Analysis of the Hydrogen Production and Delivery Infrastructure as a Complex Adaptive System

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Project ID # AN3

Overview

Timeline

- Project start date: July 2005
- Project end date: Dec 2008
- Percent complete: 35%

Budget

- Total project funding

  $3,616,634
- FY05
  - $401,071 budgeted
  - $70,000 funded
- FY06
  - $1,225,830 budgeted
  - $600,000 funded
- FY07
  - $1,719,500 budgeted
  - $ 1,100,000 anticipated
- FY08
  - $270,233 budgeted

Barriers

- Barriers addressed
  - Lack of understanding of the transition of a hydrocarbon-based economy to a hydrogen-based economy
  - Lack of consistent data, assumptions and guidelines
  - Lack of prioritized list of analyses for appropriate and timely recommendation

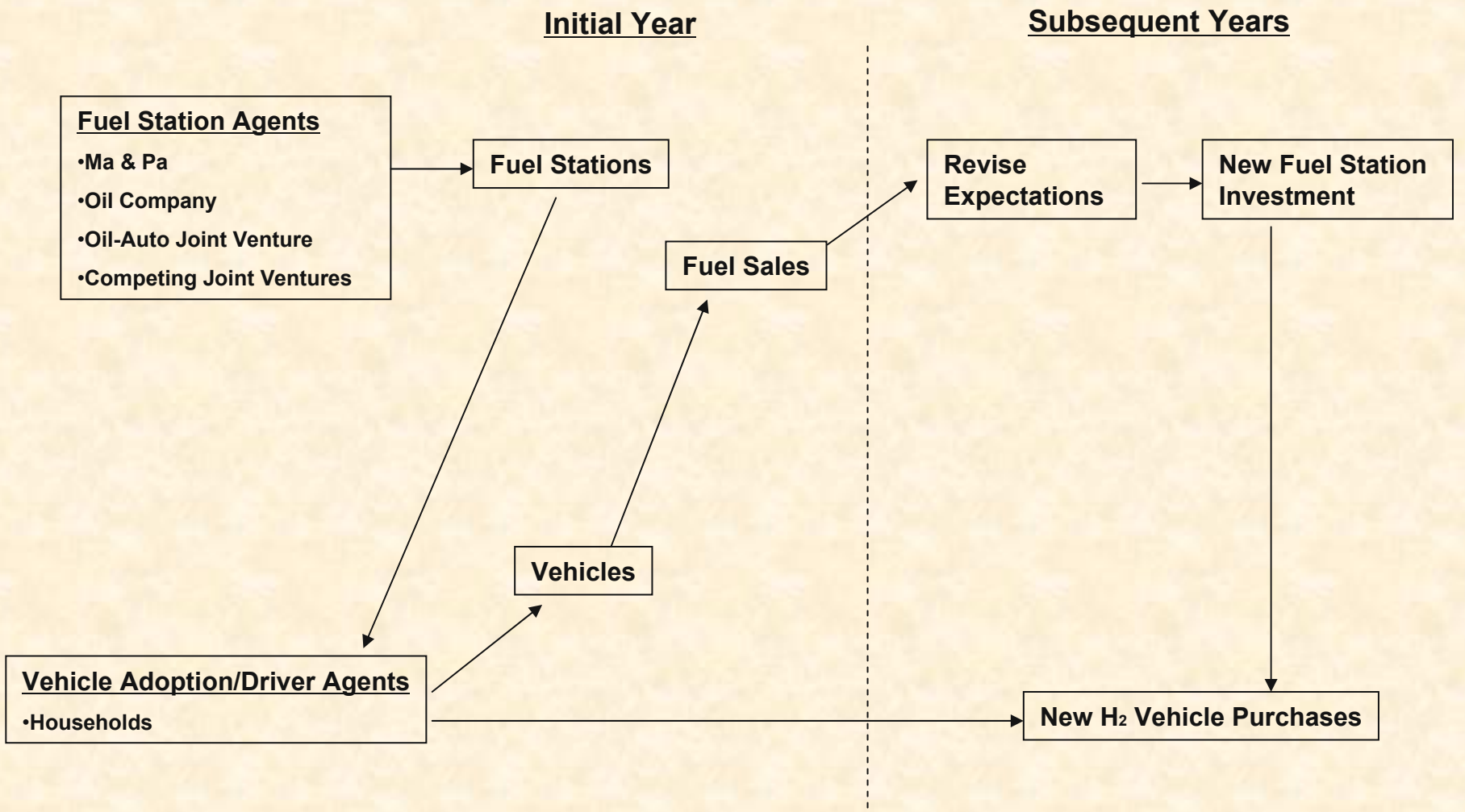
Partners

- RCF, prime
- Argonne National Laboratory
- Air Products and Chemicals
- BP
- Ford Motor Co.
- University of Michigan
- World Resources Institute

Objectives

- Use agent-based modeling (ABM) to provide insights into likely infrastructure investment patterns
- Deal with chicken-or-egg aspect of early transition
- Provide answer to the question, “Will the private sector invest in hydrogen infrastructure?”

Overview of the Agent Based Model



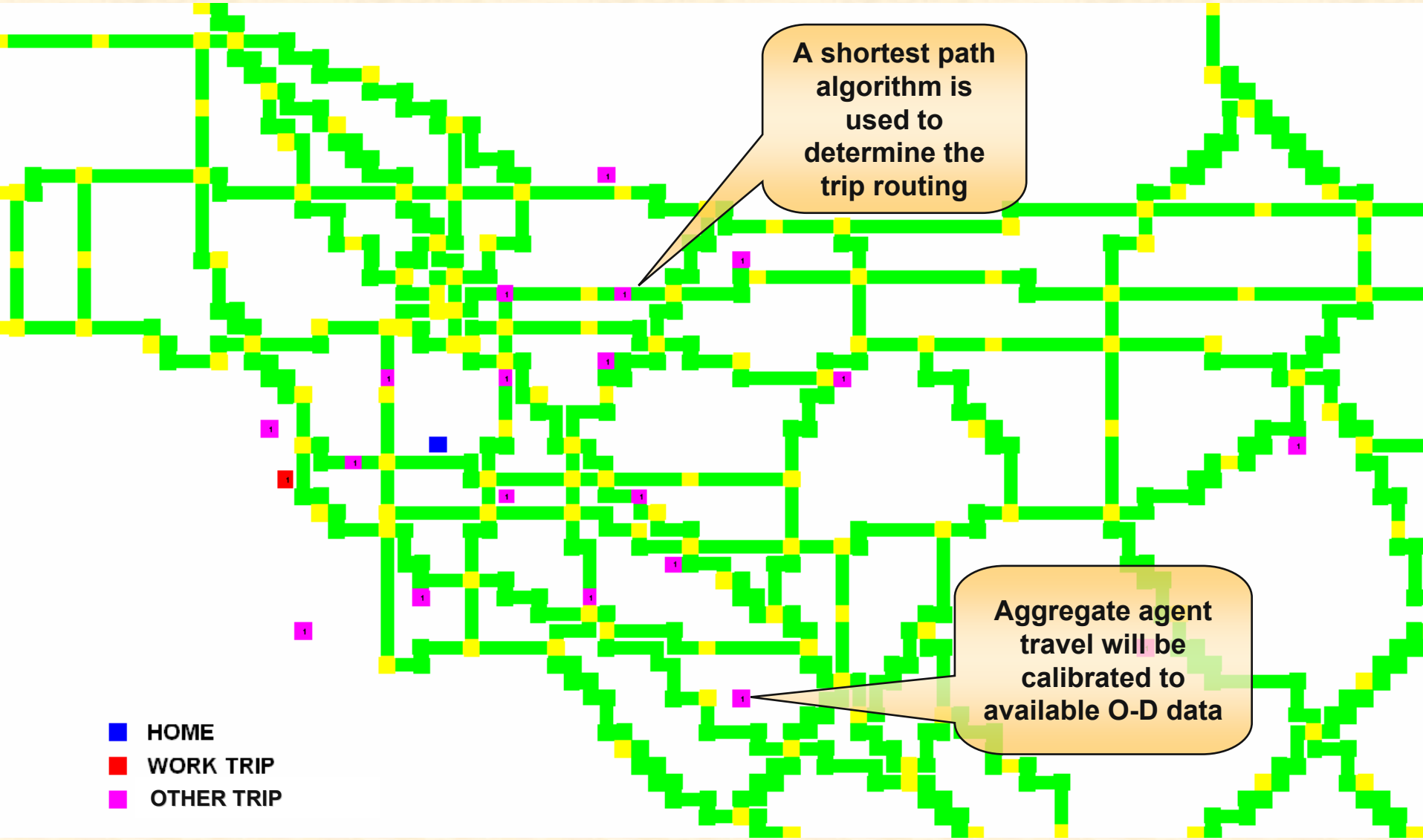
Assumptions: Driver Agents

- Drivers purchase vehicles based on their assessment of fuel availability
  - Inconvenience of refueling
  - Worry regarding the risk of running out of fuel
- Vehicle purchases depend on
  - General knowledge about hydrogen vehicles
  - Imitation of their neighbors
  - Difference in attitude towards hydrogen (e.g., *green vs. non-green buyers)*
  - Socio-demographic characteristics

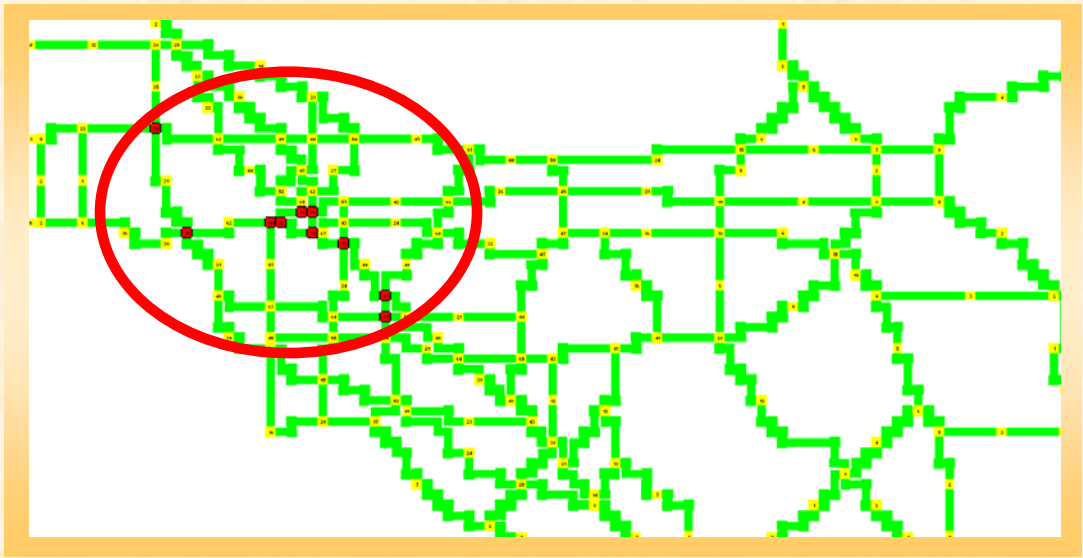
Assumptions: Investor Agents

- Investors want to maximize returns over costs *(profit motive)*
- Investor agent is constrained by cost of funds for risky investments and willingness to take risk *(risk aversion coefficient)*
- Investors build stations based on expectations about a complicated situation *(satisficing)*
- In each period, investors learn from experience and revise their expectations *(Bayesian Learning Model)*
- Allows for *non-optimal responses*

Detailed Modeling of Drivers' Refueling Behavior through Home & Work Locations, Commuting & Other Trips

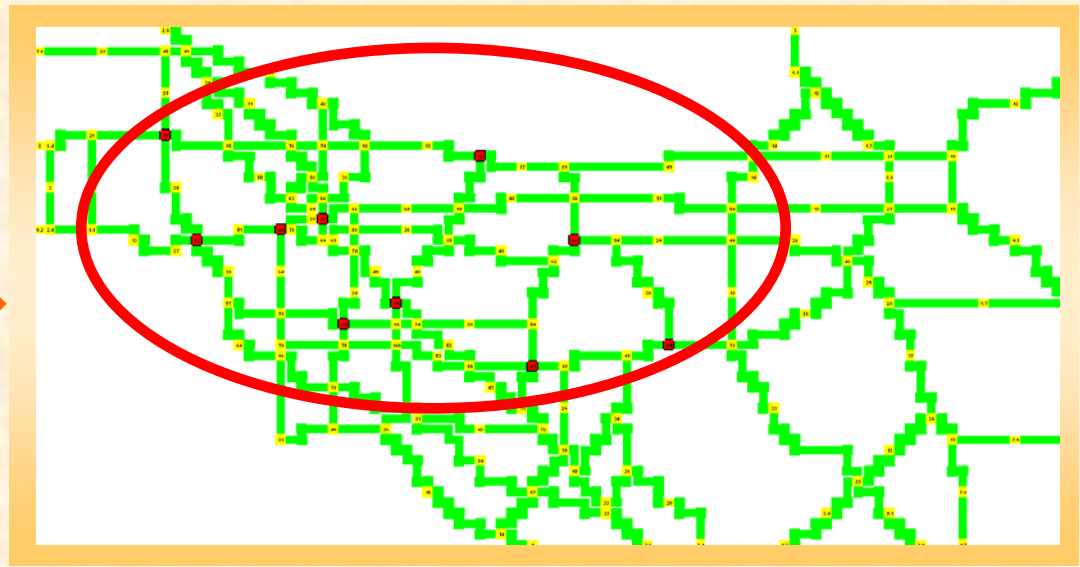


Once the Investor Decides the Number of Stations Planned, the Agent Needs to Site them: Results Depend on How Much Information Investor Agent Is Assumed to Have



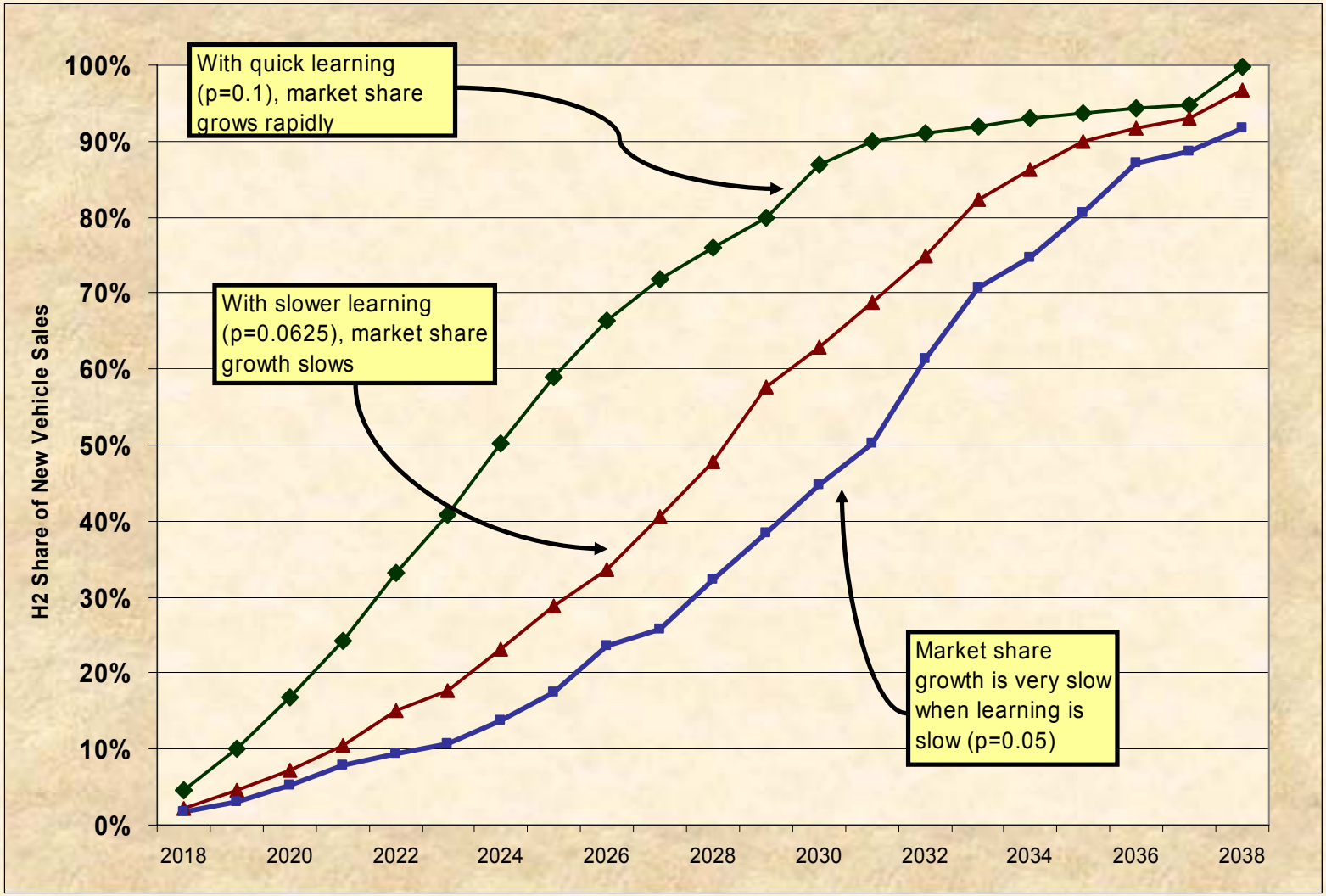
If the investor agent relies only on traffic counts for siting decision, potential station locations are concentrated in smaller pockets

If the investor agent uses additional information on travel origin and destination, potential station locations are spread over a larger geographic area



Parameter Sensitivity: Consumer Example 1

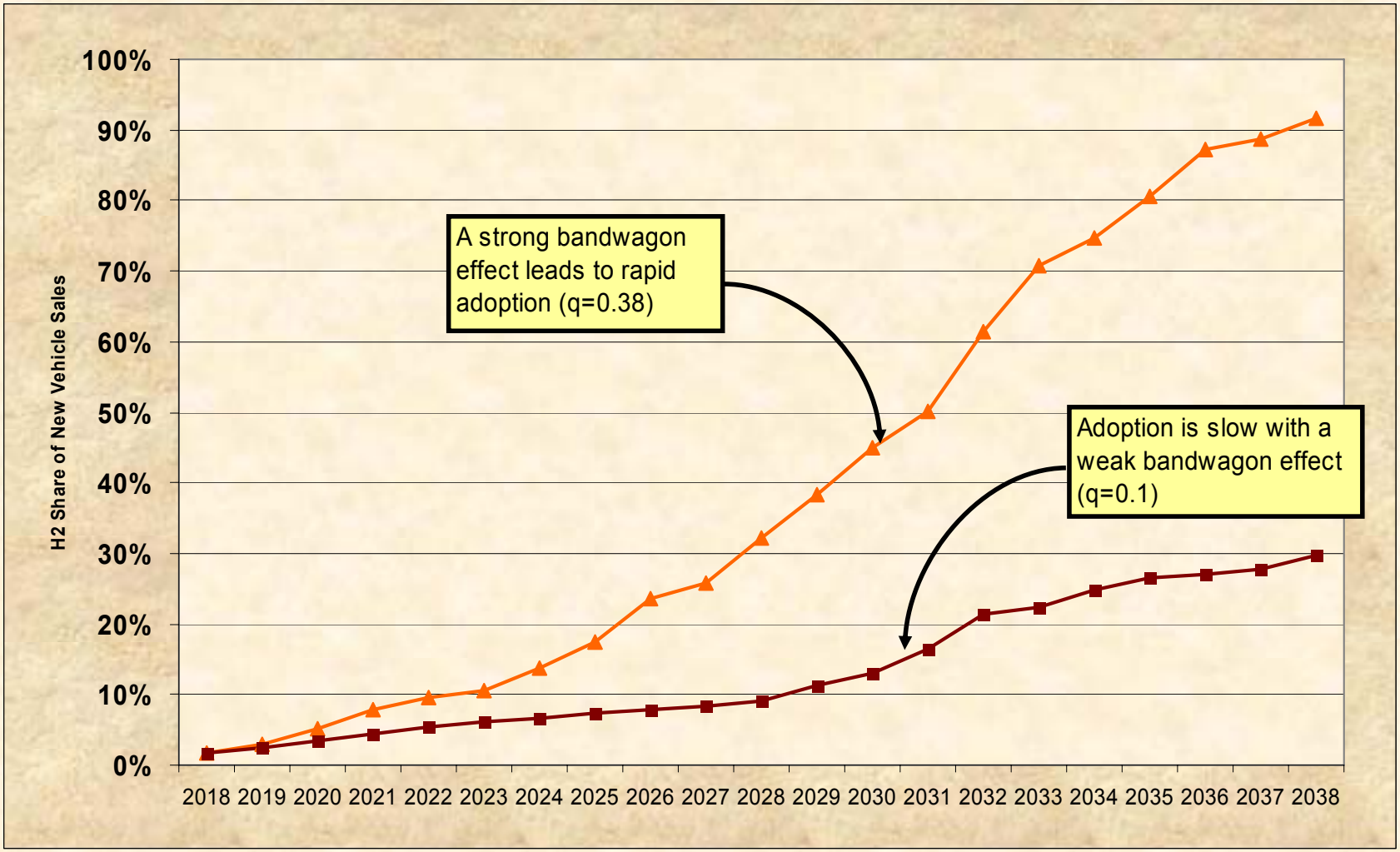
Consumer Learning Behavior Affects Adoption



Preliminary Results

Parameter Sensitivity: Consumer Example 2

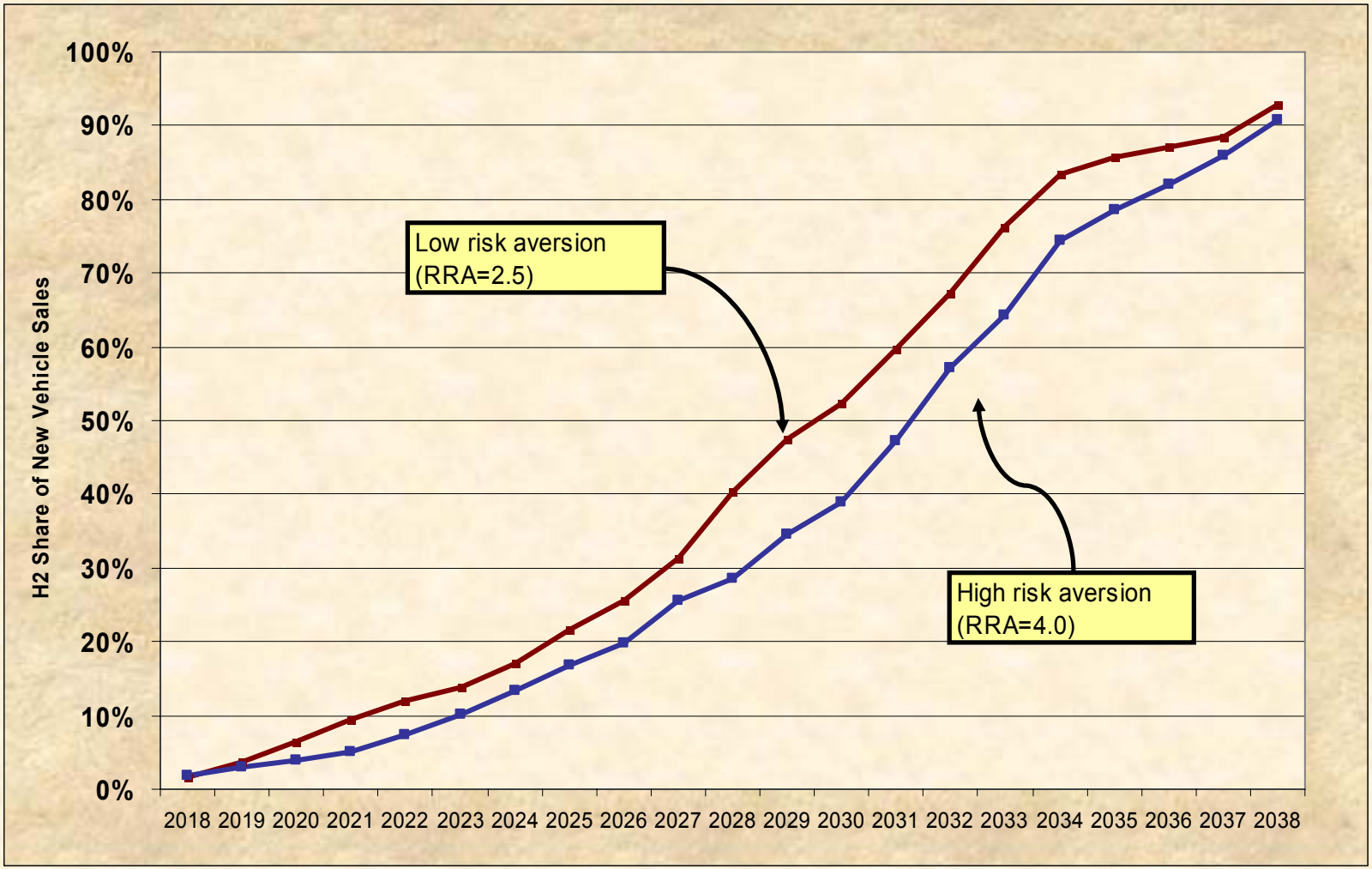
Stronger Bandwagon Effect Speeds Up Adoption



Preliminary Results

Parameter Sensitivity: Investor Example

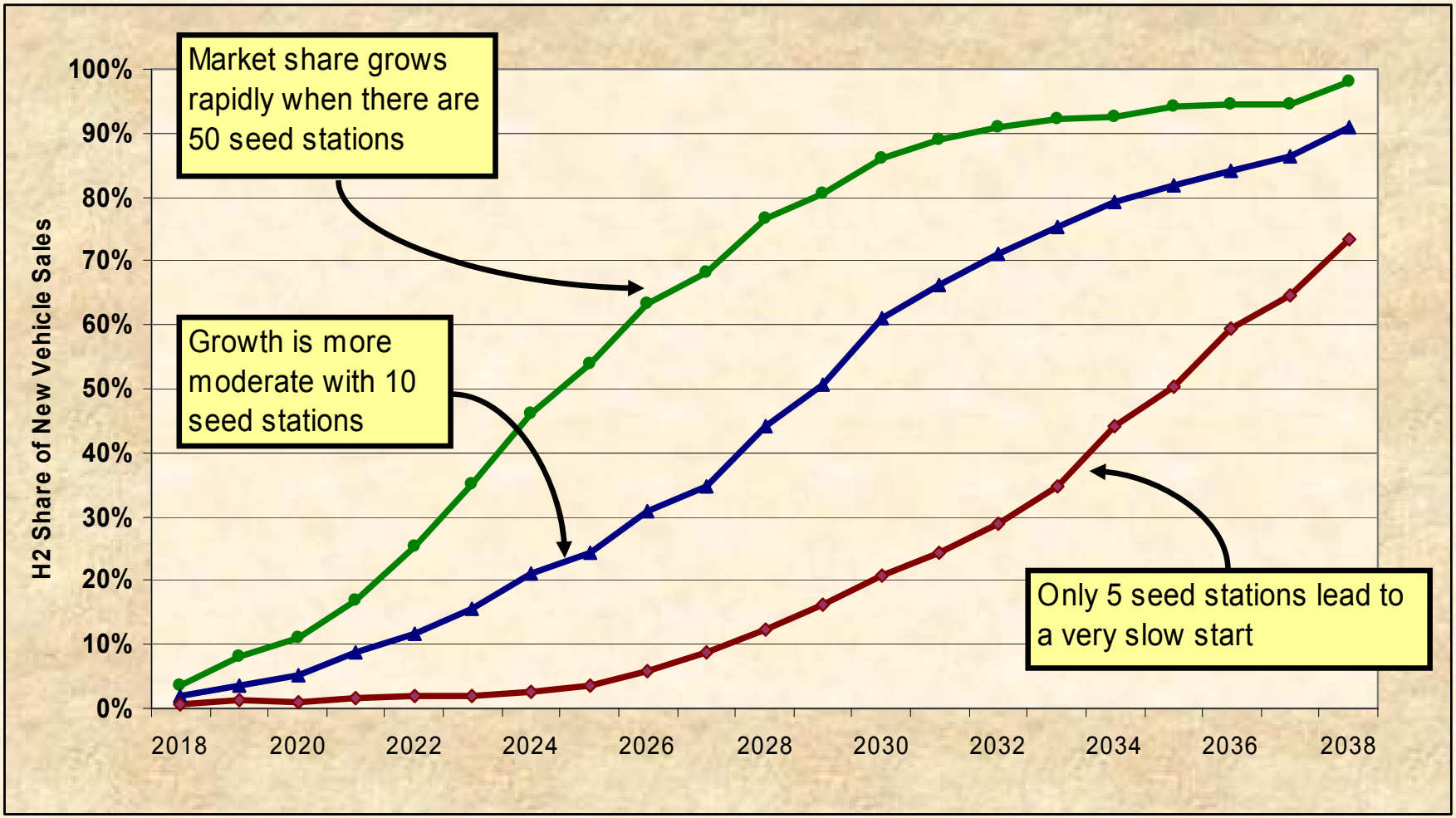
High Investor Risk Aversion Slows Down Adoption



Preliminary Results

Policy Analysis

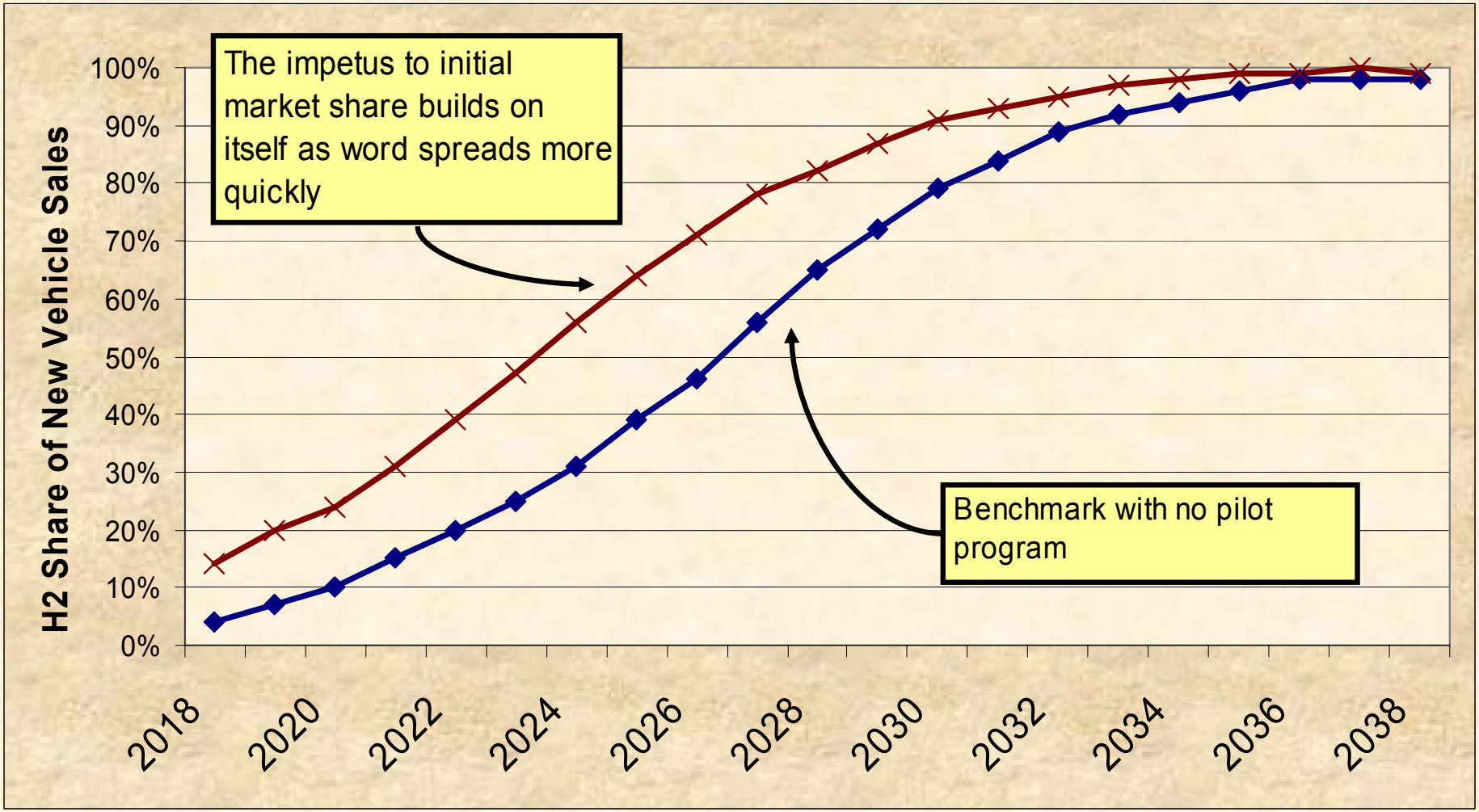
More Seed Stations Accelerate Adoption



Preliminary Results

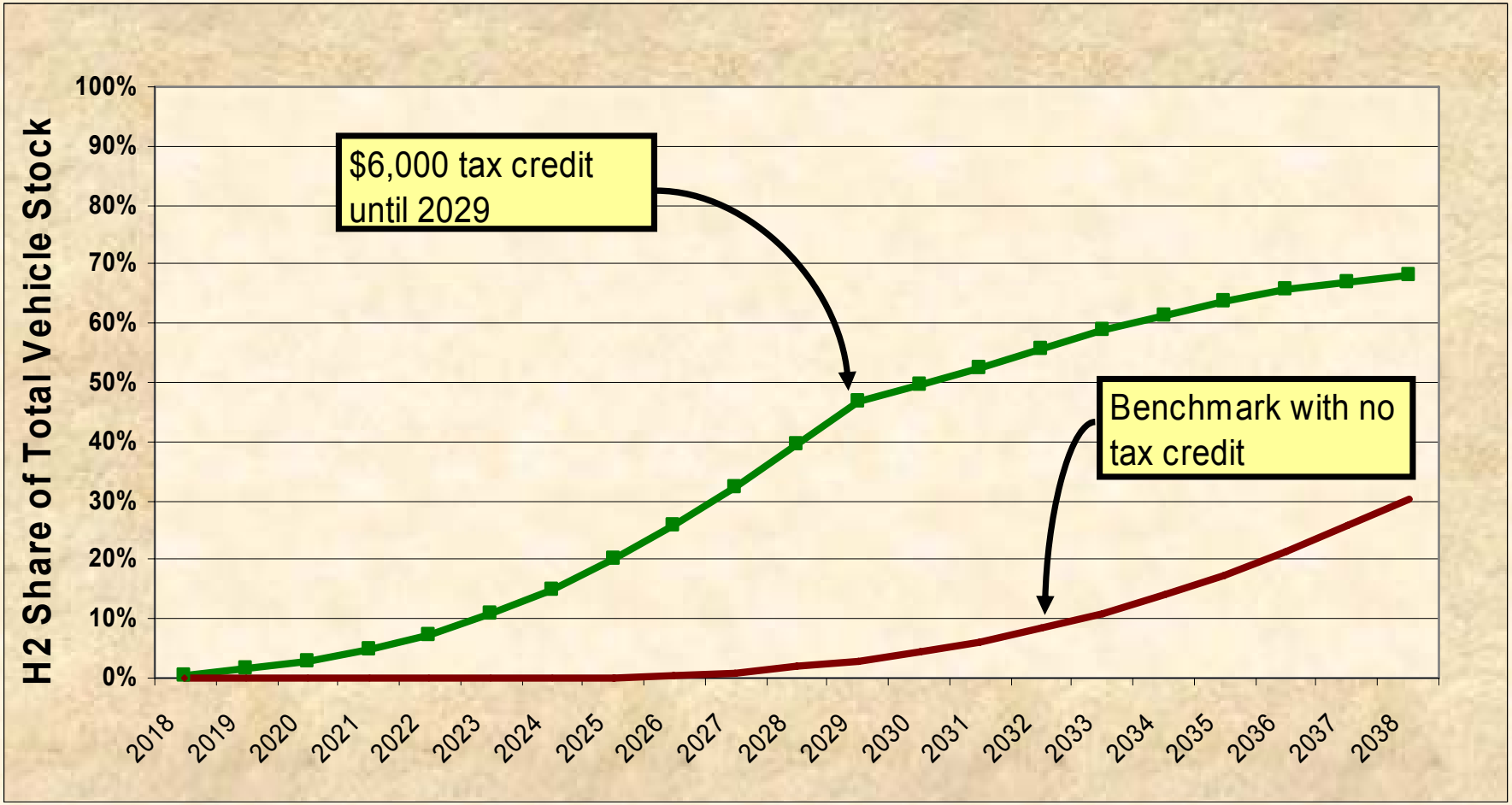
Policy Analysis

Pilot Program Increases Early Market Share



Policy Analysis

Tax Credit in Early Years Enables Take-off if Initial Market Conditions are Unfavorable



Preliminary Results

Future Work

FY 07			FY 08		
Q3	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**
1st version of ABM					
		Model Expansion • Centralized production, pipeline distribution, truck distribution • Driver agents (more complex re-fueling; inter-city trips, taste differences) • Investor agents (non-optimal rules of thumb, Bayesian and other learning) • Market organization (degree of competition; financial markets)			
		Details of Policy Options (seed stations, pilot projects, tax credits)			
			Coordination with MSM		
		Sensitivity, Validation and Report			

Summary

- Will the private sector invest? Yes. Eventually.
- Early path of adoption depends on objectives other than cost minimization (risk aversion, non-optimal rules of thumb, degree of competition, consumer tastes and learning)
- Government assistance including tax credits, pilot programs and government risk sharing can help achieve early adoption goals