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# Hawaii Hydrogen Initiative (H2I) Financial Scenario Analysis

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2013 DOE Hydrogen and Fuel Cells Program Review

National Renewable Energy Laboratory

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**Project ID AN042**

**This presentation does not contain any proprietary, confidential, or otherwise restricted information**

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# Overview

## Timeline

Project start date: Q1, FY12
Project end date: Q1, FY13
Percent complete: 100%

## Barriers

4.5.A: Future Market Behavior
4.5.B: Stove-piped/Siloed Analytical Capability
4.5.D: Insufficient Suite of Models and Tools
4.5.E: Unplanned Studies and Analysis

## Budget

Total project funding: $230k
100% DOE-funded
FY2012: $200k
FY2013: $30k

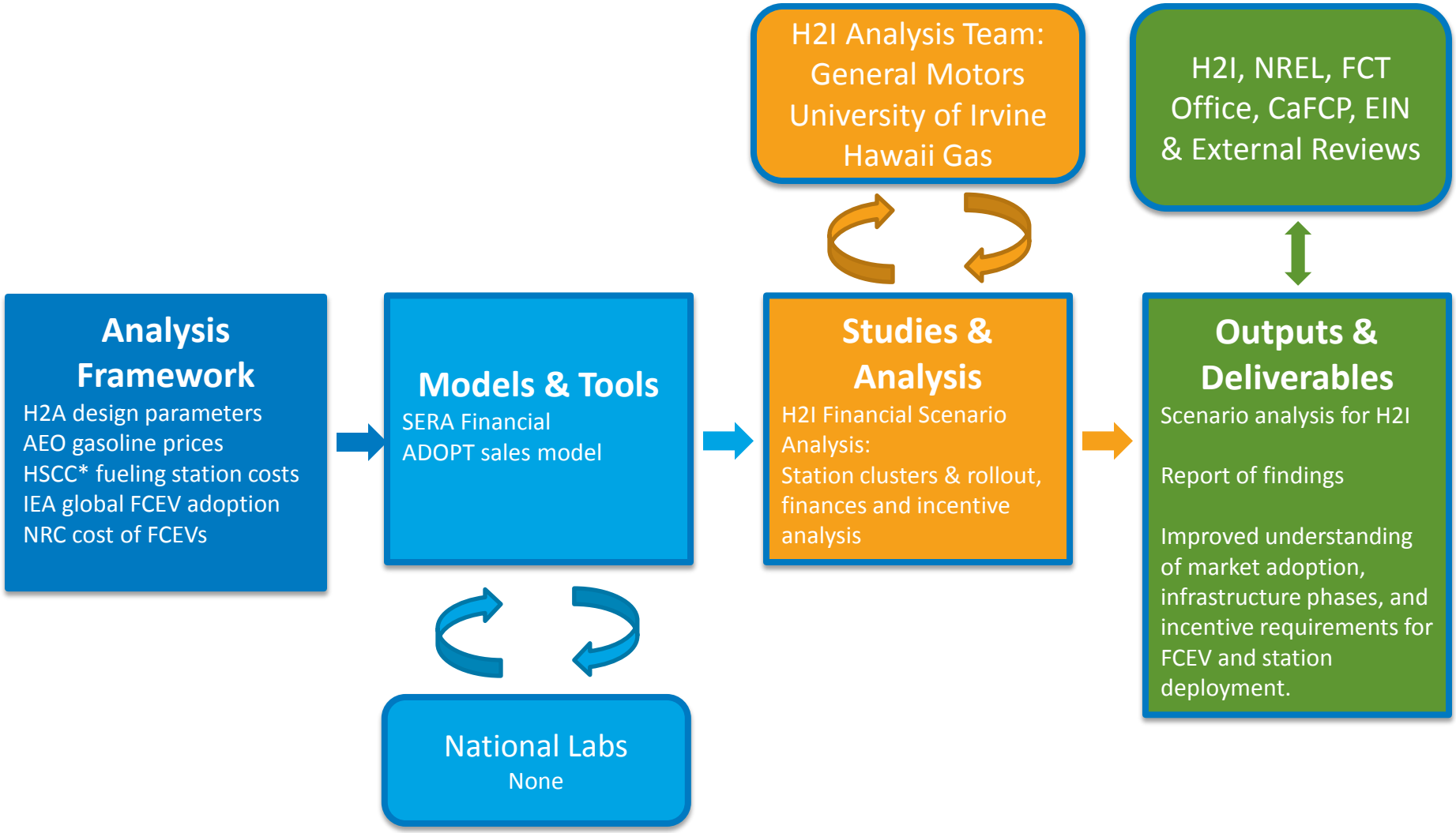
## Partners

| | |
|---|---|
| Louis Berger Group | [H2I - lead] |
| General Motors | [FCEV deployment lead] |
| U.C. Irvine | [station placement analysis] |
| Hawaii Gas | [gas producer & supplier] |
| Wellford Energy | [financial modeling guidance] |

# Project Overview

Approach

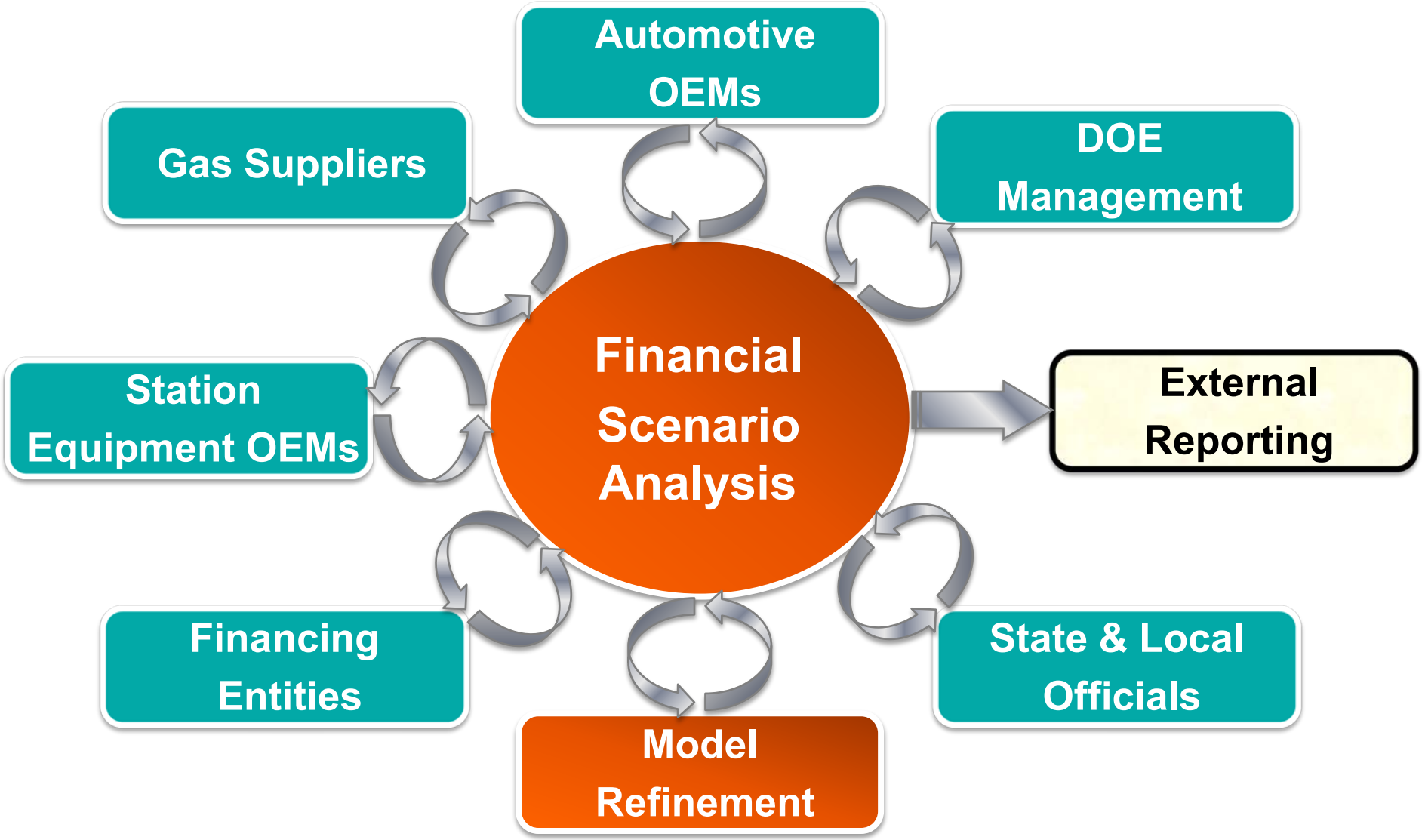
***Effects of Technology Cost Parameters on Hydrogen Pathway Succession***




***HSCC = Hydrogen Station Cost Calculator, NREL Publication Pending**

# Relevance: Financial Tool for Stakeholders

**Analysis incorporates interests of many stakeholders for station cluster financial analysis**



# Relevance: Objectives

**Analysis helps to identify opportunities and constraints for equity, debt, and public financing**

## Produce financial projection scenarios

- Consider vehicle adoption rates
- Determine infrastructure support requirements
- Evaluate full range of expenses
- Apply competitive revenue ceiling
- Perform accounting cycle analysis
- Perform multi-year financing projections

## Provide Hawaii Hydrogen Initiative (H2I) team with scenario analysis

- Communicate risk and sensitivities
- Facilitate strategic planning
- Evaluate incentive requirements

# Approach: Model Structure

**Overall model strategy evaluates station supply chain with vehicle sales as an input.**

## Vehicle Sales

- Promotional introduction
- Private vehicle adoption
- Market competition
- Fleet vehicles
- Fuel efficiency
- Driving habits

## Fueling Stations

- Station coverage
- Station size distribution
- Station types

## Production & Delivery

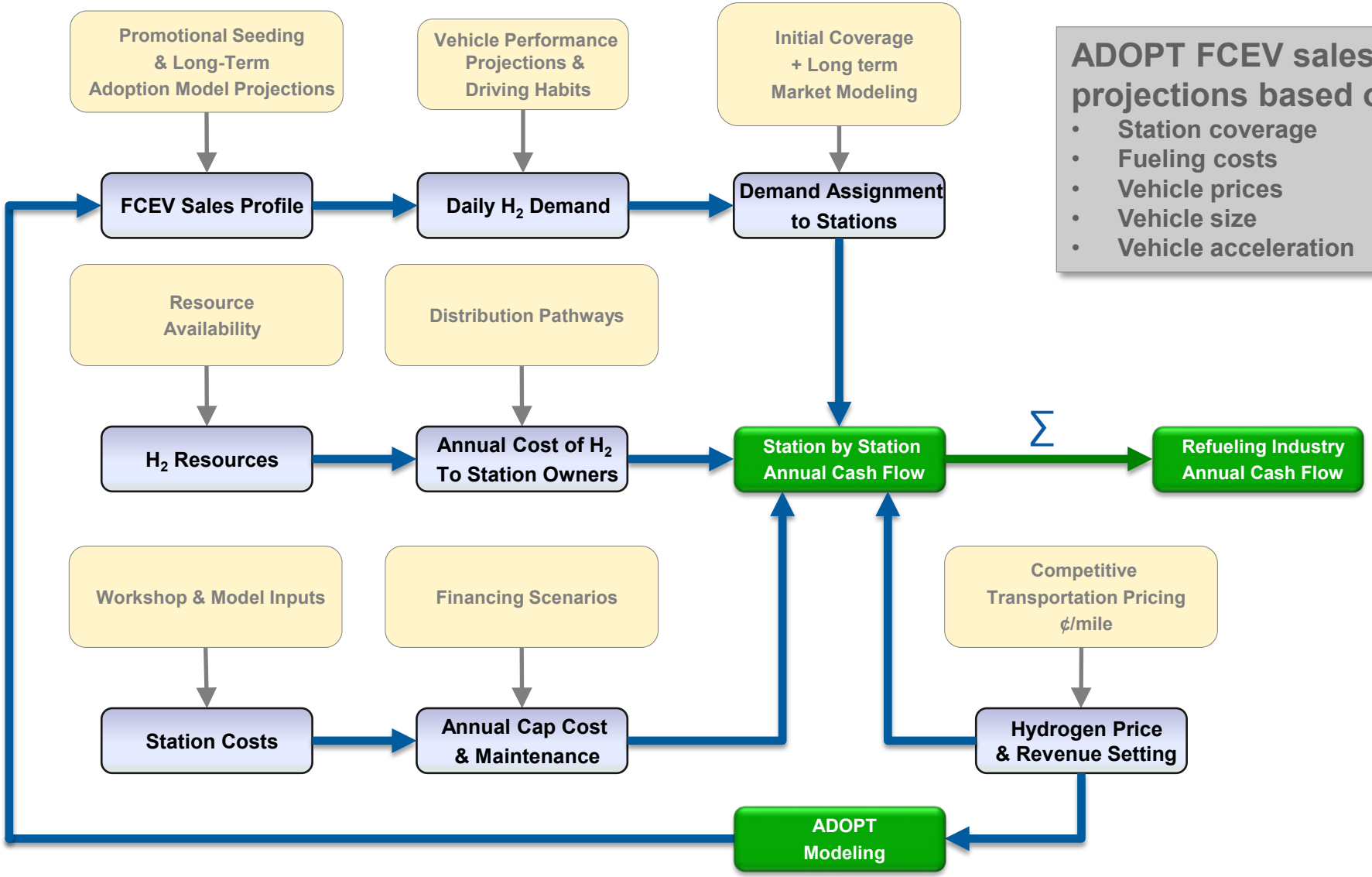
- Production sources
- Delivery methods
- Supply chain costing

## Financing & Incentives

- Multi-source financing
- Incentive requirements
- Risk analysis

# Approach: Model Structure

## Model is integrated with vehicle choice modeling Automotive Deployment Options Projection Tool (ADOPT model)

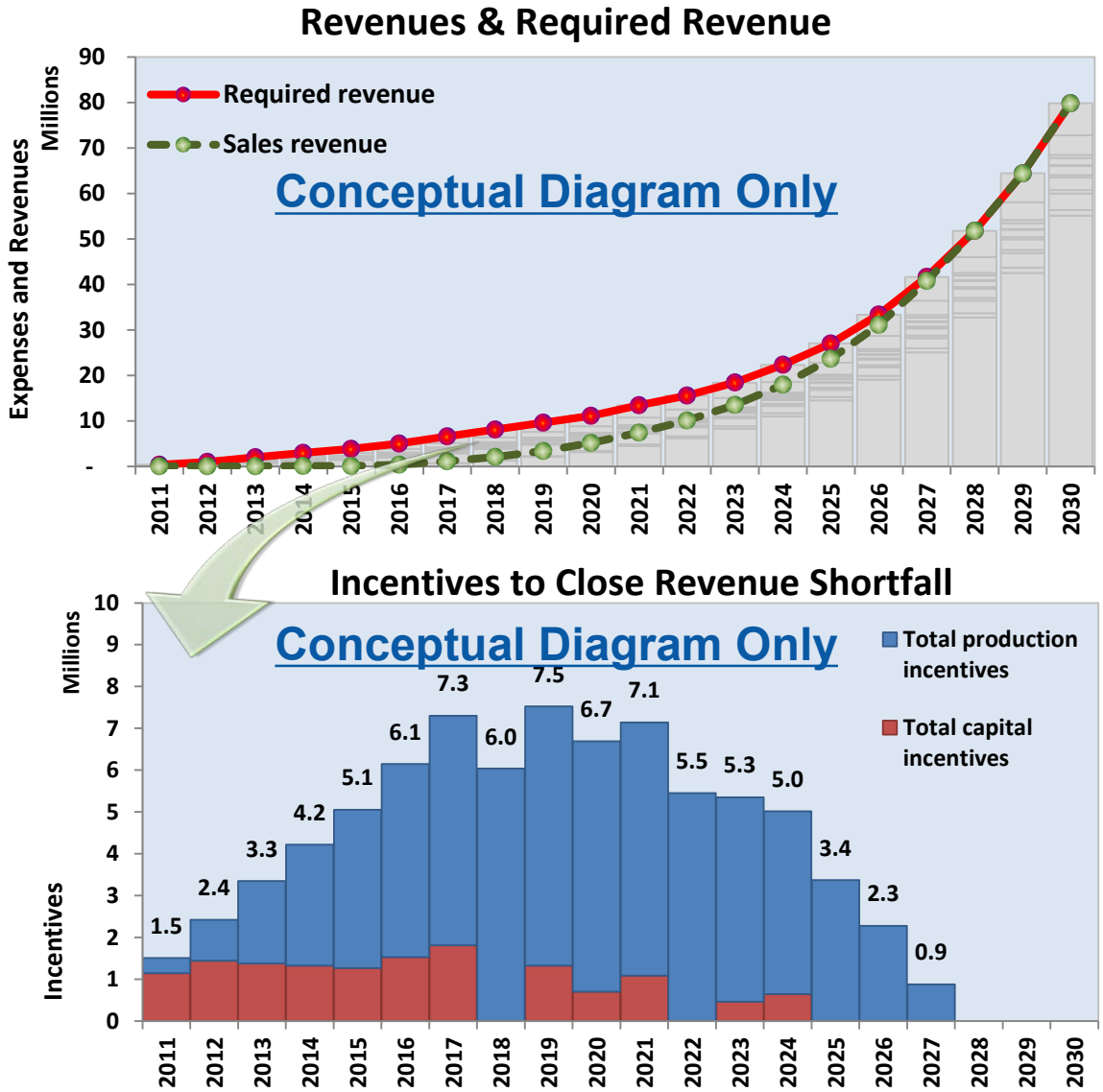



**ADOPT FCEV sales projections based on:**

- Station coverage
- Fueling costs
- Vehicle prices
- Vehicle size
- Vehicle acceleration

# Approach: Model Structure

**Model structure quantifies how the revenue shortfall can be filled with multiple types of incentives.**




**Incentives were split in two components:**

**Production incentive**

- Incentivizes good station placement & efficient operation
- Closes operating expense revenue gap

**Capital incentive**

- Reduces up-front cost barrier to market entry
- 50% reduction in capital expenses, tapering out by 10% annually after 2020.
- Applies on first time installations and upgrades

# Accomplishments: Scenario Analysis Provided

**Multiple scenarios were produced internally – Two are articulated in this presentation**

## Baseline scenario (low vehicle sales)

- **Modest vehicle incentives (US & HI)**

## Optimistic scenario (high vehicle sales)

- **Full parity vehicle incentives**
- **Lower cost fuel**

## Global inputs for both scenarios

- **Global hydrogen infrastructure source:**
  "Transport, Energy and CO2", IEA 2009
  http://www.iea.org/textbase/nppdf/free/2009/transport2009.pdf
- **Station cost vs. cumulative infrastructure:**
  NREL Hydrogen Station Cost Calculator (HSCC) 2012
- **Vehicle cost vs. global deployment:**
  "Transitions to alternative transportation technologies – a focus on hydrogen", NRC, 2008 (temporal increase in market share Case 1 was used for all analysis)

# Accomplishments: Scenario Analysis Provided

**Key vehicle parameters were selected for ADOPT analysis**

## Fuel cell vehicle efficiency

- Both scenarios use the following on-road, fleet average fuel efficiencies
  - 68 mpg in 2015
  - 72 mpg in 2050

## Acceleration

- 6.5 seconds for both scenarios (0-60 mph)
- This may be somewhat optimistic, rationale is superior 0-40 mph electric drive acceleration, and largely urban driving conditions on Oahu.

## Range

- 300 miles per full refueling

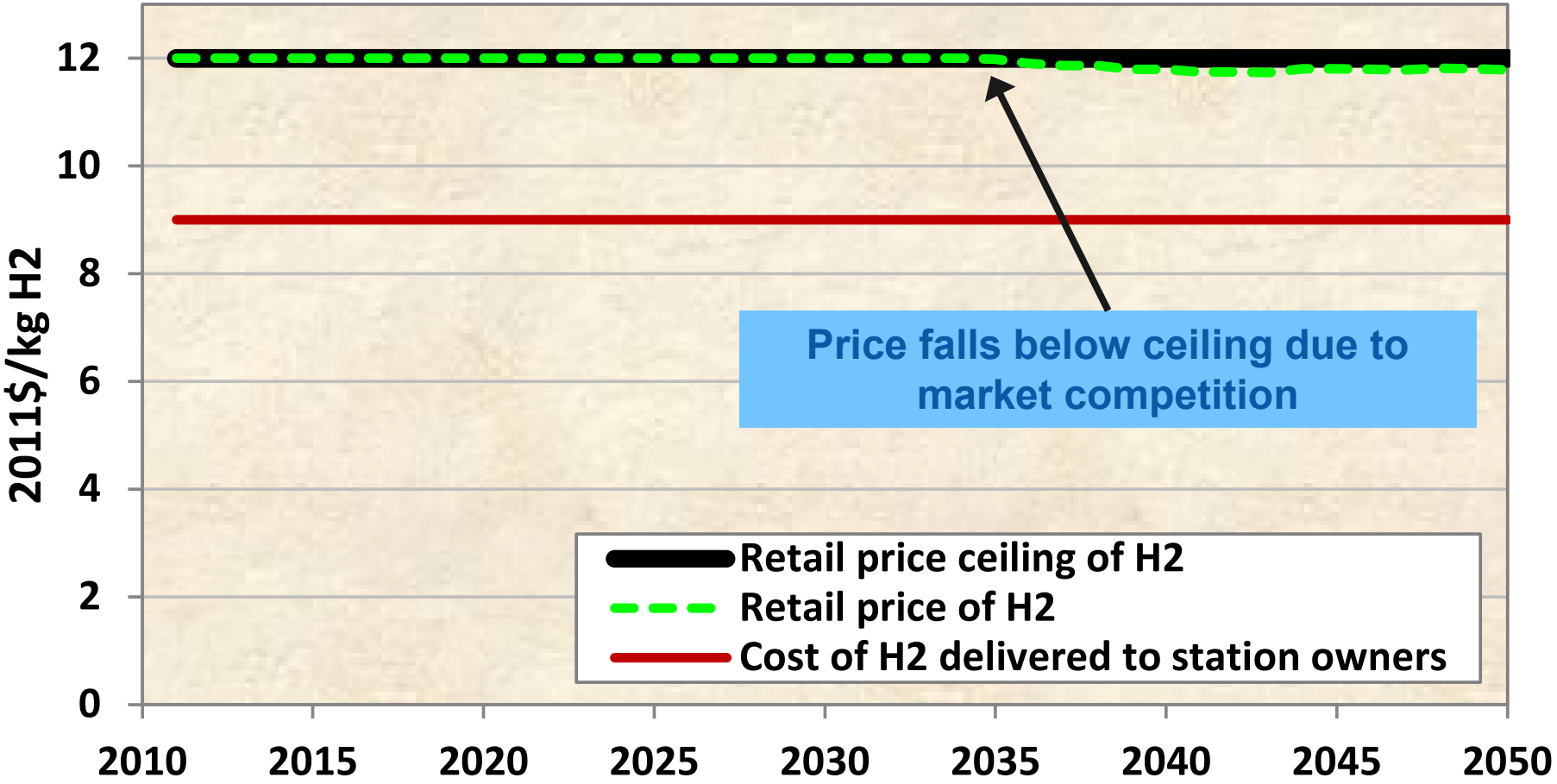
## Average vehicle cost (sales-weighted, before incentives)

- 2015 = $87,400
- 2020 = $35,600
- 2030 = $28,300
- 2040 = $28,500
- 2050 = $28,700

**ADOPT determines market share based upon price (cost minus incentives and internal subsidies)**

# Accomplishments: Scenario Analysis Provided

**Baseline scenario price ceiling targets parity fuel cost per mile with conventional gasoline vehicles (nominal price of gasoline for Oahu, adjusted by FCEV fuel efficiency)**

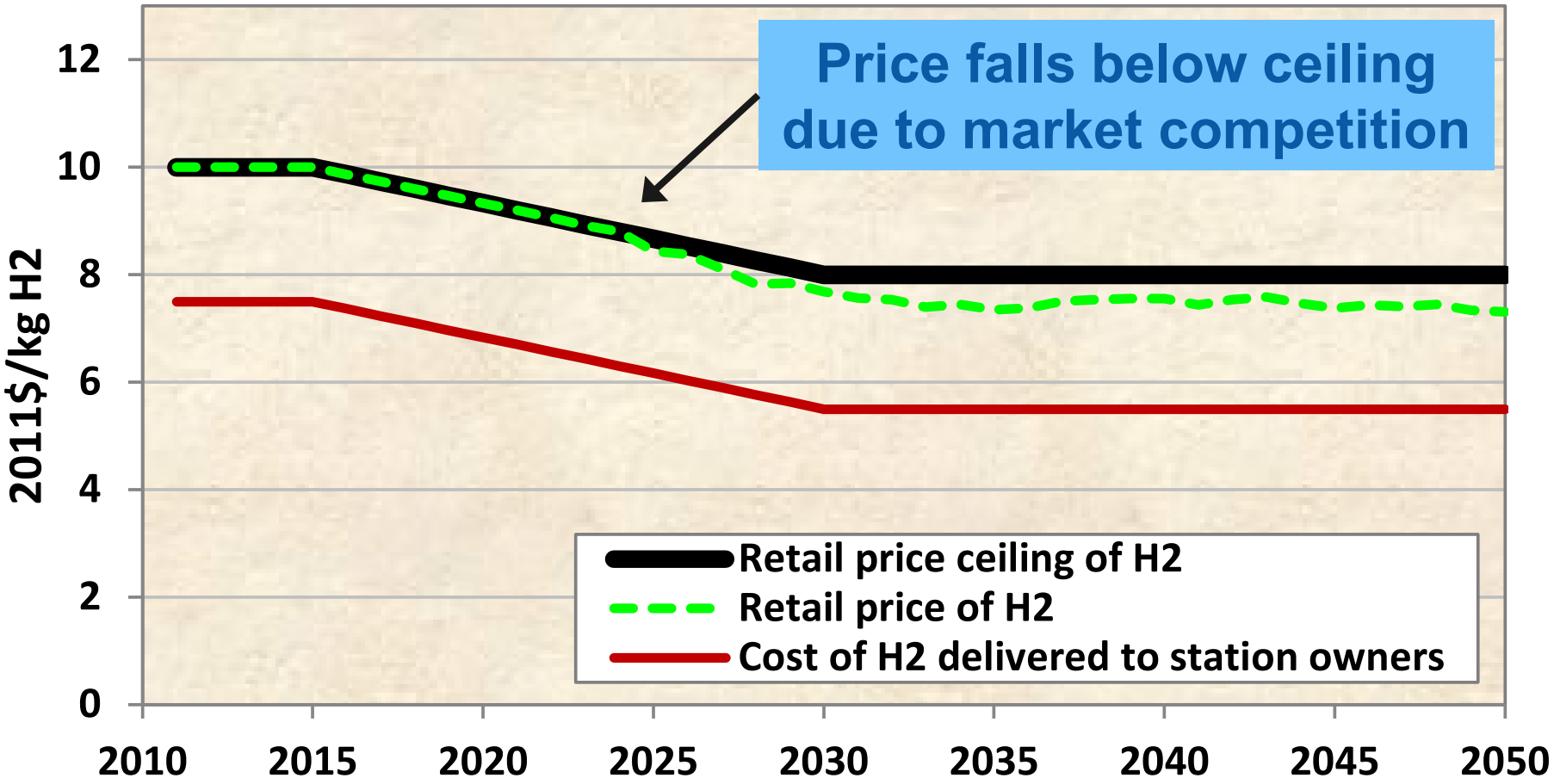



## Feedstock Costs:

- Scenario assumes a delivered hydrogen cost of $9/kg to station owner
- Price of electricity = 24¢/kWh

# Accomplishments: Scenario Analysis Provided

**Optimistic scenario assumes a price ceiling of $8-$10/kg, which is a more competitive price than gasoline, stimulating market adoption**

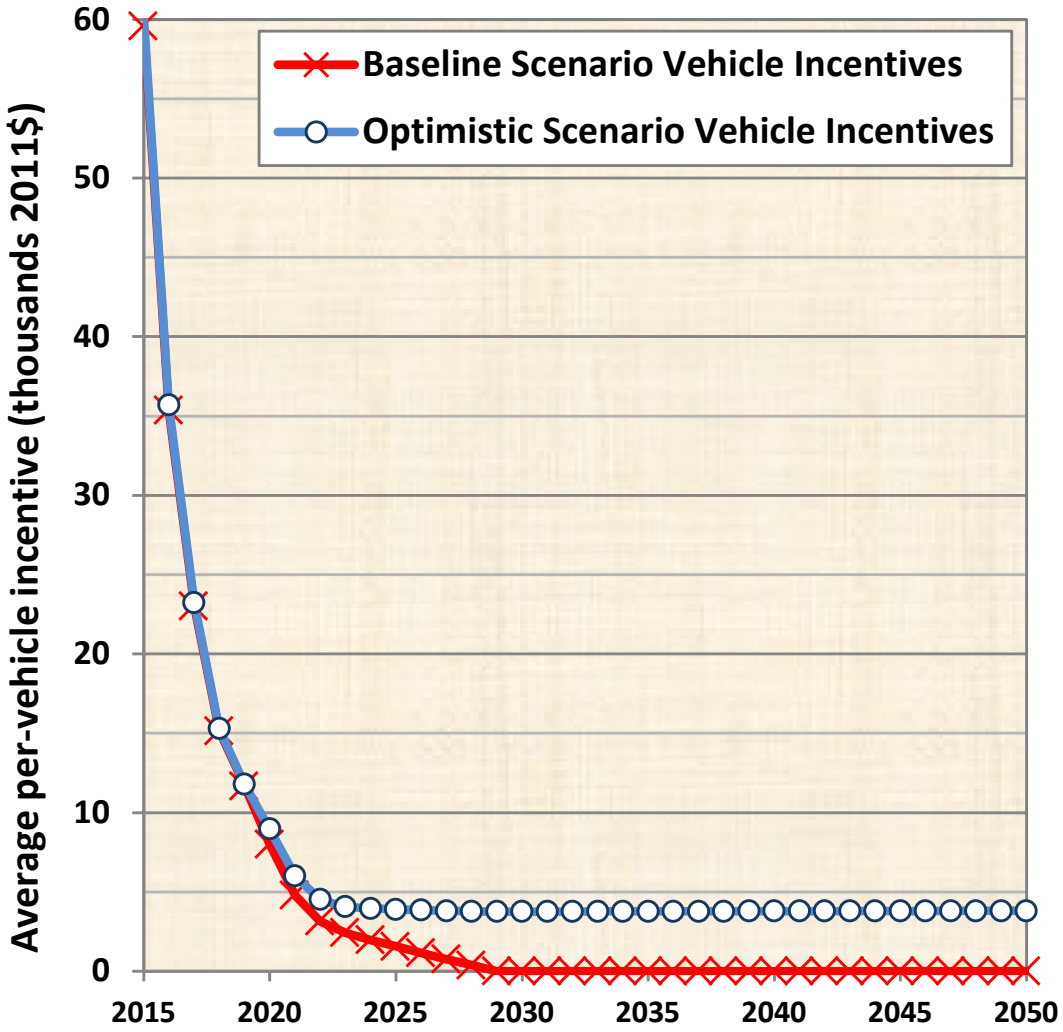



## Feedstock Costs:

- Assumption that higher volume production results in lower cost hydrogen
- Price of electricity = 24¢/kWh

# Accomplishments: Scenario Analysis Provided

**Two levels of vehicle incentives were used for scenario differentiation. More FCEV subsidies drive higher sales and improved station economics.**




**Incentive sources are not restricted to public subsidies:**

- Early adopter subsidization
- Luxury market premium
- "Green" premium
- State & federal incentives
- OEM subsidization

**Baseline:**

- Full parity with conventional platforms in early years
- Incentives fade out by 2029

**Optimistic:**

- Full parity with conventional platforms in perpetuity

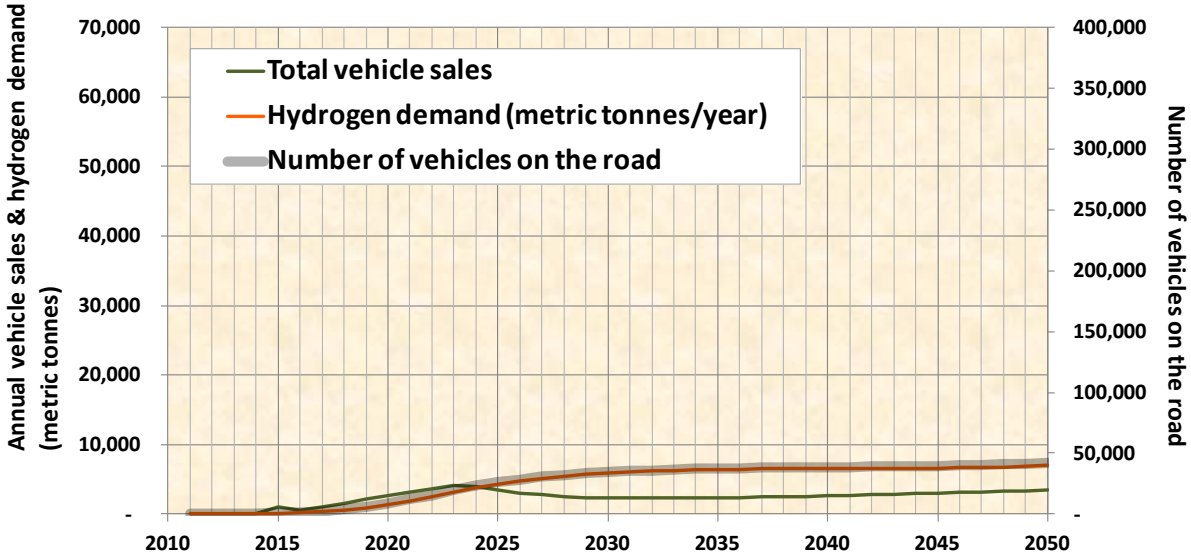
**Vehicle cost source: Transitions to Alternative Transportation Technologies: A Focus on Hydrogen, NRC 2008**

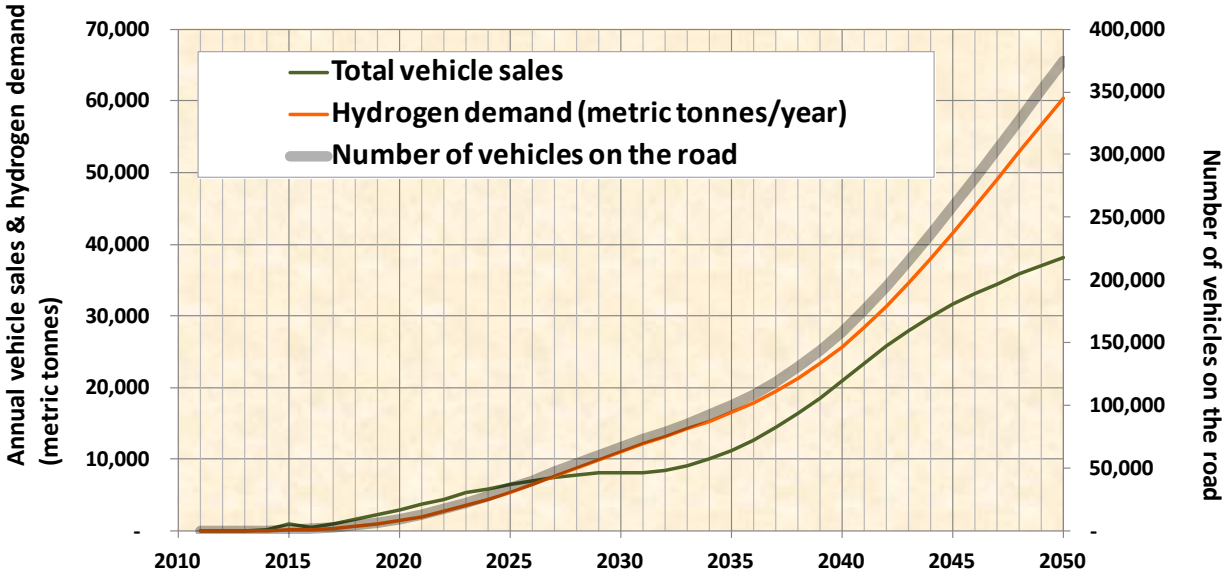
# Accomplishments: Scenario Analysis Provided

**Vehicle sales projections with ADOPT model. Higher vehicle incentives and cheaper fuel result in higher sales in the optimistic case.**

**Baseline:**
- Full parity with conventional platforms in early years
- Incentives fade out by 2029

**Optimistic:**
- Full parity with conventional platforms in perpetuity



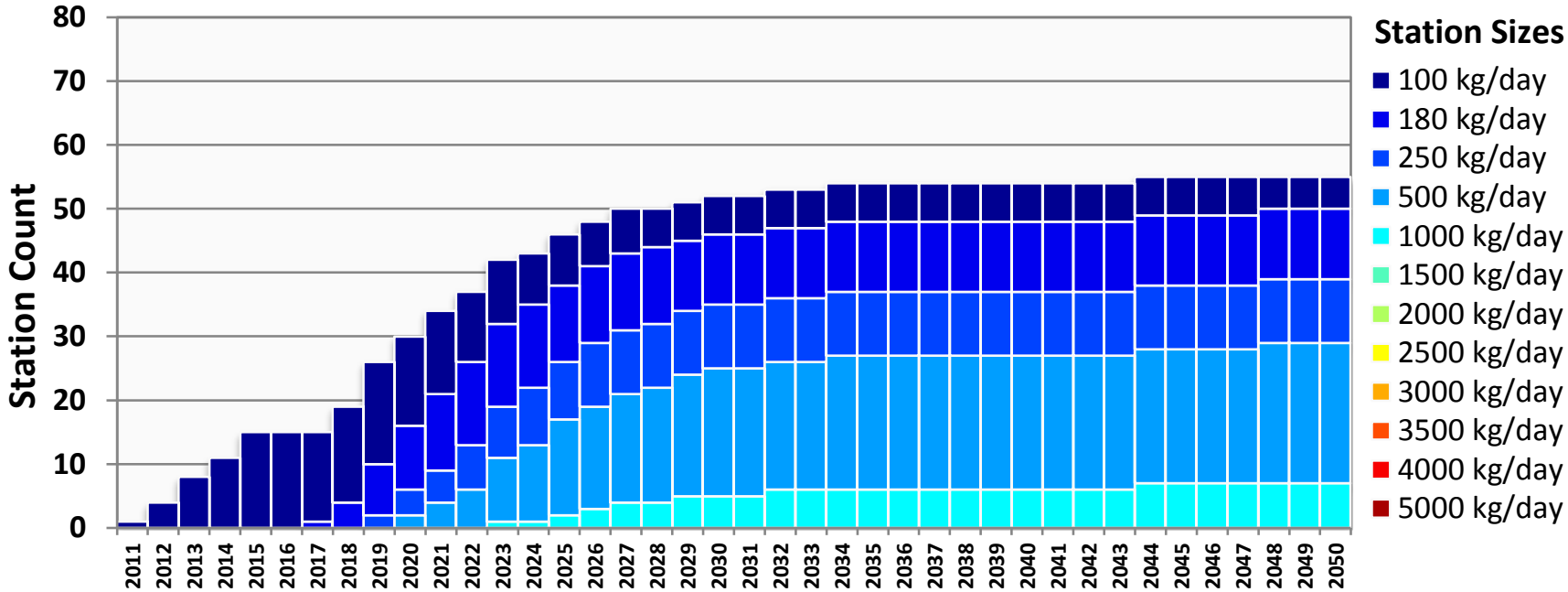



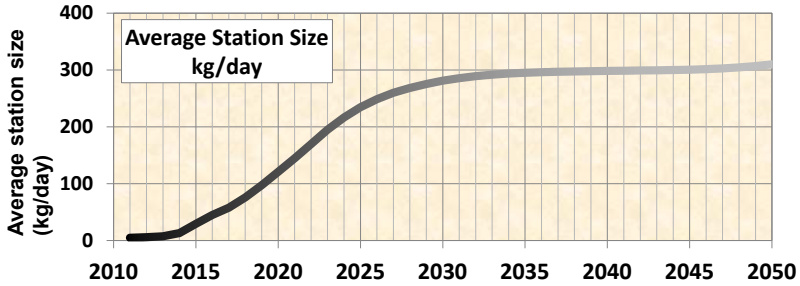

**Linear vehicle retirement function used:**

**4 years = 100% vehicles on road**
**25 years = 100% vehicles retired**

# Accomplishments: Scenario Analysis Provided

**Scenario station build out projection (Baseline Scenario)**
**Slower adoption of FCEV results in prevalence of smaller capacity stations.**



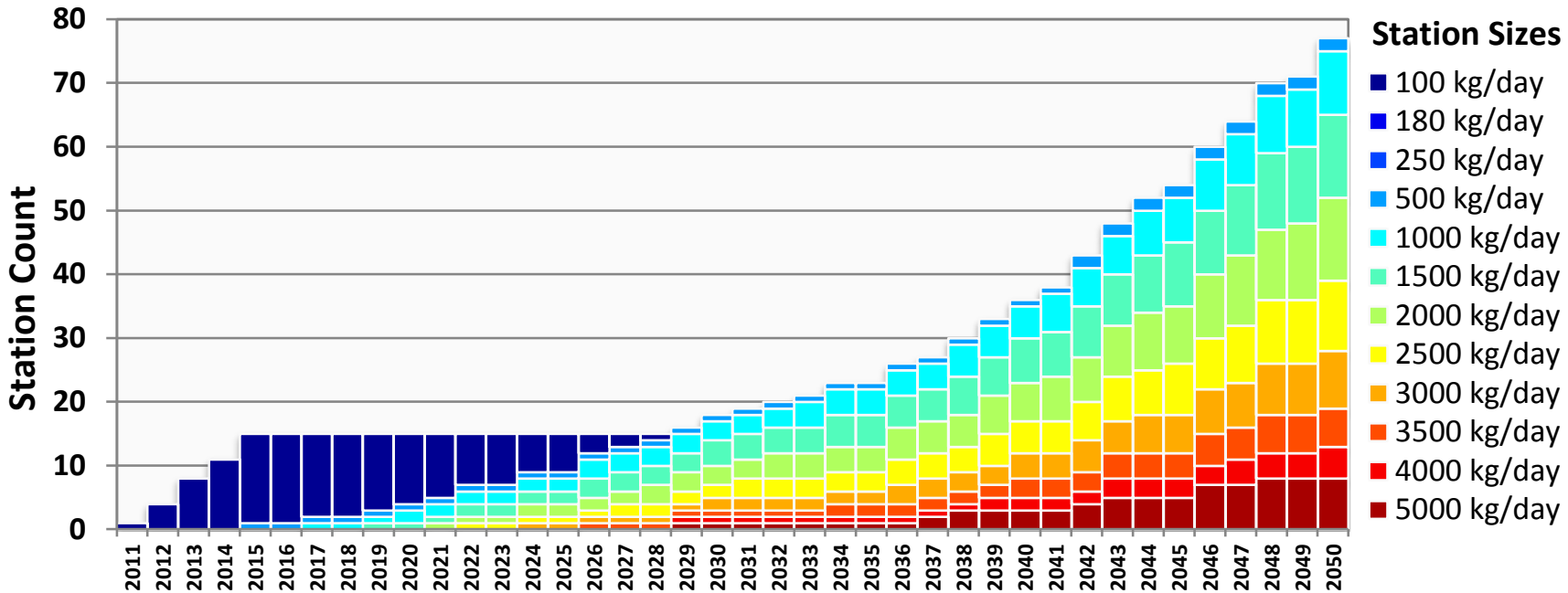



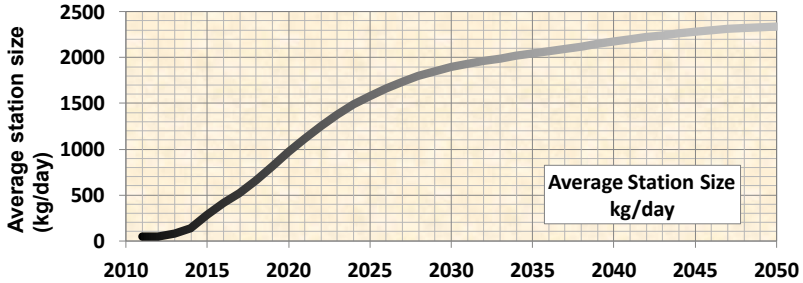

## Station abundance by capacity:

- **Initial coverage stations = 100 kg/day**
- **Subsequent stations sizes distributed in lines with gas station distributions**

# Accomplishments: Scenario Analysis Provided

**Scenario station build out projection (Optimistic Scenario)**
**Accelerated adoption of FCEV provides demand for larger capacity stations.**



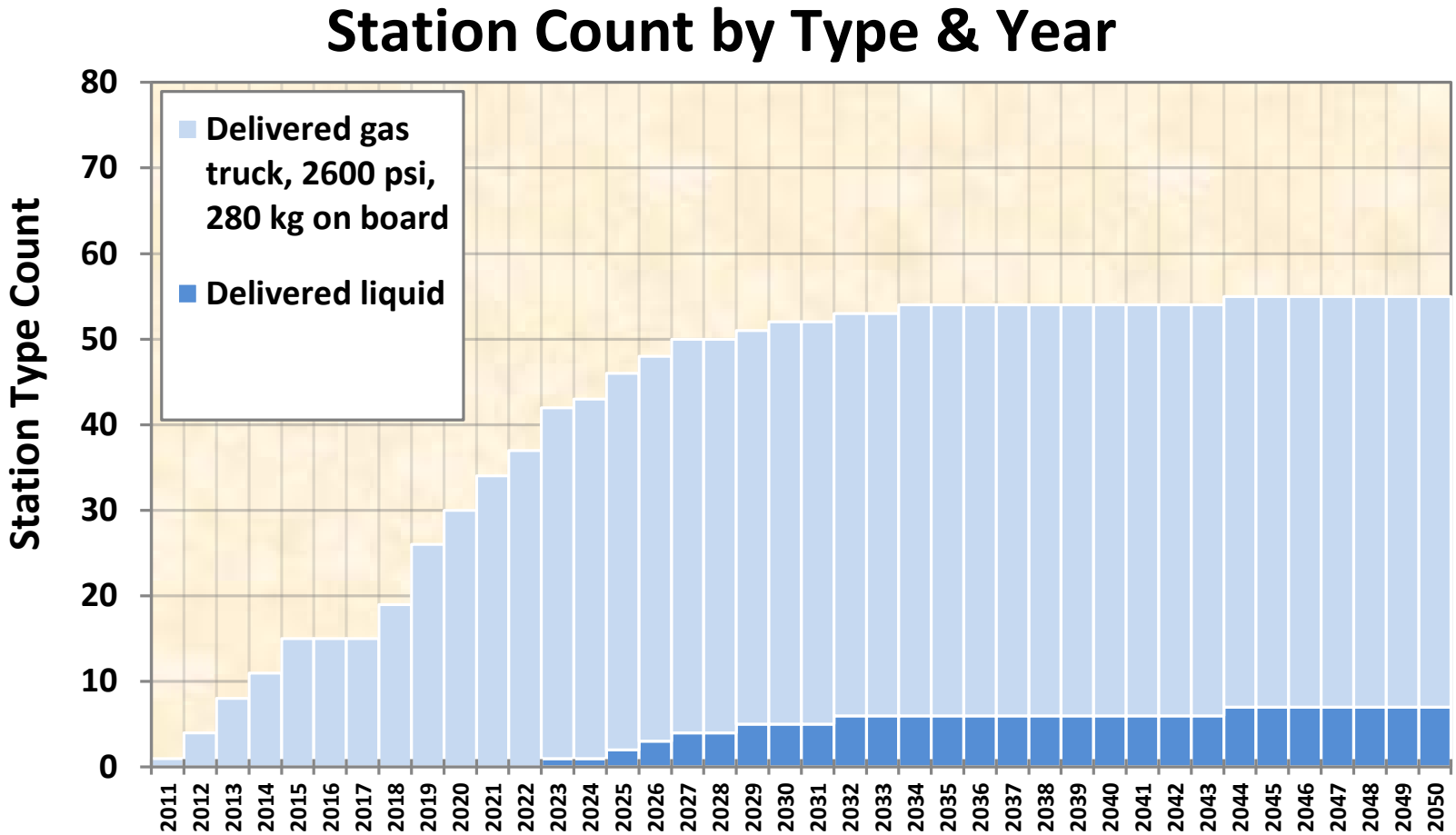




## Station abundance by capacity:

- **Initial coverage stations = 100 kg/day**
- **Subsequent stations sizes distributed in lines with gas station distributions**

# Accomplishments: Scenario Analysis Provided

**Scenario station type projection (Baseline Scenario)**
**Small capacity stations dominate and liquid stations prevail.**

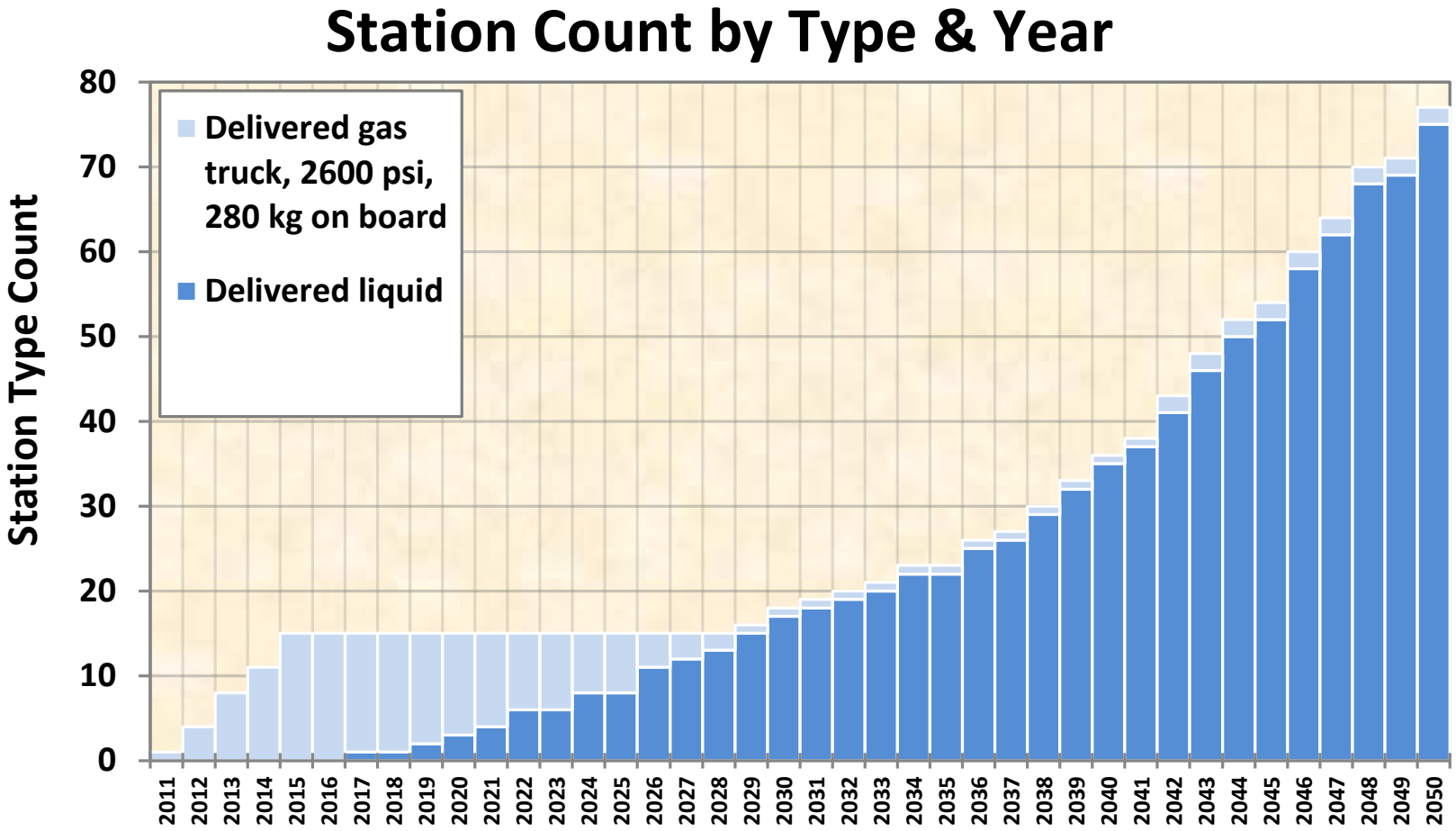



## Station types assignments:

- Stations <500 kg/day = gaseous hydrogen delivered to the stations
- Stations >500 kg/day = liquid hydrogen delivery to the stations

# Accomplishments: Scenario Analysis Provided

**Scenario station type projection (Optimistic Scenario)**
**Large capacity stations dominate and liquid stations prevail.**

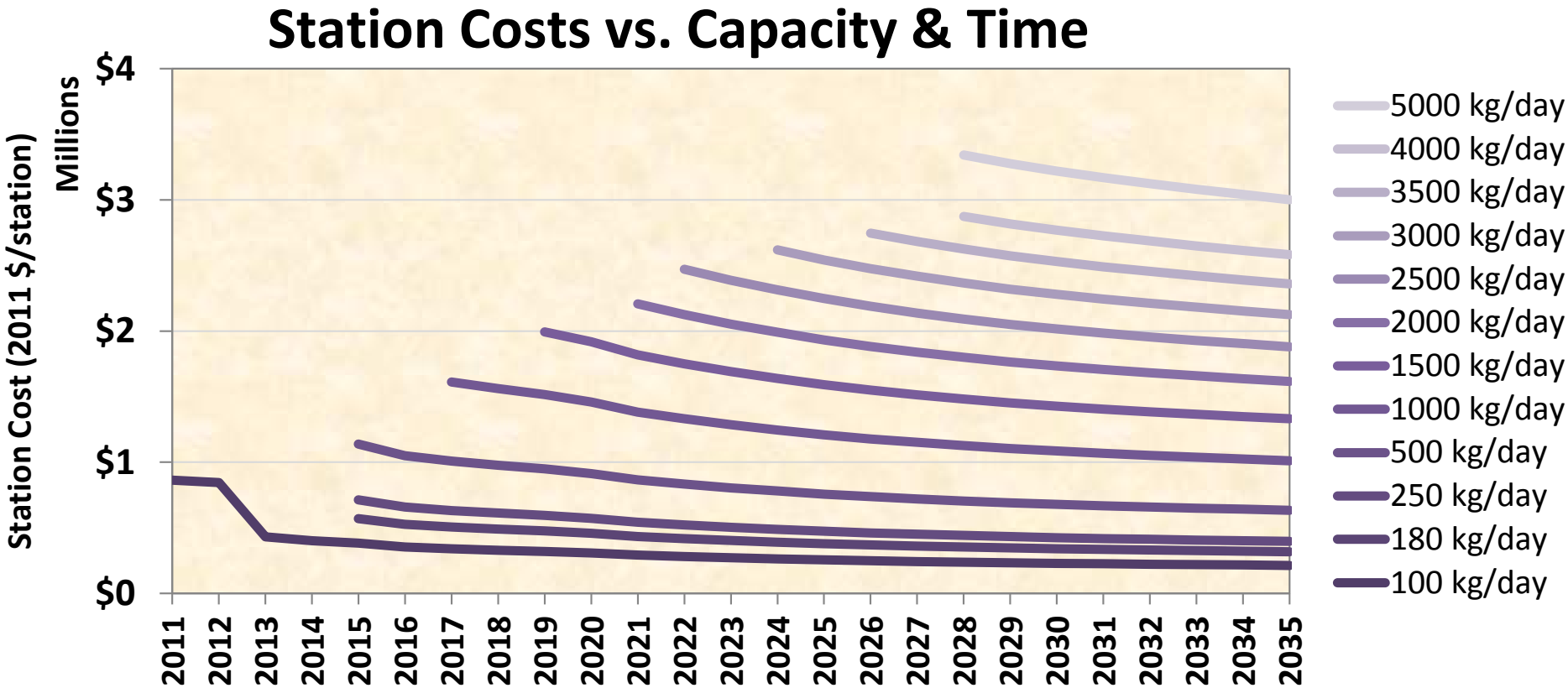



## Station types assignments:

- Stations <500 kg/day = gaseous hydrogen delivered to the stations
- Stations >500 kg/day = liquid hydrogen delivery to the stations

# Accomplishments: Scenario Analysis Provided

**Scenario station cost projections (industry inputs).**




**Station Costs:**

**Station costs decrease over time according to world deployment driven learning curves**
**Station scaling factors are provided from industry partners**
**Larger stations are cheaper on per-capacity basis (economies of scale)**

# Accomplishments: Scenario Analysis Provided

**Cash flow analysis inputs.**
**Values are aligned with H2A assumptions**

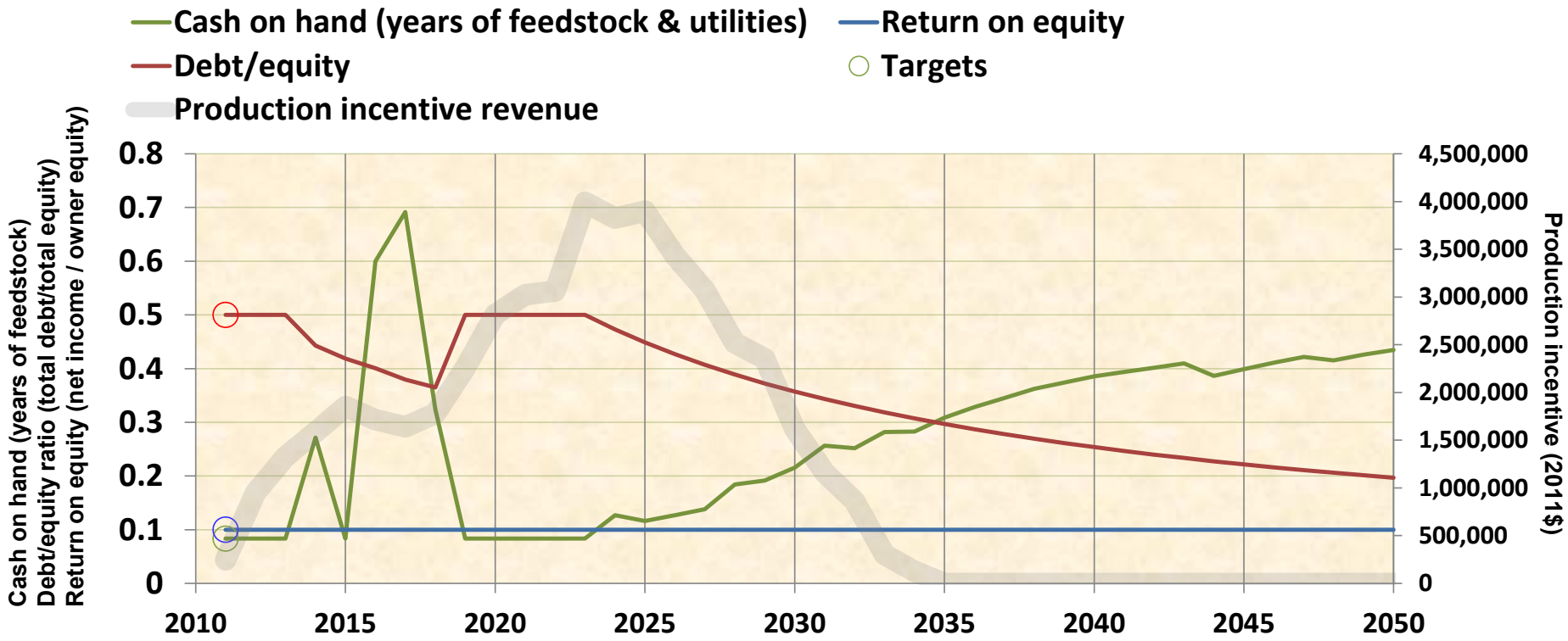
- Depreciation = 7 years, straight-line
- Maintenance as % of contemporary station cost = 2.4%
- Labor rate = $40/hr
- Credit card fees = $2.5% (flow-through)
- Property tax & insurance = 2% of cap cost
- Interest on debt = 6%
- Total tax rate = 38%
- Sales tax = 8% (flow-through)
- Sales & administrative expenses = 2%
- Licensing & permitting = 1115 $/year
- Rent = $3,400
- Total capital incentives through 2017 = 15%
- Inflation rate = 0%*

- Target after-tax real IRR = 10% (return on investor equity)
- Debt/equity ratio = 0.5 (target)
- Cash on hand = 1 month of feedstock & utility expense (target)

Note: All analysis is performed on real $, 2011 basis
Model can be adjusted to operate with nominal $'s as well

# Accomplishments: Scenario Analysis Provided

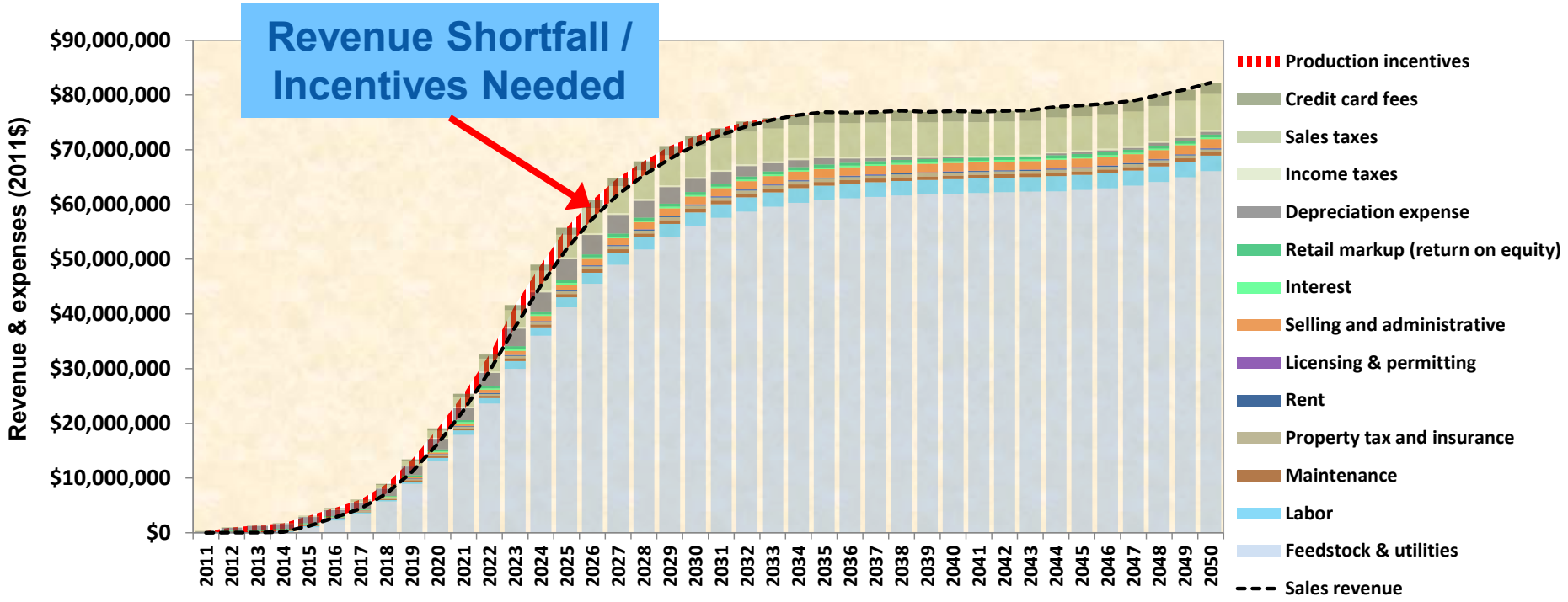
## Cash Flow Analysis Results (Baseline Scenario)




- Financial solver determines revenues to produce 10% return on equity
- Debt to equity ratio drops in years when capital is not raised as equity grows
- Cash on hand increases in years of low capital expenditures
- Production incentive needs diminish by 2035

# Accomplishments: Scenario Analysis Provided

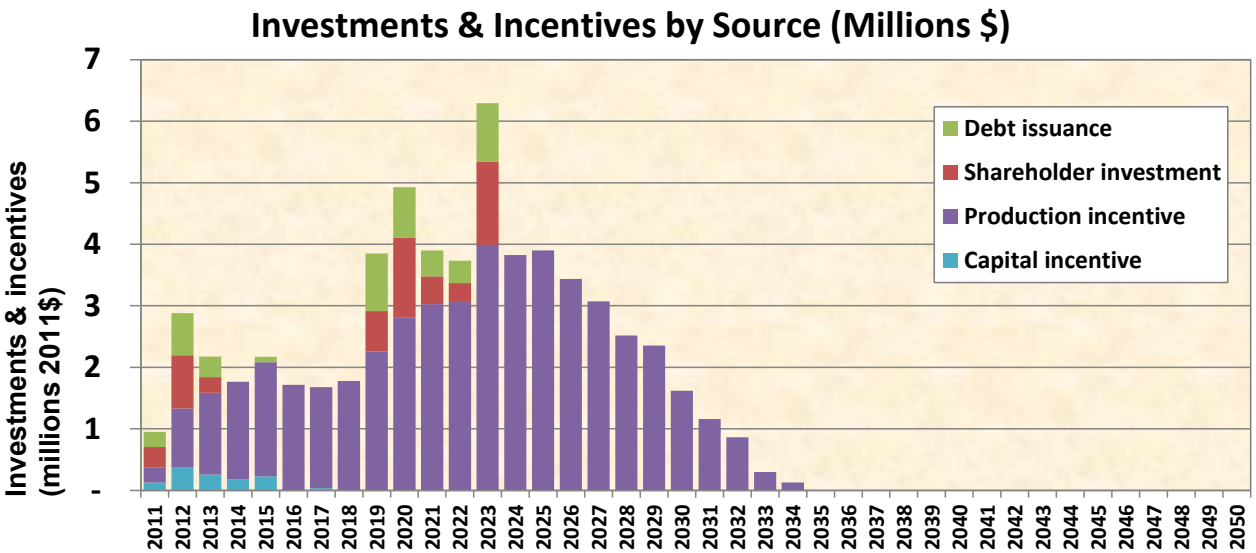
## Cash Flow Analysis Results (Baseline Scenario)

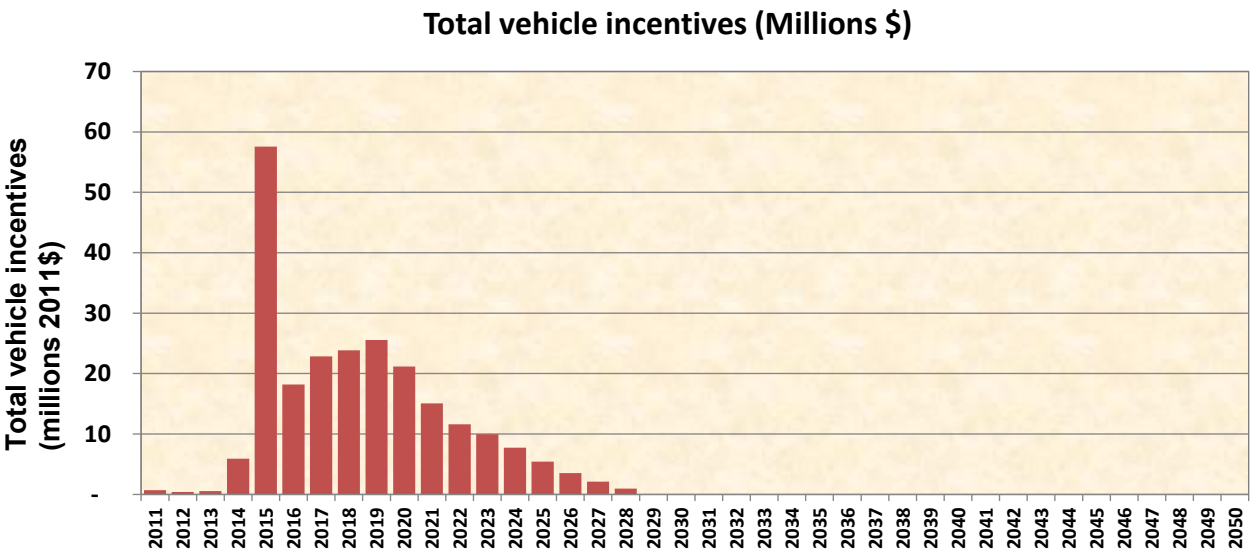



**Analysis evaluates required revenue to cover all expenses plus a return on equity. Discrepancy between expenses and realizable revenue is quantified as "production incentive revenue"**

# Accomplishments: Scenario Analysis Provided

**Investment & Incentives (Baseline Scenario)**
**Vehicle incentives are dominant. Infrastructure incentives diminish by 2035**

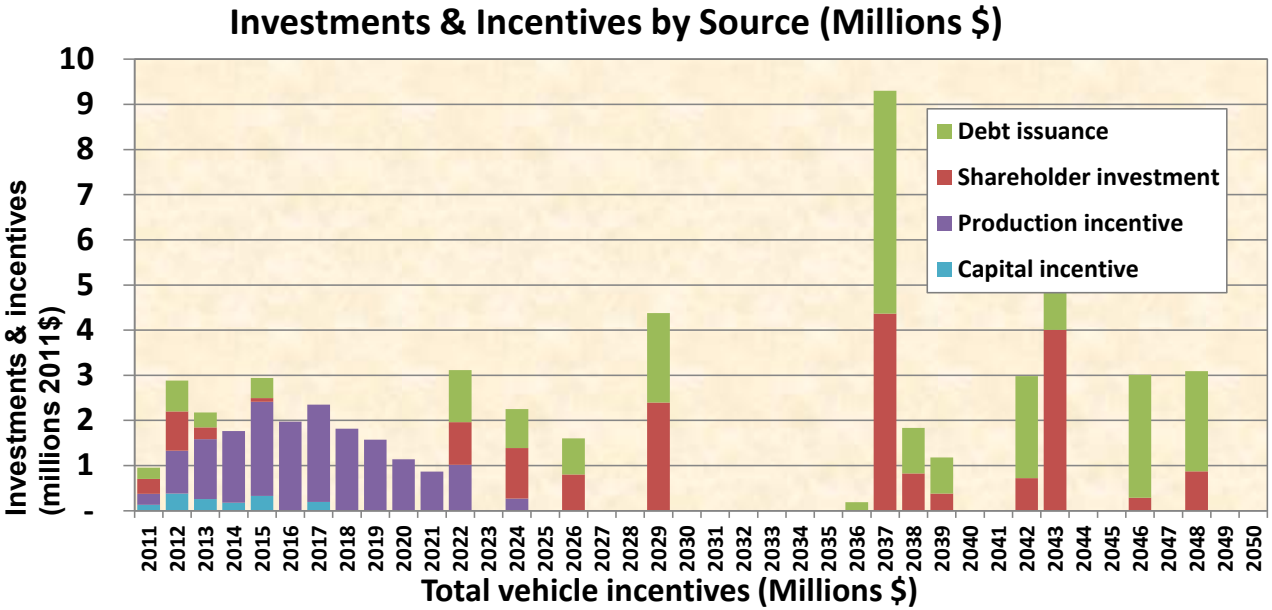


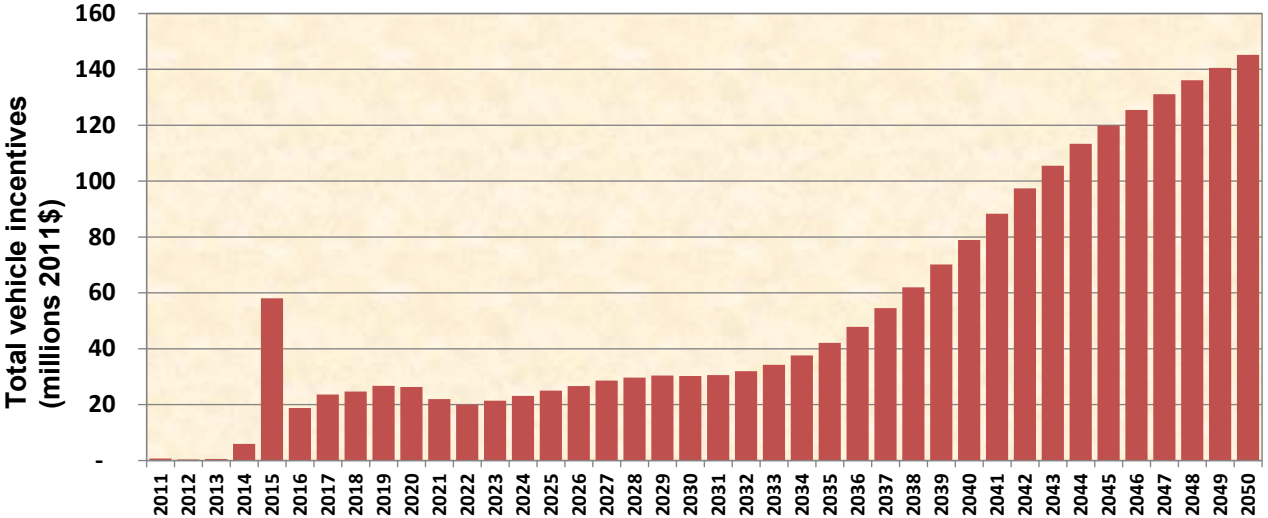

**Note: Incentives cover dispensing infrastructure only. No estimates are made at this time for finances of hydrogen production and distribution.**

# Accomplishments: Scenario Analysis Provided

**Investment & Incentives (Optimistic Scenario)**
**Vehicle incentives are very dominant.**
**Production incentives are much lower due to higher infrastructure utilization.**



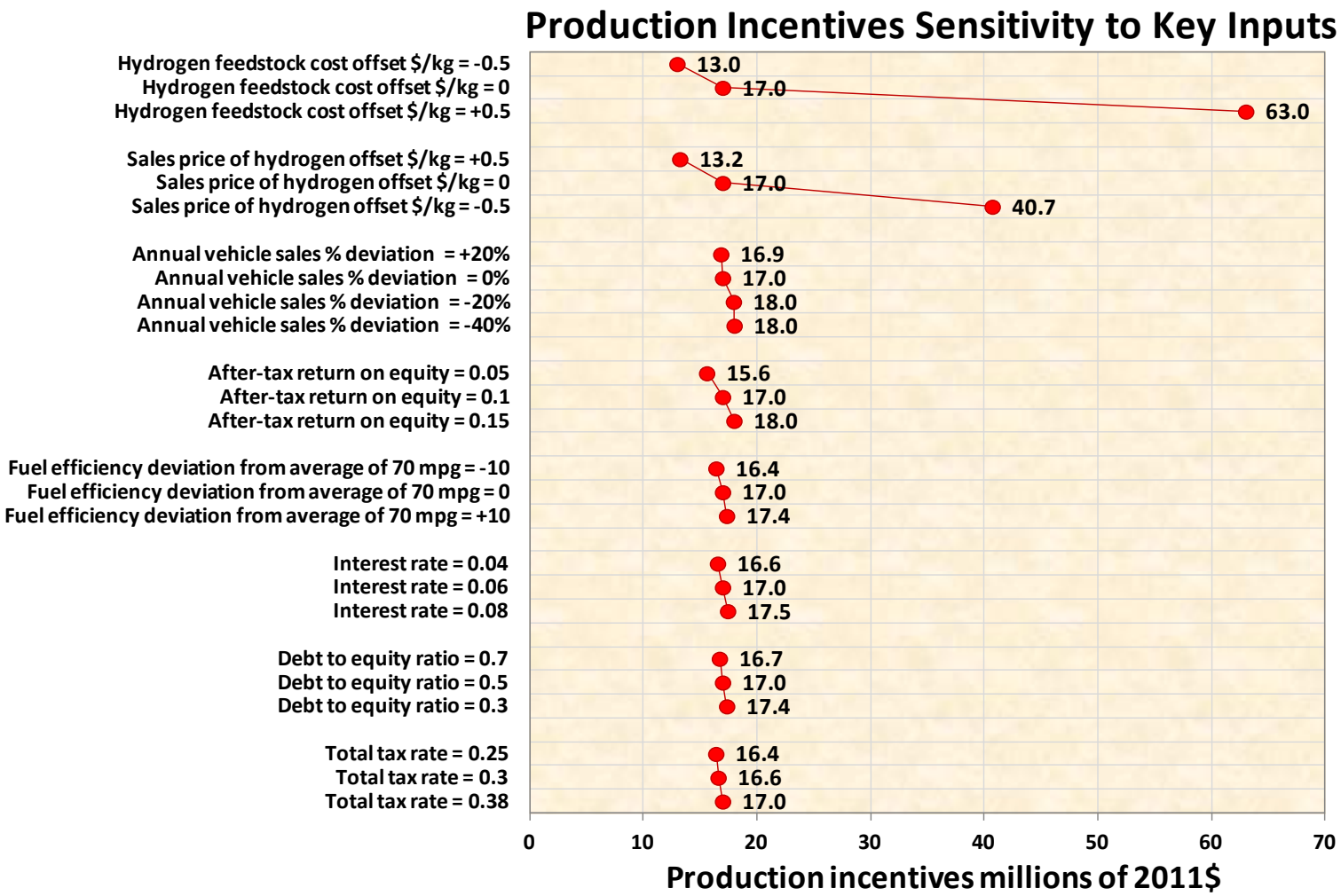

**Note: Incentives cover dispensing infrastructure only. No estimates are made at this time for finances of hydrogen production and distribution.**




**Note: Vehicle incentives continue to increase as total number of vehicles increases.**

# Accomplishments: Scenario Analysis Provided

**Sensitivity analysis of key cluster variables (Optimistic Scenario)**
**Model is fully integrated and can be used for risk analysis.**




**Note:** Fuel efficiency is one of the most important parameters for infrastructure economics. It is however not shown in this specific sensitivity study.

# Collaborations:

**NREL is a member of H2I core analysis team**

## Core analysis team collaboration:

- Louis Berger [H2I - lead]
- General Motors [FCEV deployment lead]
- U.C. Irvine [station placement analysis]
- Hawaii Gas [gas producer & supplier]
- Wellford Energy [financial modeling oversight]

## Extended H2I team members:

- Air Force Research Laboratory
- Aloha Petroleum
- County of Hawaii
- FuelCell Energy
- Office of Naval Research
- Proton Onsite
- State of Hawaii
- TARDEC*
- University of Hawaii
- U.S. Army, Pacific
- U.S. Department of Energy
- U.S. Marine Corps, Pacific
- U.S. Pacific Air Forces
- U.S. Pacific Command
- U.S. Pacific Fleet

* TARDEC = U.S. Army Tank Automotive Research, Development and Engineering Center

# Future Work

**NREL completed the first phase of support for H2I, and no future work is currently planned.**

**Modeling algorithms developed for H2I are being used for other hydrogen initiative locations**

**Algorithms are being integrated into NREL's scenario evaluation, regionalization and analysis (SERA) model.**

**Additional model features to be added**

- **Refinement of geographic dependence of station upgrading**
- **Multi-region analysis (multi-state)**
- **Explicit economics at the individual station level**
- **Refine upgrade frequency (and cost) with industry input**
- **Outputs module for communication with stakeholders**

# Summary

**NREL produced a detailed deployment and financial model for Hawaii infrastructure deployment.**

**The financial model has been used to analyze scenarios of stations and fuel cell vehicle penetration and presented to the Hawaii Hydrogen Initiative (H2I).**

**Key findings:**

- **Early coverage stations will experience low capital utilization**
- **Station finances would need subsidies to support capital and operational expenses**
- **Debt and equity investments have a significant place in the early market introduction and subsequent adoption**

**Future work:**

- **NREL will continue refining and applying station infrastructure algorithms to support future deployment initiatives.**