Analyzing Transitions to Hydrogen Powered Vehicles with HyTrans

Progress Report & Preliminary Results

Paul N. Leiby
ORNL
David L. Greene
ORNL

David Bowman
Econotech
Elzbieta Tworek
Strata-G

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HyTrans works!

But it also needs work.

From: "Don't believe this!"

To: "This is dependent on key data, key assumptions, and model limitations."

Agenda

- **Brief** overview of HyTrans
- Key Issues
- Preliminary Results from 3 Scenarios
  - Vehicle Technology Case 1:
    - DOE Freedom Car Program Goals Met
  - Vehicle Tech. Case 2:
    - Alternative Technology Evolution
  - Carbon Emissions Limits
- Lessons
- Future Development

The results I will present today are **preliminary** and should not be interpreted as conclusions about the hydrogen transition.

- HyTrans is still under development.
- Have not yet incorporated HFCIT program goals via H2A models but will do so soon.
- NAS production technologies used; results presented below based on restricted sets of production options.
- Geographical regions, several major improvements to come.
- Results illustrate feasibility of optimization methodology, kinds of analyses that will be possible.

HyTrans Design Approach: Simulate a Market Solution

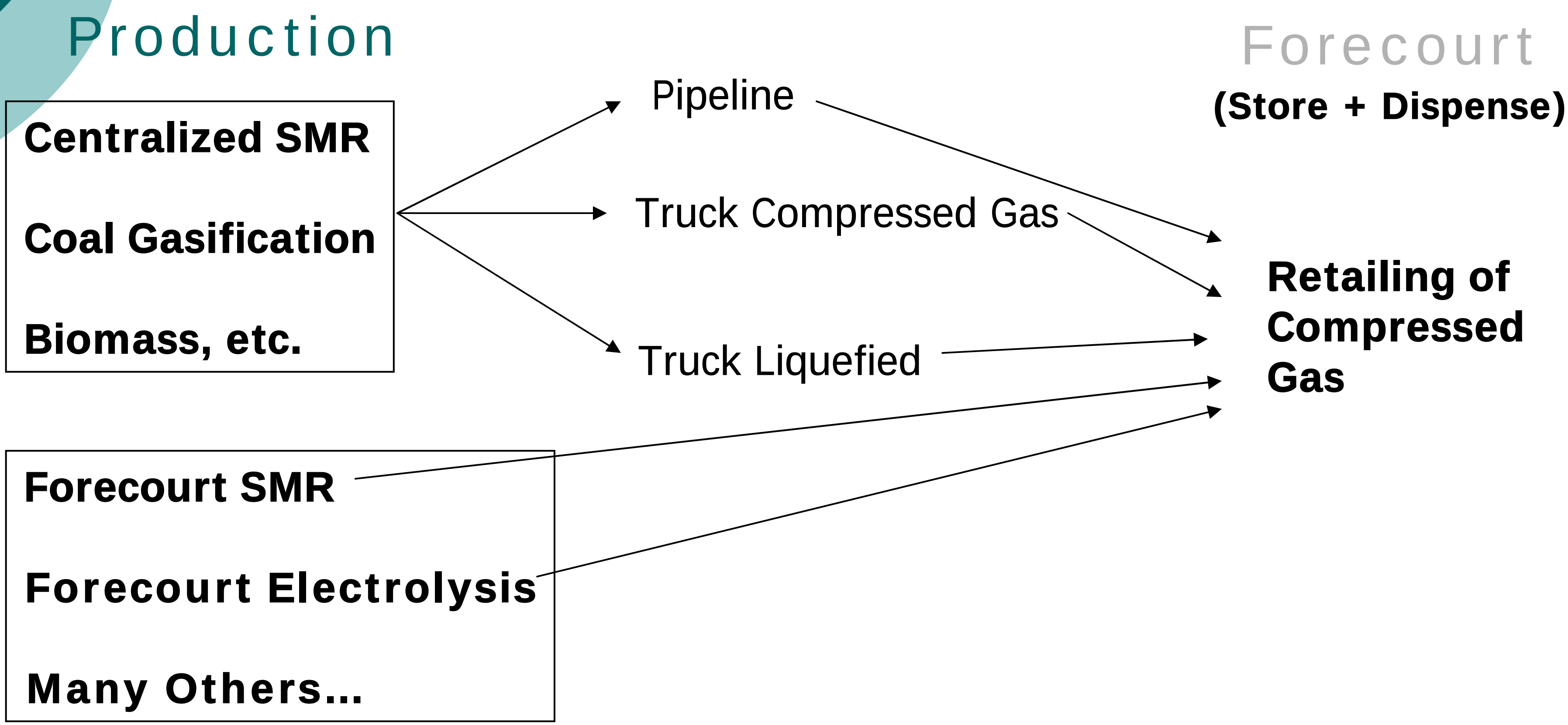
- Successor to successful TAFV model
- National model, with high, medium & low (intercity) fuel-demand-density-regions
- Integrates all main H_2 market components
  - from fuel and vehicle production
  - to distribution pathways
  - through final consumer choice and demand
- Determines a market equilibrium solution
  - Maximizes total consumption benefit minus production, distribution, and other costs
  - Assumes consumers & producers have perfect information and perfect foresight.
- Currently benchmarked to AEO2004 Reference Case oil and gasoline price forecasts. AEO2005 markedly higher.

A H2 Supply Pathway (Supply Chain)

is comprised of three parts.

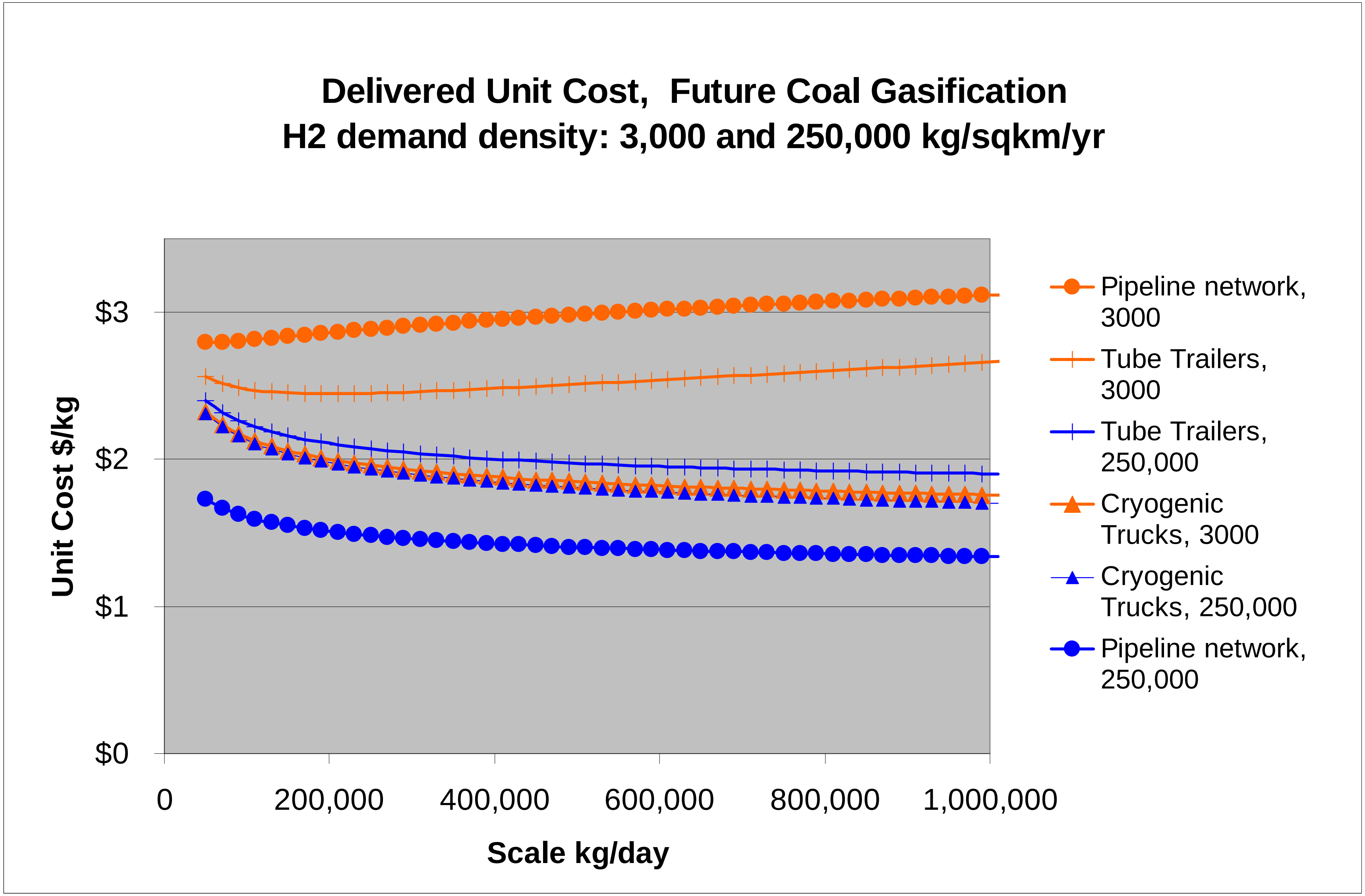
Delivery

Includes: Compression/Liquefaction+Storage+Dispensing+ Transporting+Storage+Compression/Vaporization



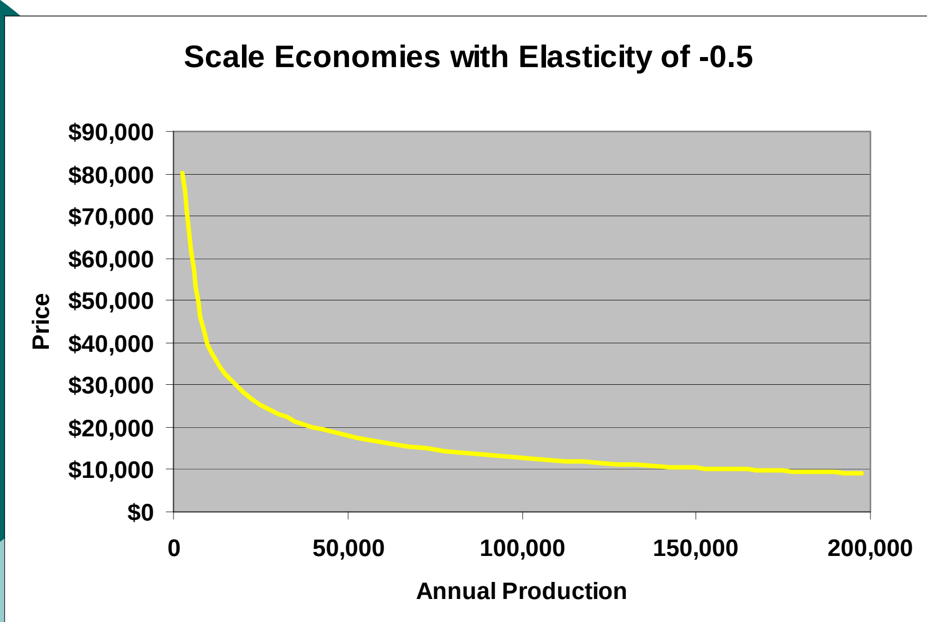
Demand density affects the competitive positions of production/delivery pathways.

(H2 delivered to vehicle excl. taxes)

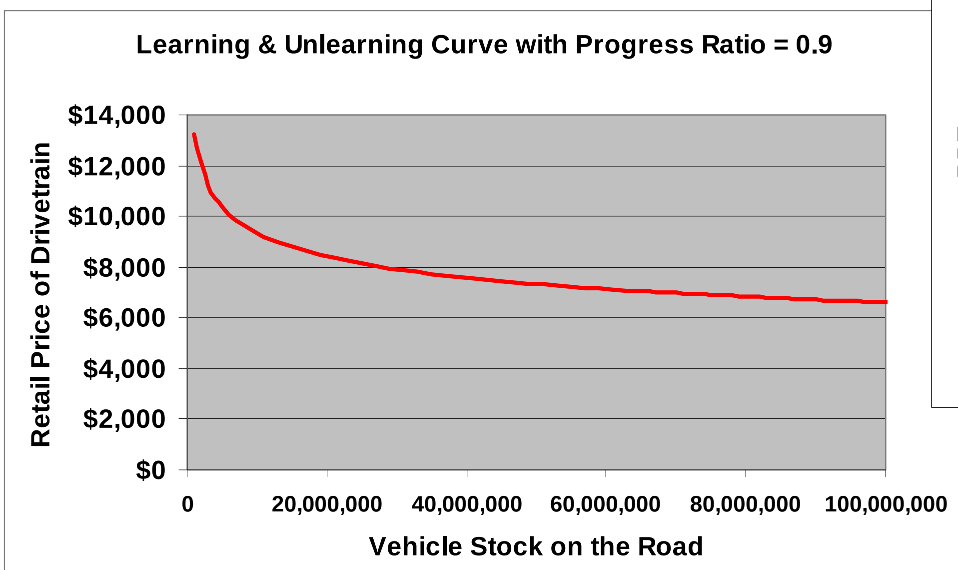


Vehicle technologies improve through 3 distinct mechanisms.

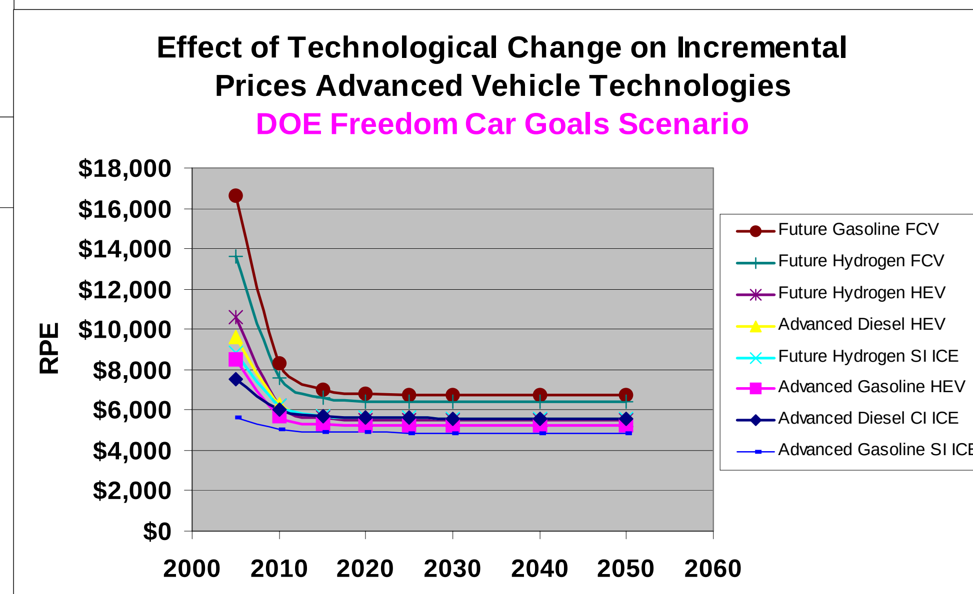
Retail Price =
Scale × Learning × Tech Change × Scenario Price



Scale w/ Annual Production/Plant



Learning & Unlearning w/ Stock on Road



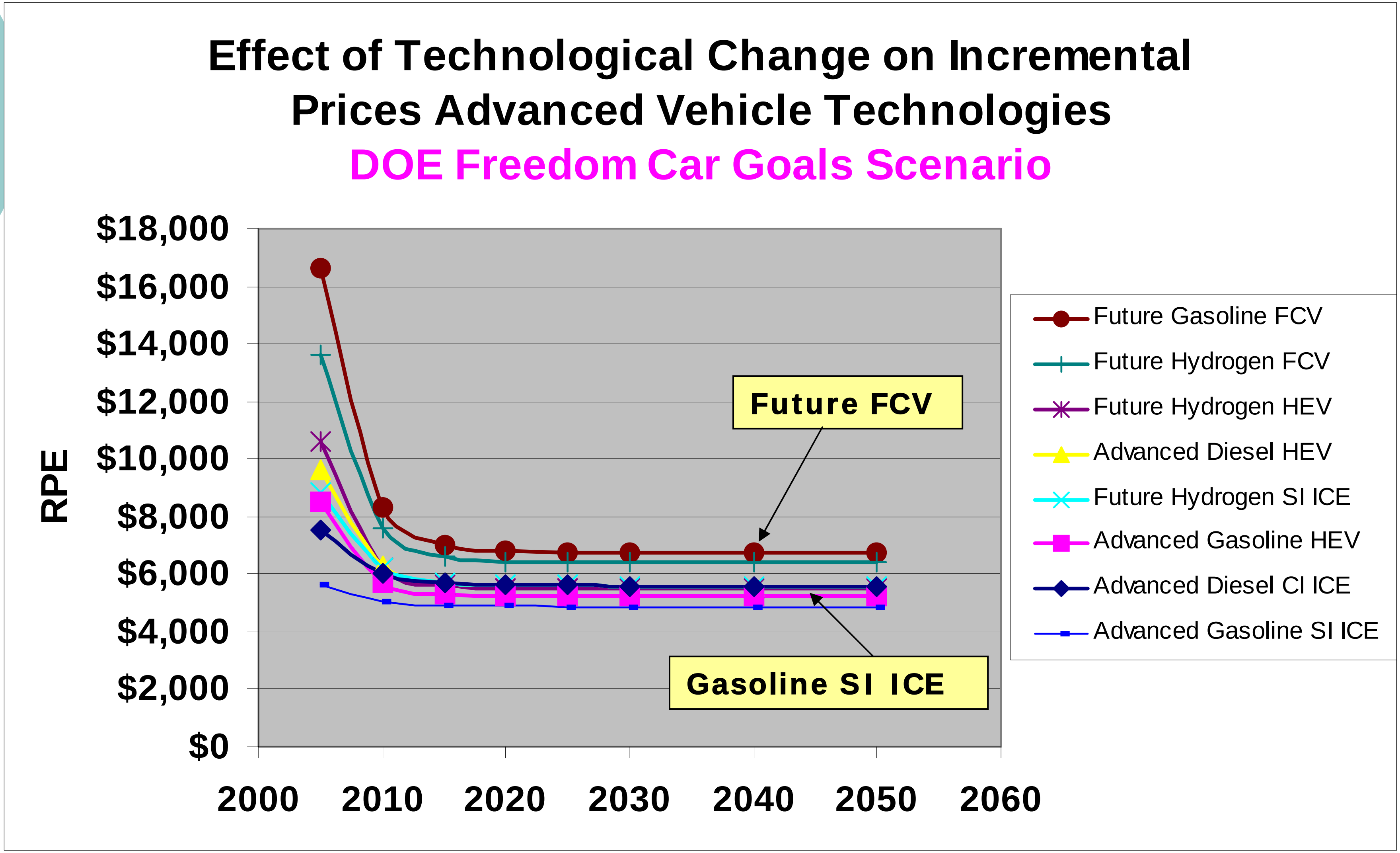
Tech Change w/ Passage of Time (Yr)

I will show some preliminary results from three scenarios.

- Based on AEO 2004 Reference Case & extrapolated.
- Two policy drivers
  - Vehicle subsidies
  - Fuel subsidies
- 1: DOE Freedom Car Goals Met
- 2: Alternative Technology Evolution
- 3: Carbon Emissions Limitations
- ***ALL scenarios here rely on NAS (2004) production cost estimates – H2A models will be incorporated in the near future.***

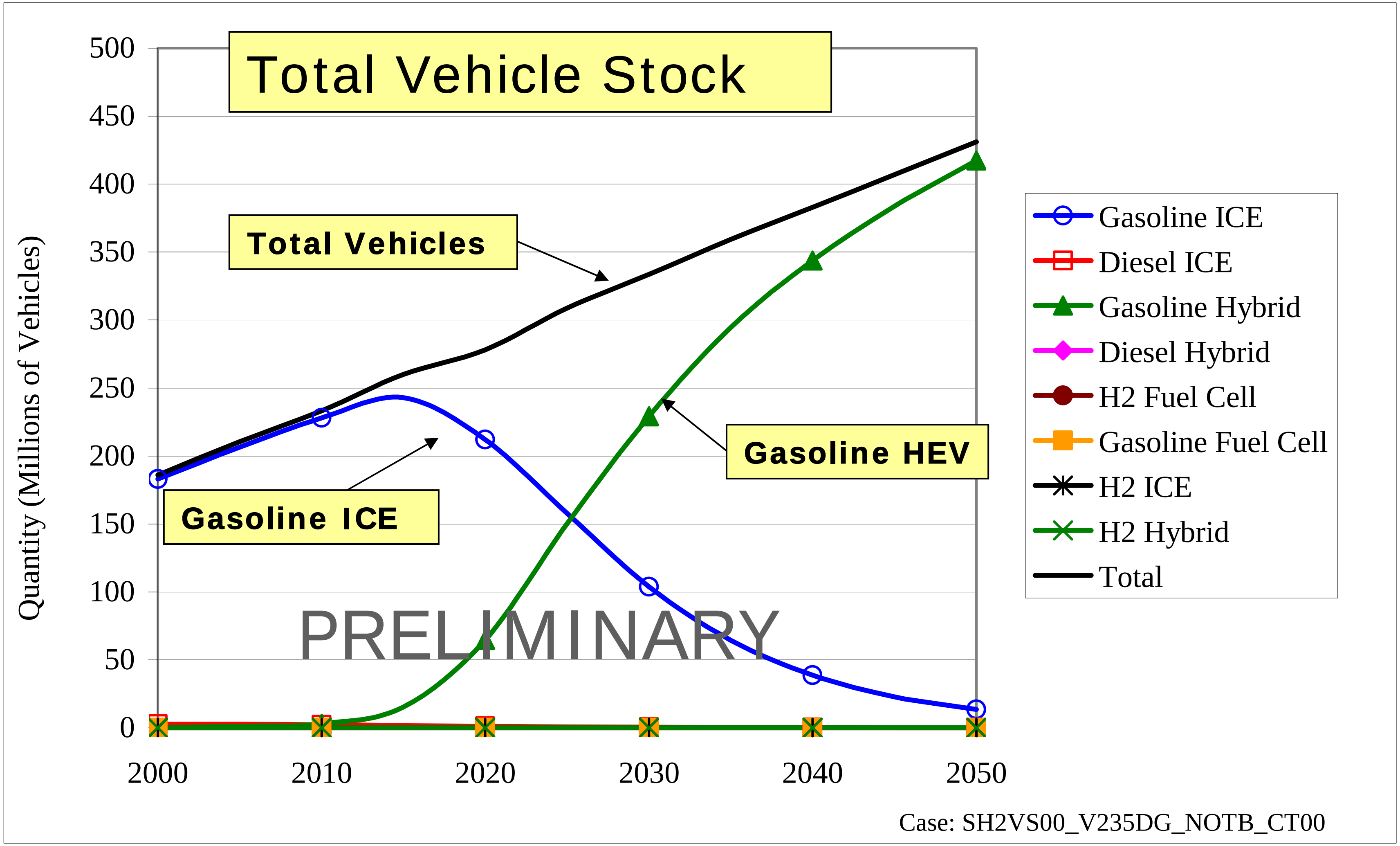
SCENARIO 1

The DOE Vehicle Technology Program Goals scenario anticipates rapid progress **for all technologies**.

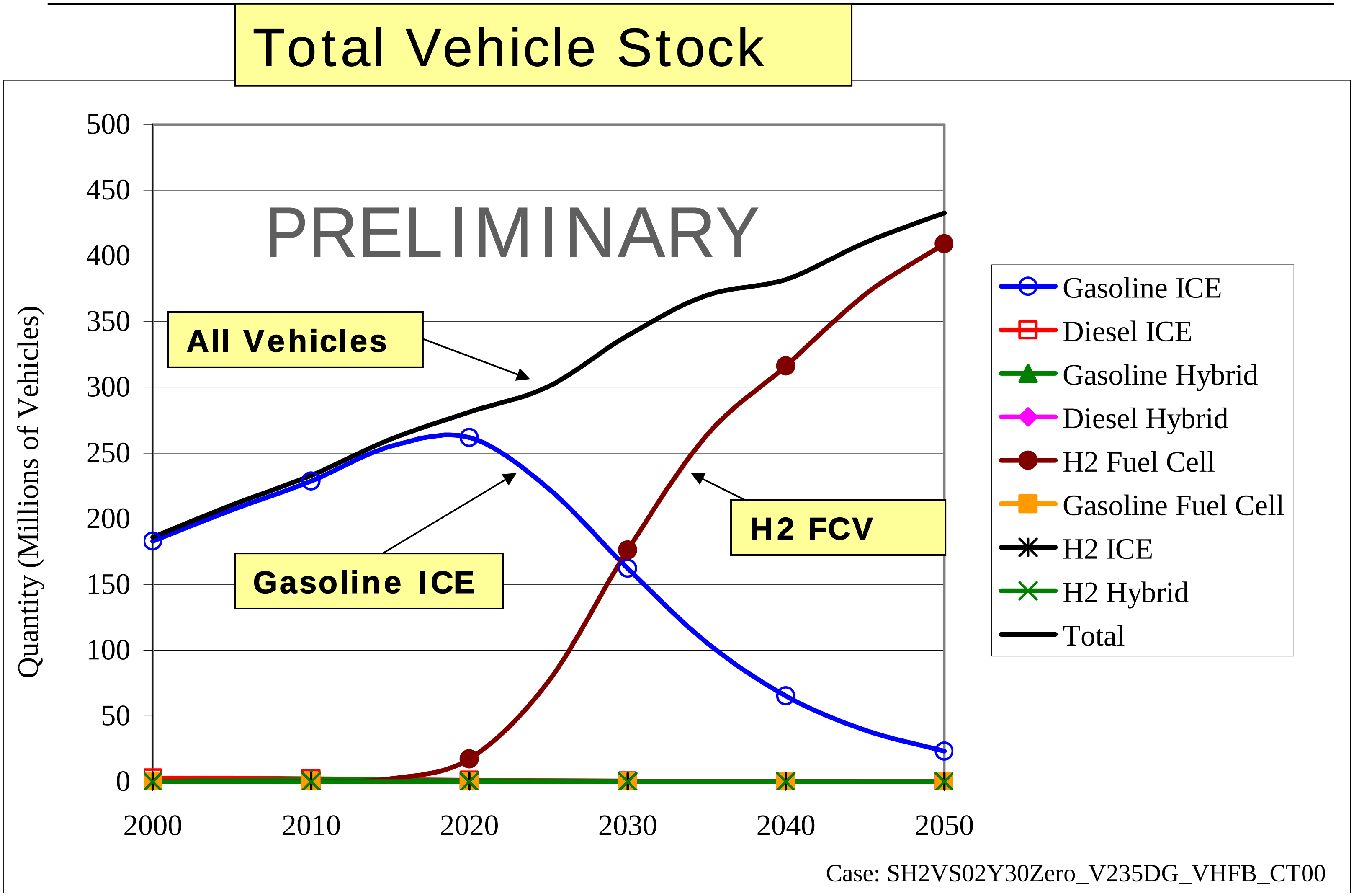


Given no new policies, HyTrans sees a shift to gasoline hybrids in scenario 1.

(Scenario 1: DOE Freedom Car Goals)

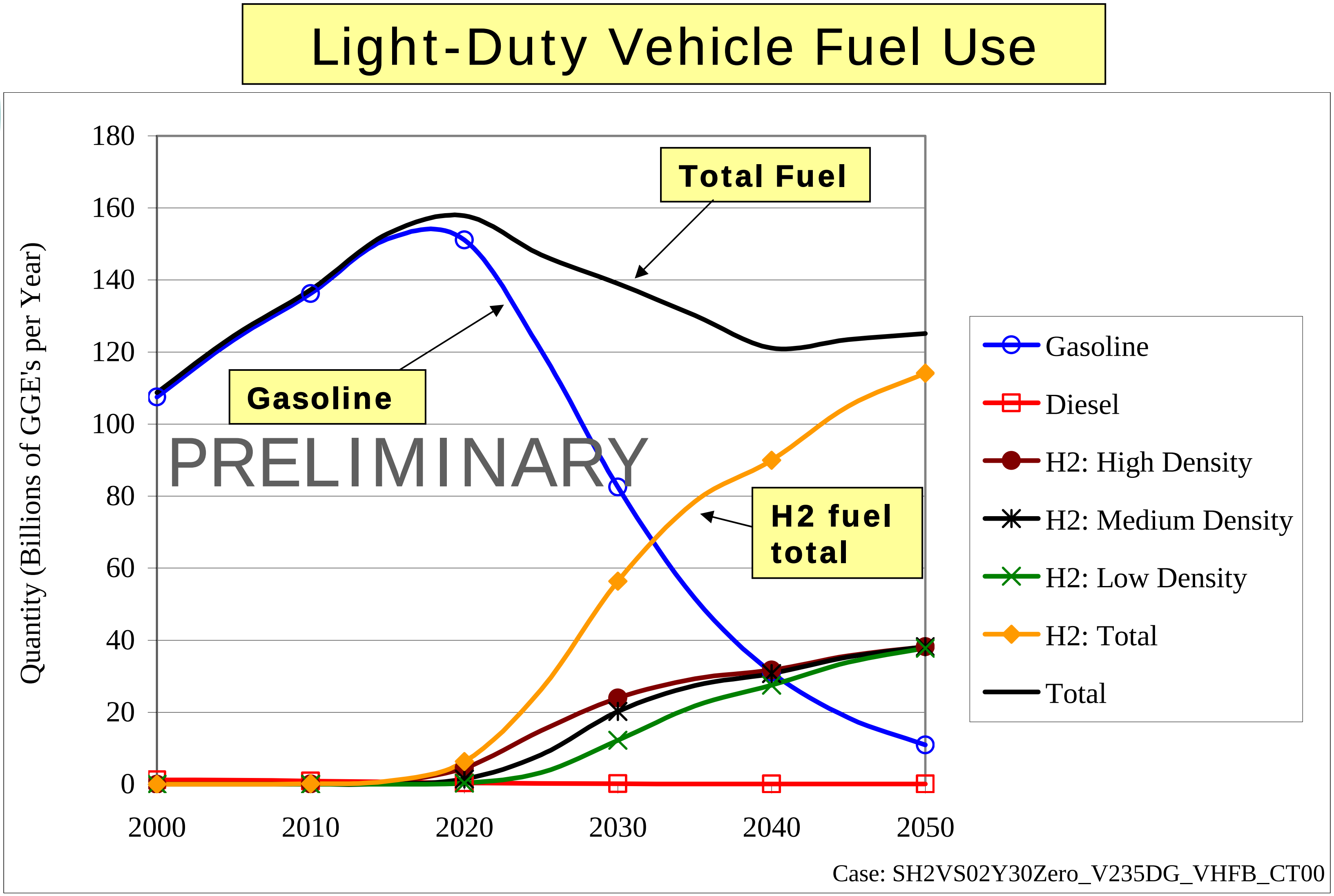


Given a temporary H2-vehicle subsidy in Scenario 1 ($2,000 until 2030, $0 afterwards), HyTrans finds a sustainable transition to hydrogen-powered light-duty vehicles.



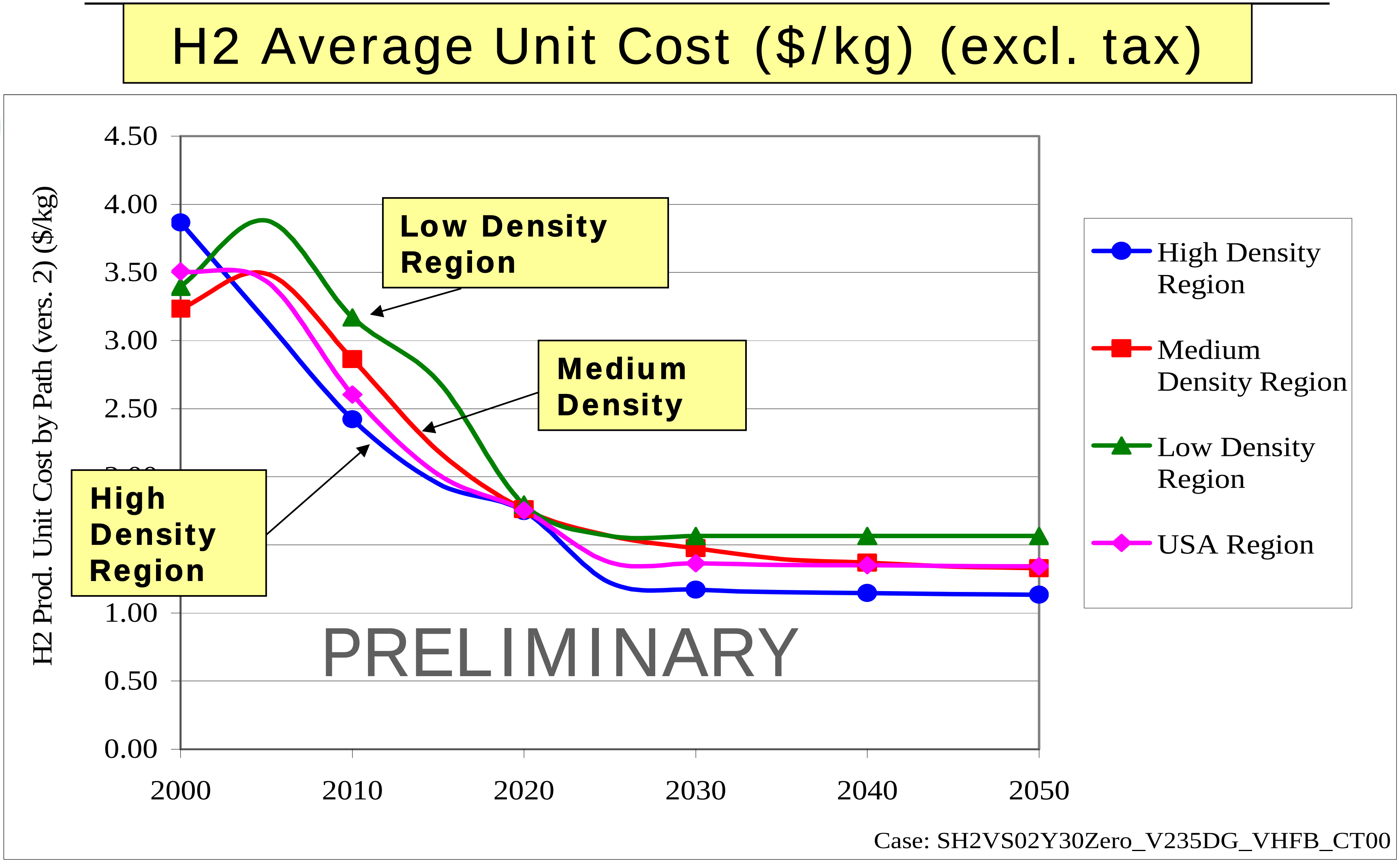
The transition to H_2 reduces vehicle fuel use in the face of steadily growing travel demand.

(Scenario 1: $2,000 H2 Vehicle Subsidy, $0 After 2030)



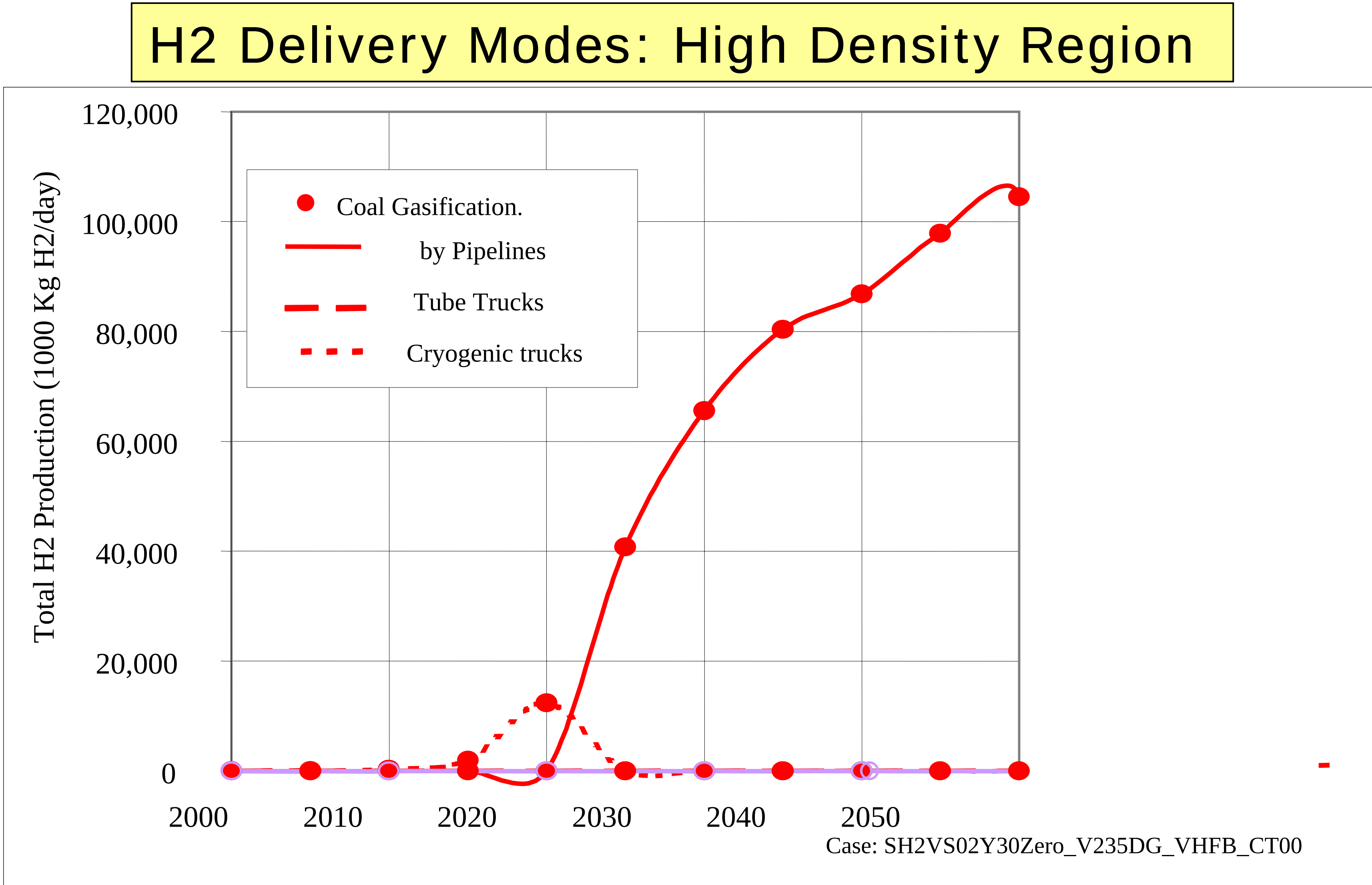
Delivered H_2 costs for central coal gasification fall over time with technological progress, scale economies and market share.

(Scenario 1: $2,000/H2-Veh Subsidy, $0 After 2030)



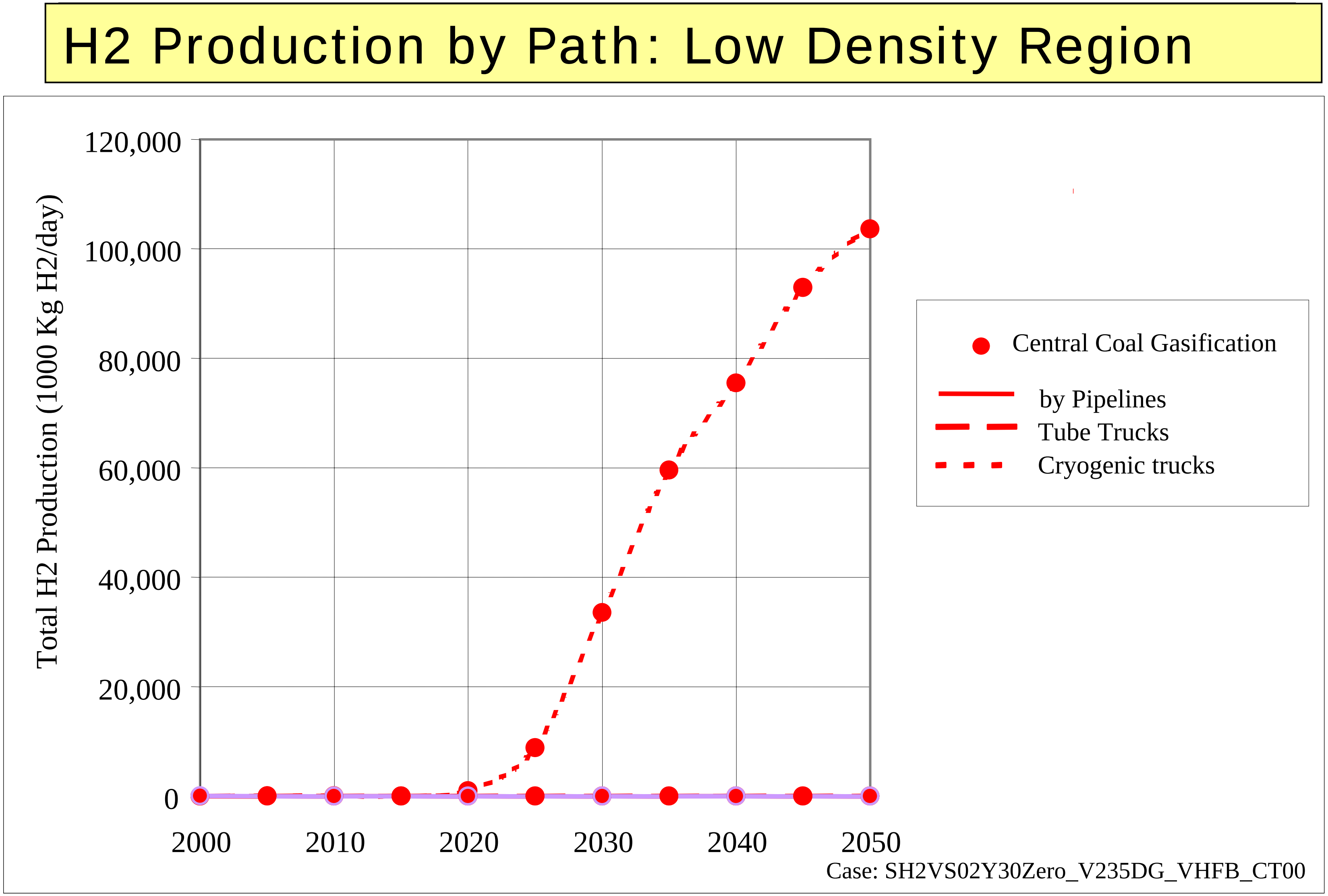
With H supplied by coal gasification, high and medium density regions start with truck and shift to pipeline as hydrogen's market share grows.

(Scenario 1: $2,000/H2-Veh Subsidy, $0 After 2030)



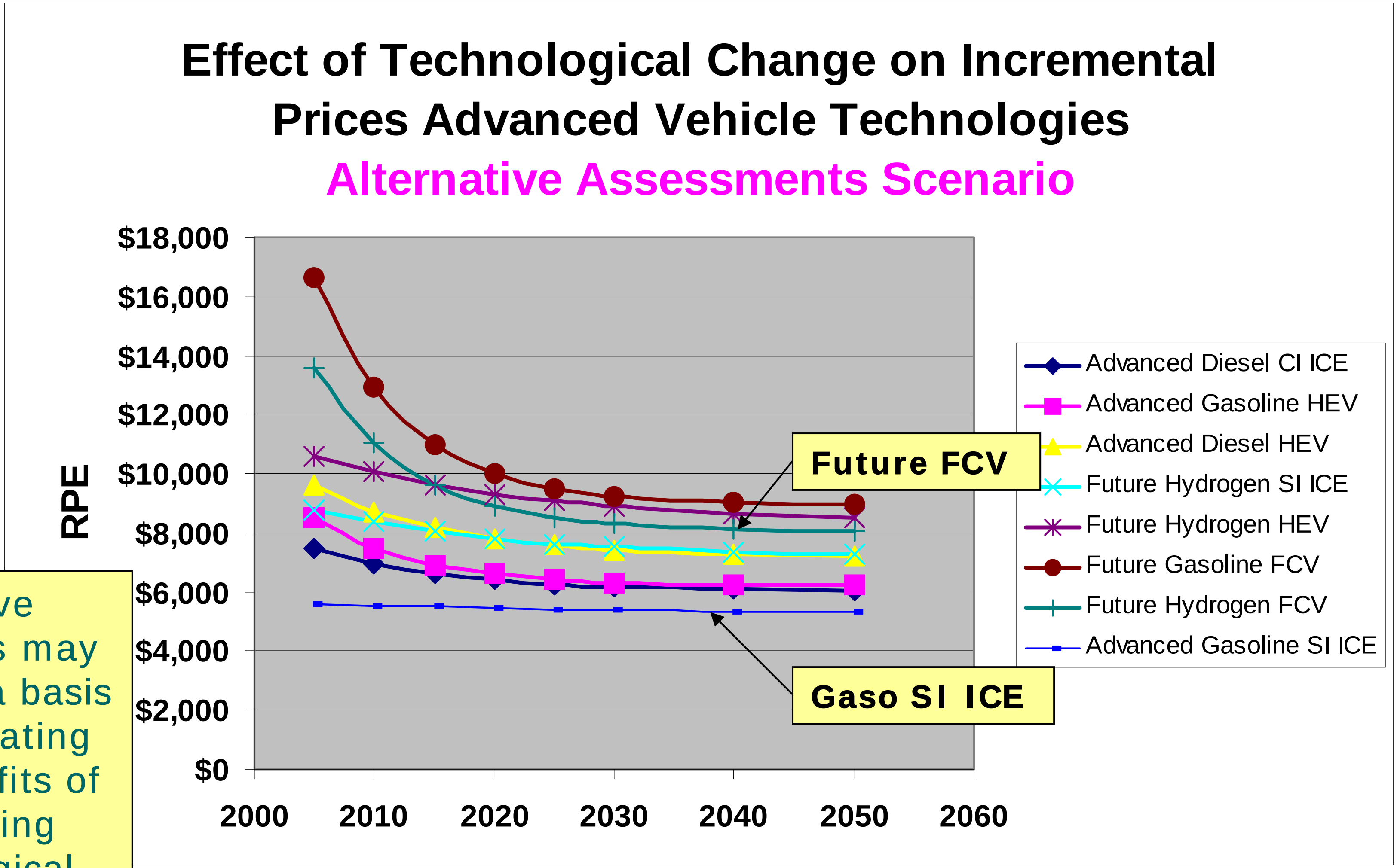
The low density (intercity) region relies on cryogenic-trucking throughout.

(Scenario 1: $2,000/H2-Veh Subsidy, $0 After 2030)



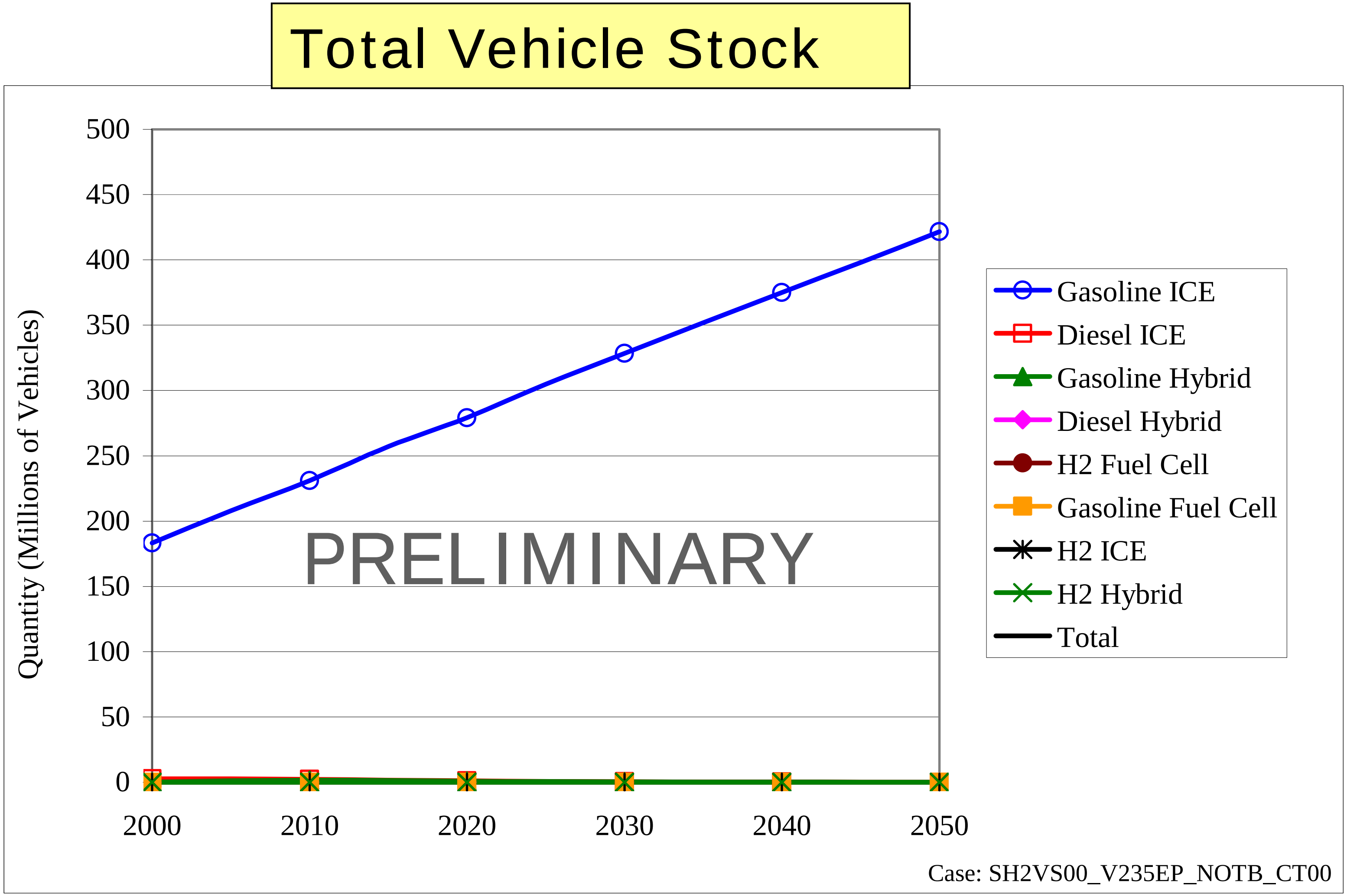
SCENARIO 2

We derived the Alternative Vehicle Technology Case from published studies. It is less favorable for some technologies, certainly for FCVs.



Alternative scenarios may provide a basis for estimating the benefits of accelerating technological progress.

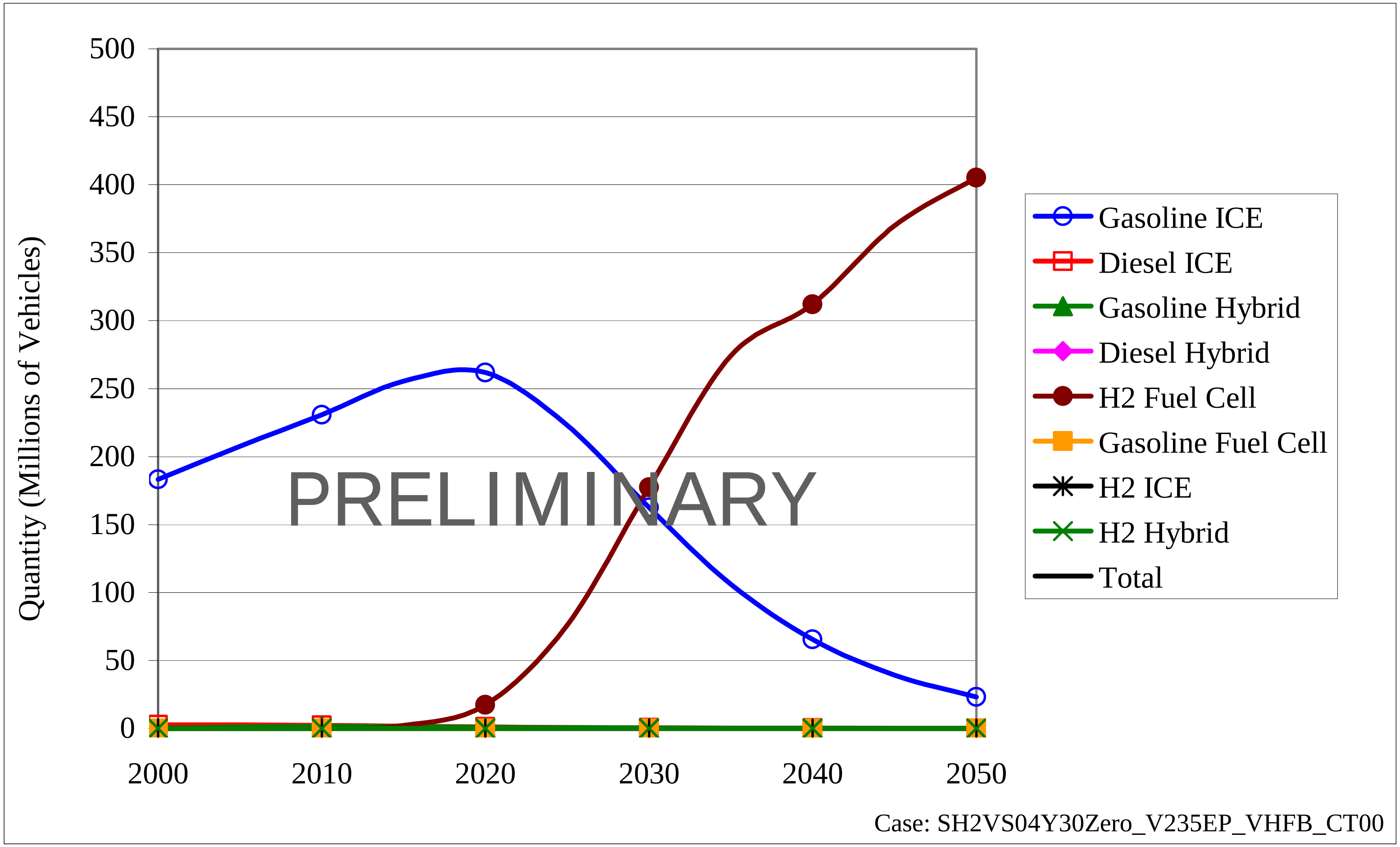
The Alternative Vehicle Technology Assumptions imply continued dominance of (advanced) gasoline-ICEs. (Scenario 2: No New Policy)



Scenario 2 requires twice the removable-subsidy to produce a sustainable transition.

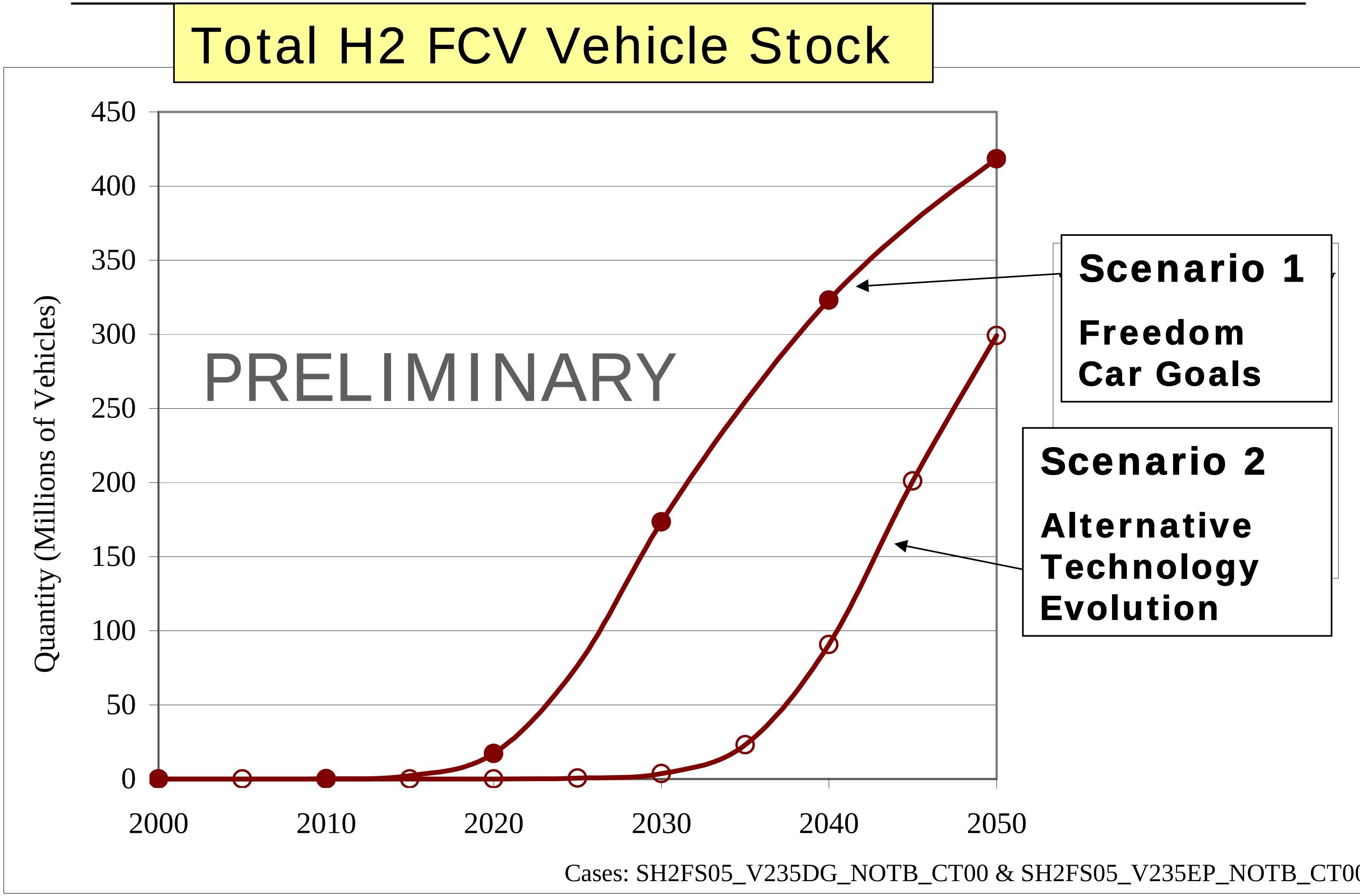
(Scenario 2: $4,000 H2-Veh Subsidy, $0 After 2030)

Total Vehicle Stock



Given the same fuel subsidy policy, the hydrogen transition occurs later in scenario 2.

(Scenarios 1 & 2: $0.90/GGE H2 Fuel Subsidy)



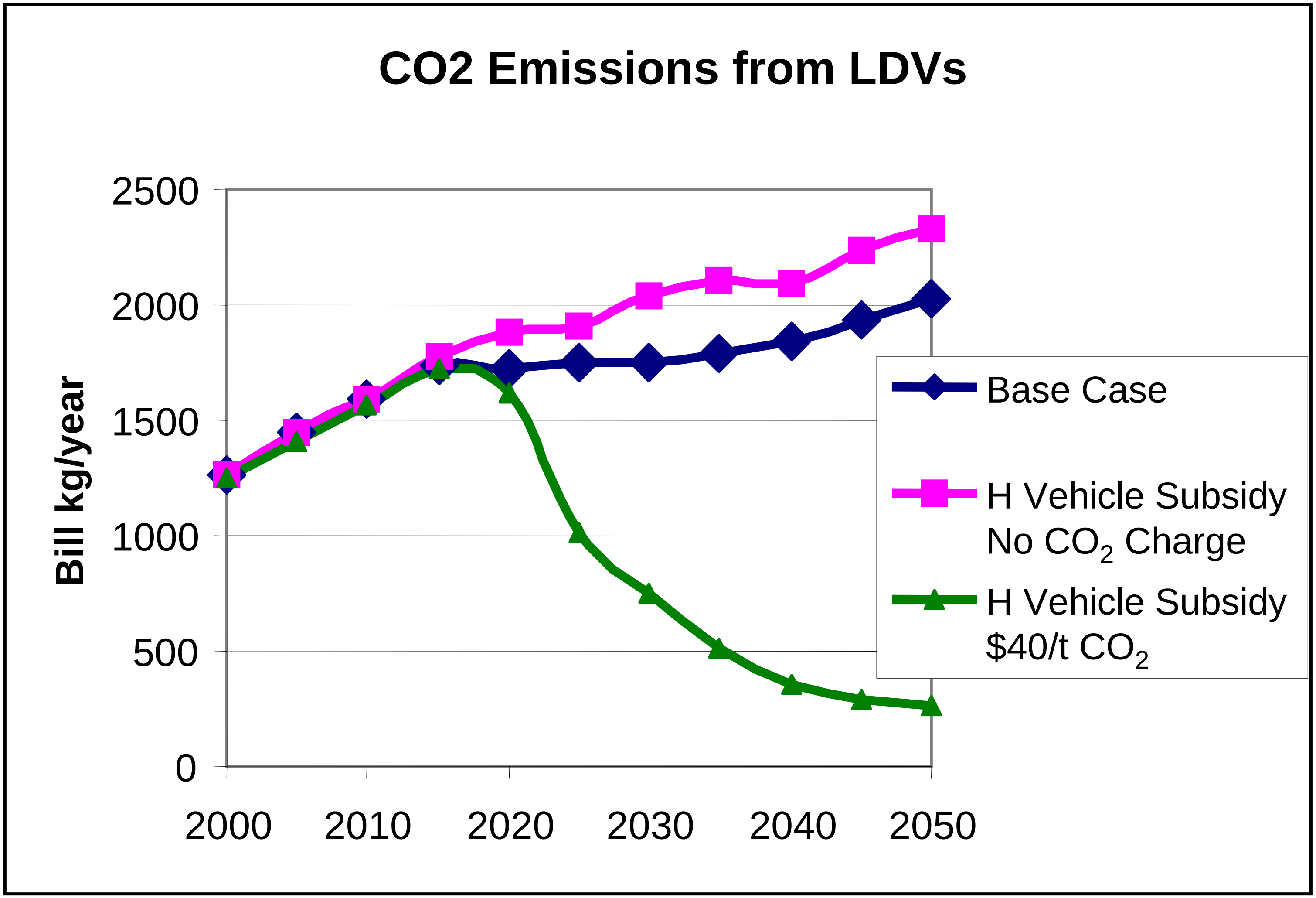
SCENARIO 3: Carbon emission Limits

How do the vehicle technology program goals change the ability to reduce CO_2 emissions from light-duty vehicles?

- GREET 1.6 Supplemented by other sources (GREET update in Spring)
- Represent carbon limits in the form of carbon taxes (cap and trade)
- Add vehicle subsidies, as well
- DOE Vehicle Technology Program Goals

Sequestering C from H_2 production yields major reductions in C emissions.

(Scenarios 1 & 3 w/ and w/o CO_2 Charge)



HyTrans is making significant progress.

- Plausible answers to:
  - Is a stable transition achievable?
  - When?
  - How long will it take?
- Can begin to test key policies
- Will be able to produce potentially useful cost and benefit measures
- Close to useful visions of the transition
- Beginning to generate insights about R&D goals
  - Good enough?
  - Effects of competing technologies

Several important deficiencies remain to be addressed.

- Market has multiple equilibria: Challenging model search
- Lack of geographic regions makes it difficult for renewable H sources.
- Fixed station size assumption appears to be excluding distributed production.
- Still reflects NAS rather than H2A production and delivery.
- Representation of learning & unlearning still not satisfactory.
  - Should be asymmetric
  - Technologies should be linked by shared components
- Need to improve representation of fuel availability
  - Intercity (Melaina methodology)
  - Variable station sizes

THANK YOU.