation model, HyTrans depends on the research of many collaborators in the systems analysis program.

- HyTrans incorporates a simplified representation of Darlene Steward and Mike Penev's H2A Power Model: Molten Carbonate Fuel Cell Case Study. (NREL)
- Also a simplified representation of Amgad Elgowainy, Marianne Mintz, and Jerry Gillette's HDSAM V2.0. (ANL)
- Our representation of fuel availability costs depends on Marc Melaina's research. (NREL)
- And many others, including GREET, the NRC and NEMS.
- Key collaborators include:
  - EconoTech: subcontractor
  - University of Tennessee: subcontractor
  - NREL: collaborator, model developer
  - ANL: collaborator, model developer
  - UC Davis: collaborator, model developer