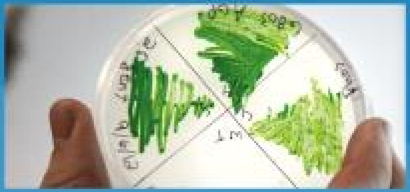



Hydrogen Financial Analysis Scenario Tool (H2FAST) Updates with Analysis of 101st Station

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SA062

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

Overview

Timeline	Barriers
Start: September 2014 End: September 2017* * Annual direction determined by DOE	**4.2 Technical Approach:** Infrastructure analysis **4.5 A. Future Market Behavior:** Scenarios to understand vehicle-fuel interactions **4.5 E. Unplanned Studies and Analysis** Response to H2USA public-private partnership and infrastructure deployment goals

Budget	Partners
FY16 DOE Funding: $100K FY17 Planned DOE Funding: $150K Total DOE Funds to Date: $250K	• H2USA Investment and Finance Working Group • California Energy Commission • Multiple external and internal subject expert reviewers • Fuel Pathways and Integration Tech Team (FPITT) • Independent and in-depth technical review by financial analysis consultant

H2FAST enables detailed infrastructure financial analysis and can interface with multitude of models

Relevance/Impact 1

Analysis examines market and financial implications of strategies to support vehicle and infrastructure expansion nationally.

- H2USA LRWG and IFWG members
- Additional external reviewers

- Fuel Cell Technologies Office
- H2USA LRWG and IFWG members

Analysis Framework
- Cost estimation
- Scenario development
- Optimization
- Financial analysis
- Data: CaFCP Roadmap trends

Models & Tools
- Integrated models
- SERA scenario development capabilities
- H2FAST

Studies & Analysis
- Market transformation analysis
- Long-term analysis

Outputs & Deliverables
- Recommendations and reports
- Inputs to working groups

Argonne: HRSAM

Acronyms

IFWG: H_2USA Investment and Finance Working Group
CaFCP: California Fuel Cell Partnership
SERA: Scenario Evaluation and Regionalization Analysis
H2FAST: Hydrogen Financial Analysis Scenario Tool
HRSAM: Hydrogen Refueling Station Analysis Model
LRWG: H_2USA Location Roadmap Working Group

H2FAST enables investor-grade, convenient, and transparent financial analysis

Objectives

- Provide convenient detailed hydrogen infrastructure financial analysis to facilitate investments in hydrogen refueling stations and improve policy-design decisions to support early hydrogen station and fuel cell electric vehicle (FCEV) market development
- Inform multiple stakeholders:
  - Policy and government decision makers
  - Station operators
  - Equity investors
  - Strategic investors
  - Lenders
- Enable transparent incentive analysis
- Provide embedded investment risk analysis

Investment grade finances
Easy to use
Multi-stakeholder perspective
Engaged with industry

Impacts on FCTO barriers during reporting period

- Enhanced analysis of future hydrogen fueling market behavior (Barrier A)
- Provided timely analytical capabilities to H_2USA partnership and FCTO (Barrier E)

Model framework, inputs, outputs

Approach 1

Model computation framework: Generally Accepted Accounting Principles (GAAP)

- **Income statement** projections (revenues, expenses, taxes)
- **Cash flow statement** projections (cash on hand, capital expenditures, financing transactions)
- **Balance sheet** projections (assets, liabilities, equity)

User inputs

- Capital and Maintenance costs
- Incentives (grants, operating incentives, take or pay contracts)
- Demand profile (e.g., construction time, demand ramp-up)
- Feedstock use (consumption, H_2 purchase cost, escalation)
- Retail price of hydrogen
- Financial parameters (e.g. depreciation schedule, interest rates, etc.)

Model outputs

- **Financial performance parameters** (e.g., internal rate of return, pay-back period, break-even price of hydrogen)
- **Time series charts** for all line item parameters
- Per-kilogram **cash flows break-down** (revenues, expenses, financing cash flows)
- Uncertainty distributions (for risk analysis studies)

GAAP analysis framework

Inputs:
station capital
performance
financial circumstances

Outputs:
graphical and tabular

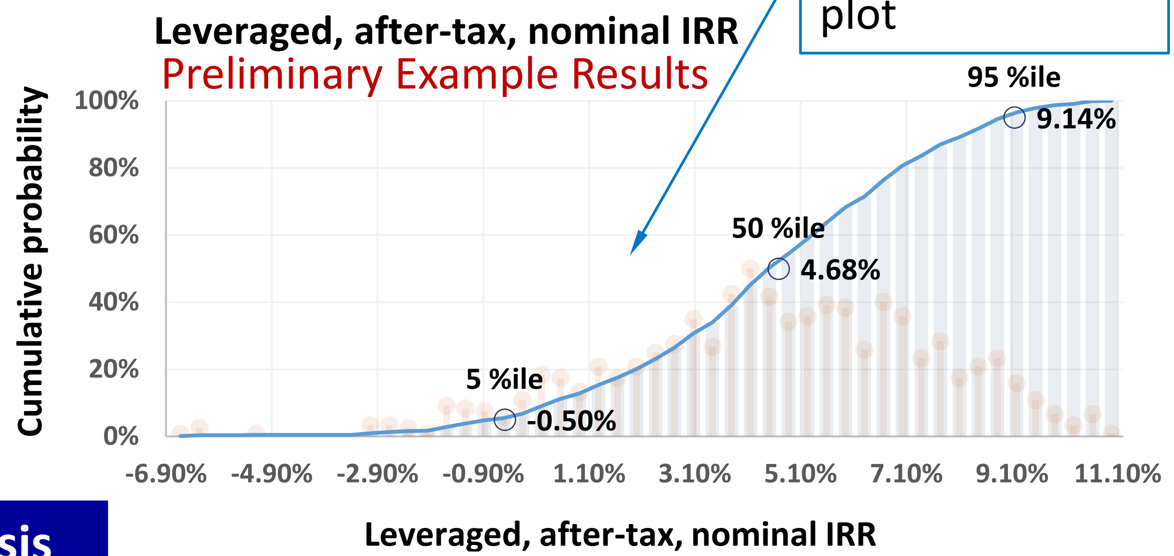
Model allows for range specification of uncertain variables and computes uncertainty ranges of outputs

Approach 2

Overall Financial Performance Metrics	Most likely value	5%'ile	95%'ile	Plot
Leveraged, after-tax, nominal IRR	5.88%	-0.54%	9.50%	
Profitability index	1.35	0.83	1.78	
Investor payback period	10 years	8	16	
First year of positive EBITD	analysis year 2	2	2	
After-tax, nominal NPV @ 10% discount	$ (894,655)	$ (2,345,175)	$ (102,307)	
Estimated break-even leveraged price ($/kg)	$ 12.45	$ 10.28	$ 16.42	

Break-even leveraged price can be used to yield IRR target

Click to select distribution to plot



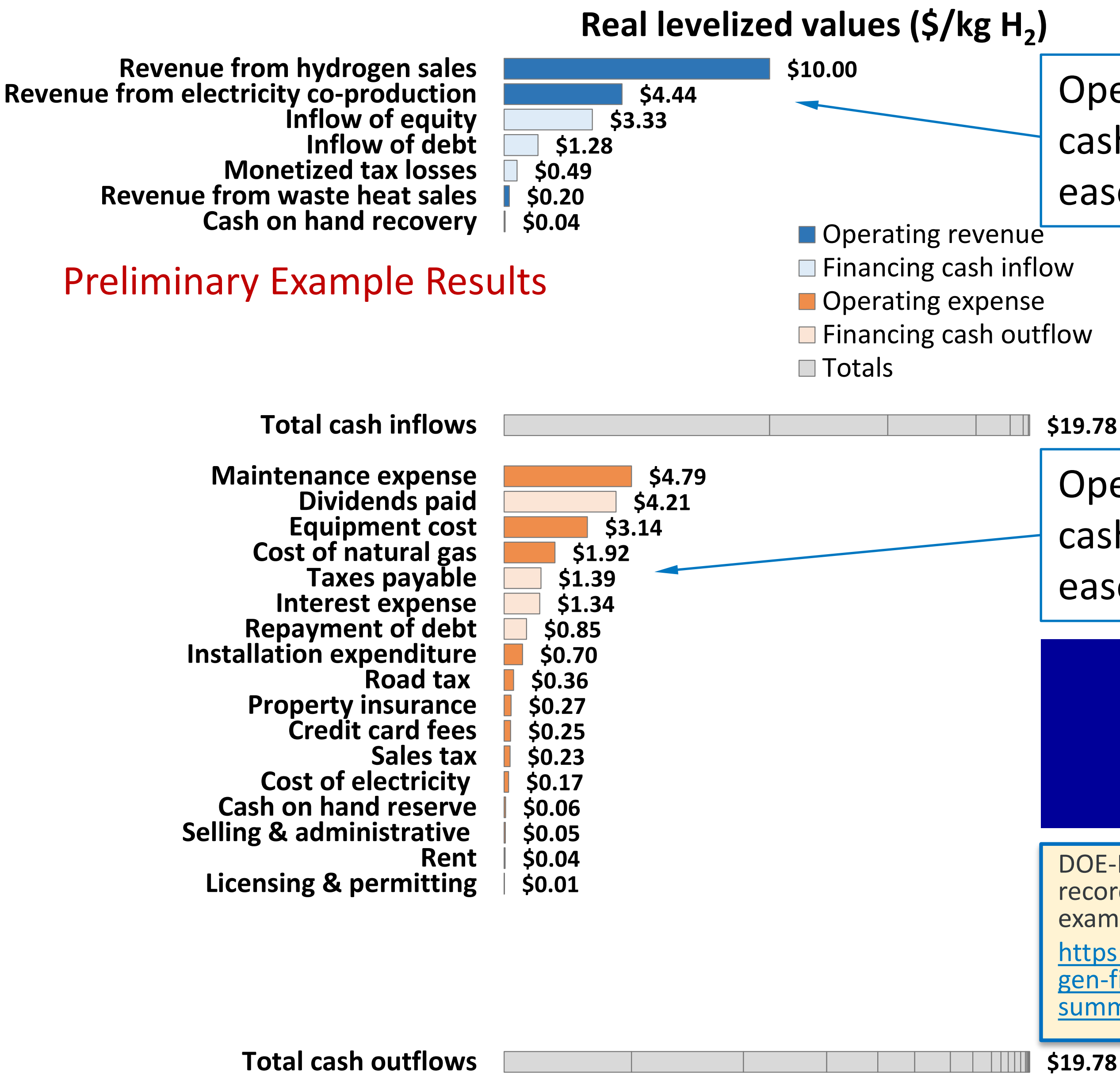
Model does uncertainty analysis

Most input values can be varied

Results reflect uncertainty ranges

Model allows instant attribution of revenues, expenses and financial cash flows

Approach 3



Operating revenues and financing cash inflows are normalized for ease of comparison.

Operating expenses and financing cash outflows are normalized for ease of comparison.

Model provides instant revenue and expense attribution

DOE-FCTO Webinar on H2FAST was presented and recorded for stakeholders with guidance and examples: https://energy.gov/eere/fuelcells/downloads/hydrogen-financial-analysis-scenario-tool-h2fast-model-summary-and

Model was integrated into SERA for national and regional scenario analysis

Analysis summary

- Three H_2 infrastructure deployment scenarios
- Contiguous 48 states
- Timeframe: 2015–2050
- Station count and size support urban region H_2 demand growth

Financial performance drivers

- Station cost reduction (learning curves)
- Larger stations over time (driven by higher demand per location)
- Faster utilization growth

Objective of analysis

- Estimate cross-over point when stations will be financially profitable without incentives

Approach

- Model relevant local conditions
- Estimate NPV of every projected station

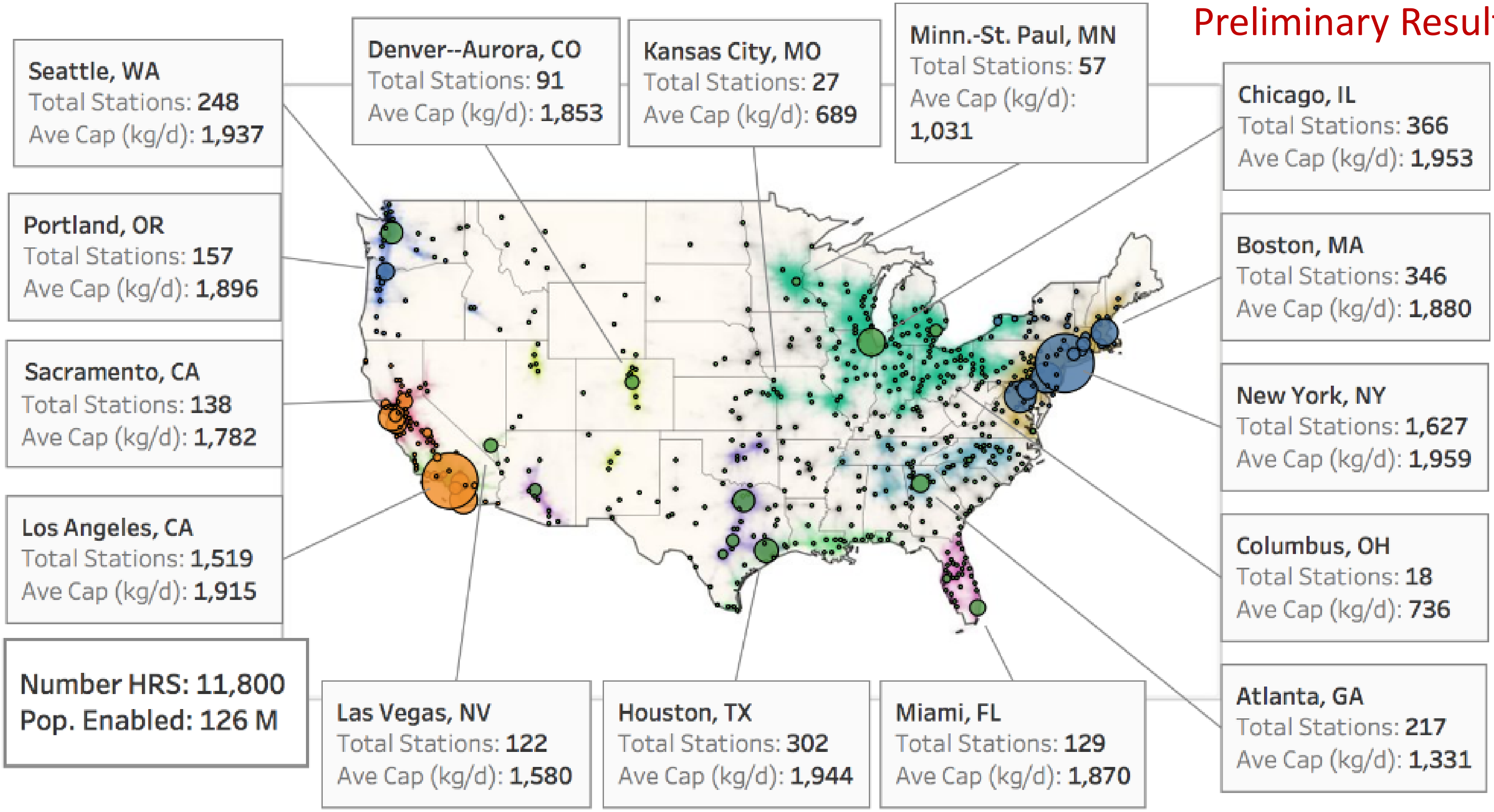
H2FAST is embedded in SERA

Evaluates financial performance of each projected

Example results: cumulative number of stations built from 2015–2050

Accomplishments 2

Preliminary Results



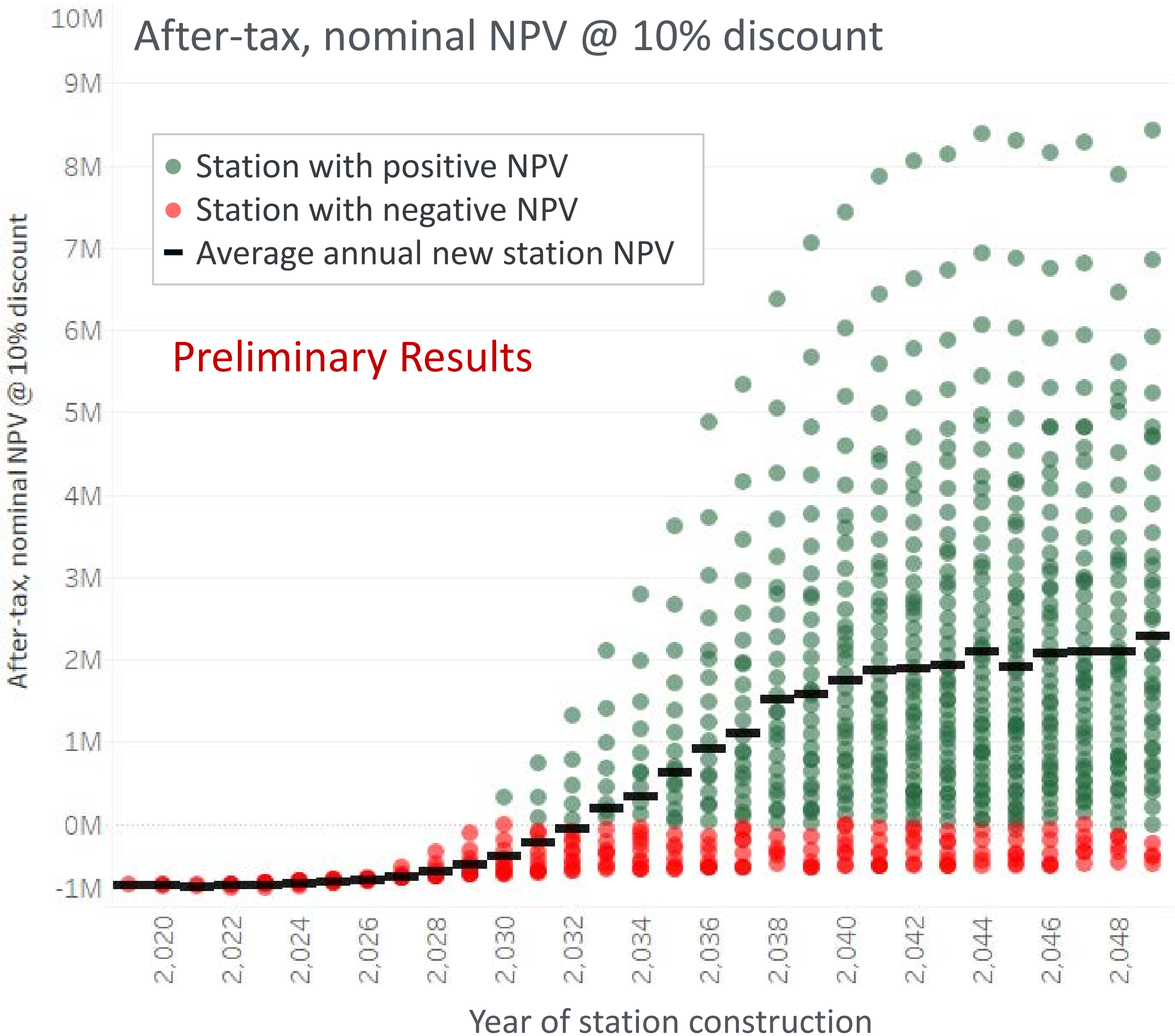
H2FAST financial analysis was performed for each station

- Capital cost vs. year and size
- Cost of delivered hydrogen
- Price of retail hydrogen
- Cost of energy commodities

Densest markets are populated first

Early markets get most stations and benefit from economies of scale

Example results of Massachusetts station NPV



Annual average new station NPV is used for assessing financial sustainability

Observations:

- Poorly performing stations are seen throughout analysis span
- Average station NPV indicates when profits from well performing stations can offset losses of other stations
- Average NPV may be a good indicator of when infrastructure may be self-sustaining
- In this scenario, Massachusetts infrastructure could be self-sustaining after 2033

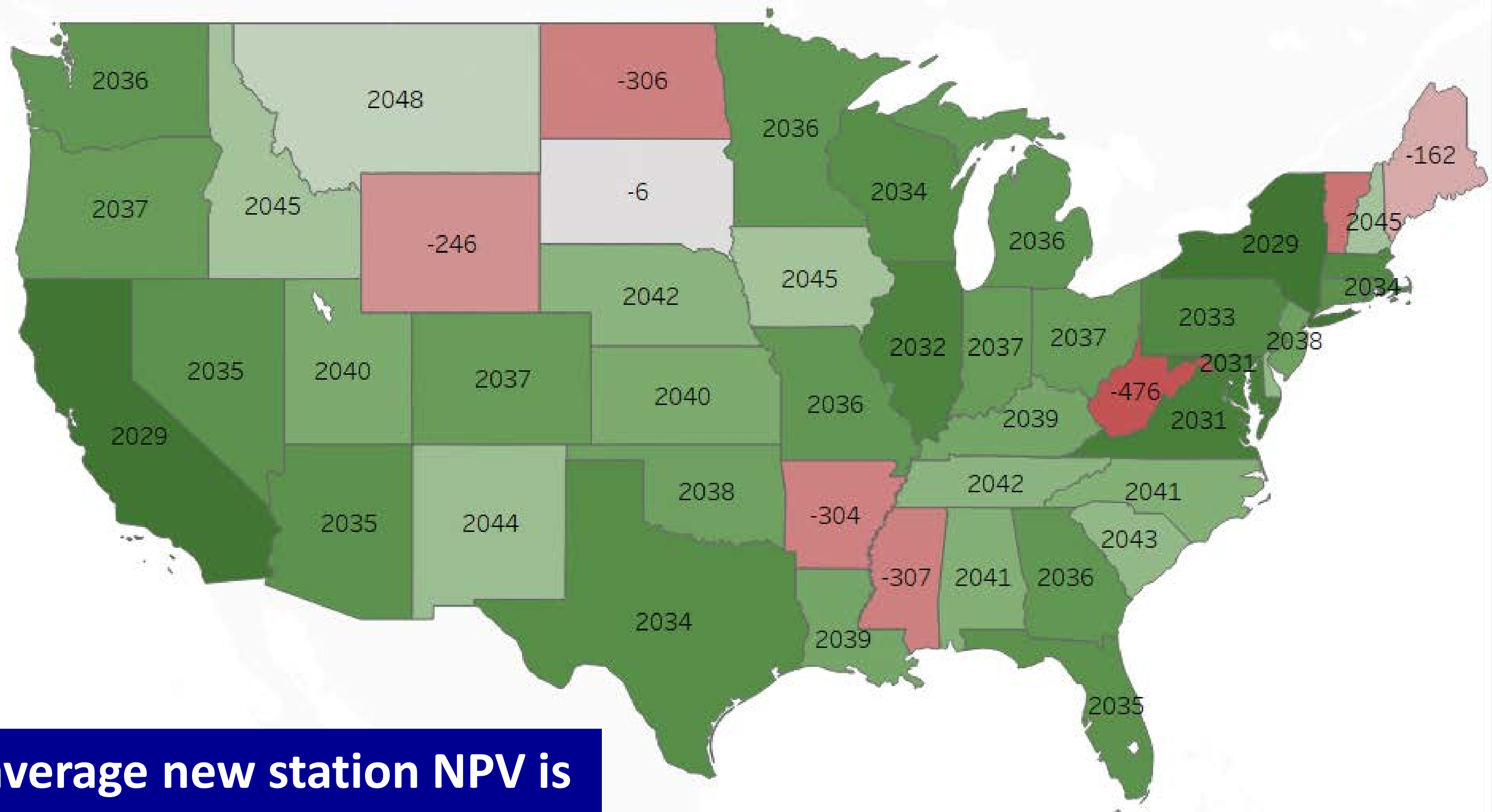
Projection of individual states pivot point years

Year = 2049

Ave. NPV < 0, (K$/station)

First year ave. NPV > 0

Preliminary Results



Annual average new station NPV is used for assessing financial sustainability

Model was used for retail stations analysis

Retail station analysis (California, California Energy Commission-funded)

- Yielded real world data and examples of infrastructure deployment

Highlighted lesson learned: Cost of electricity for new hydrogen stations

- California blended electricity rate = 15.73 ¢/kWh*
- California stations experience cost of electricity = 50 ¢/kWh**

California stations experience substantially higher cost of electricity than EIA would suggest

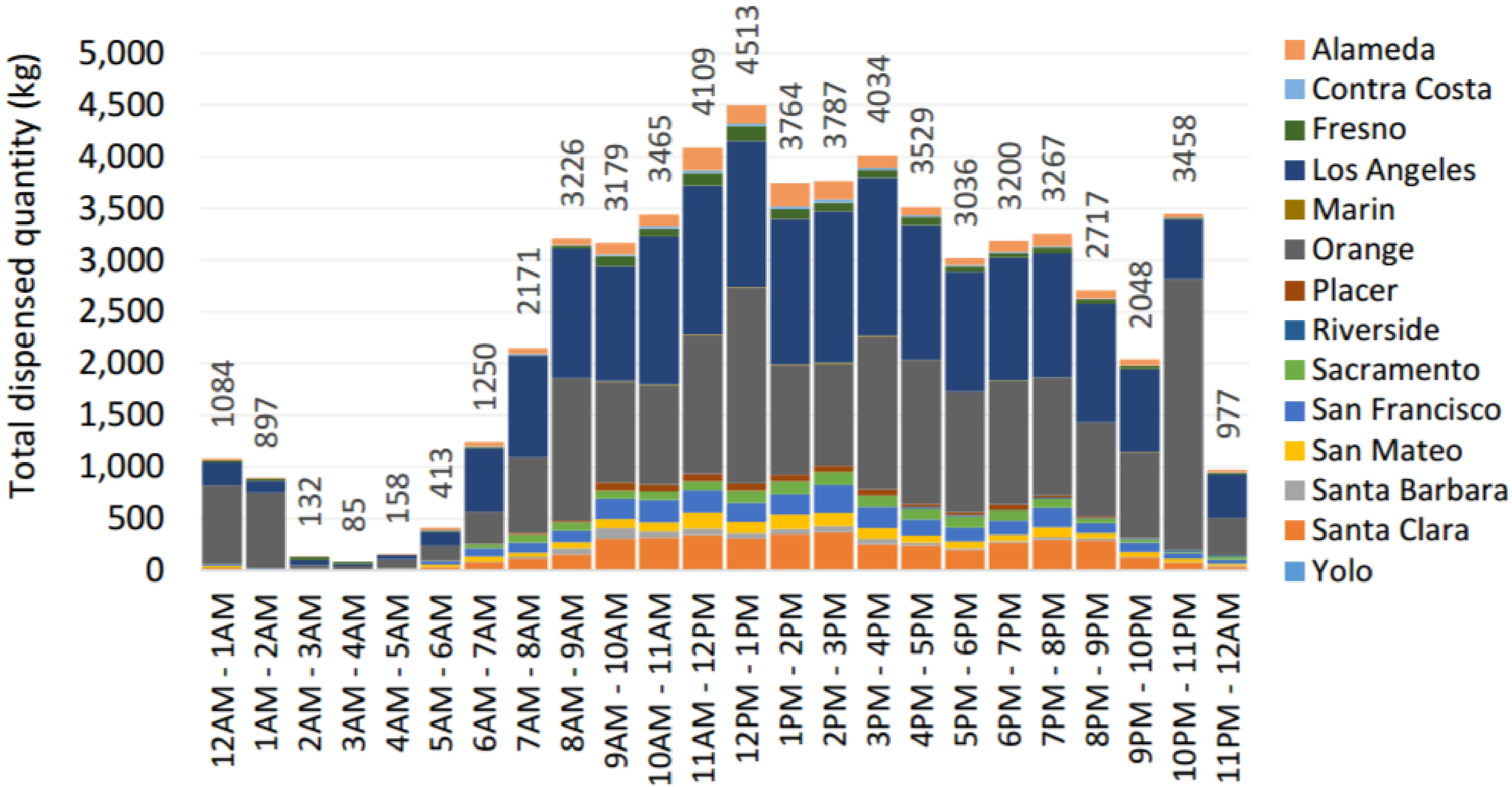
* Source: EIA, Table 2.10 Average Price of Electricity to Ultimate Customer by End-Use Sector, by State, 2015 and 2014

** Source: Joint Agency Staff Report on Assembly Bill 8: 2016 Assessment of Time and Cost Needed to Attain 100 Hydrogen Refueling Stations in California, http://www.energy.ca.gov/2017publications/CEC-600-2017-002/CEC-600-2017-002.pdf

Model was used for retail stations analysis

Accomplishments 6

Figure D-7: Total Dispensing vs. Hour of Day by County (H70 and H35)

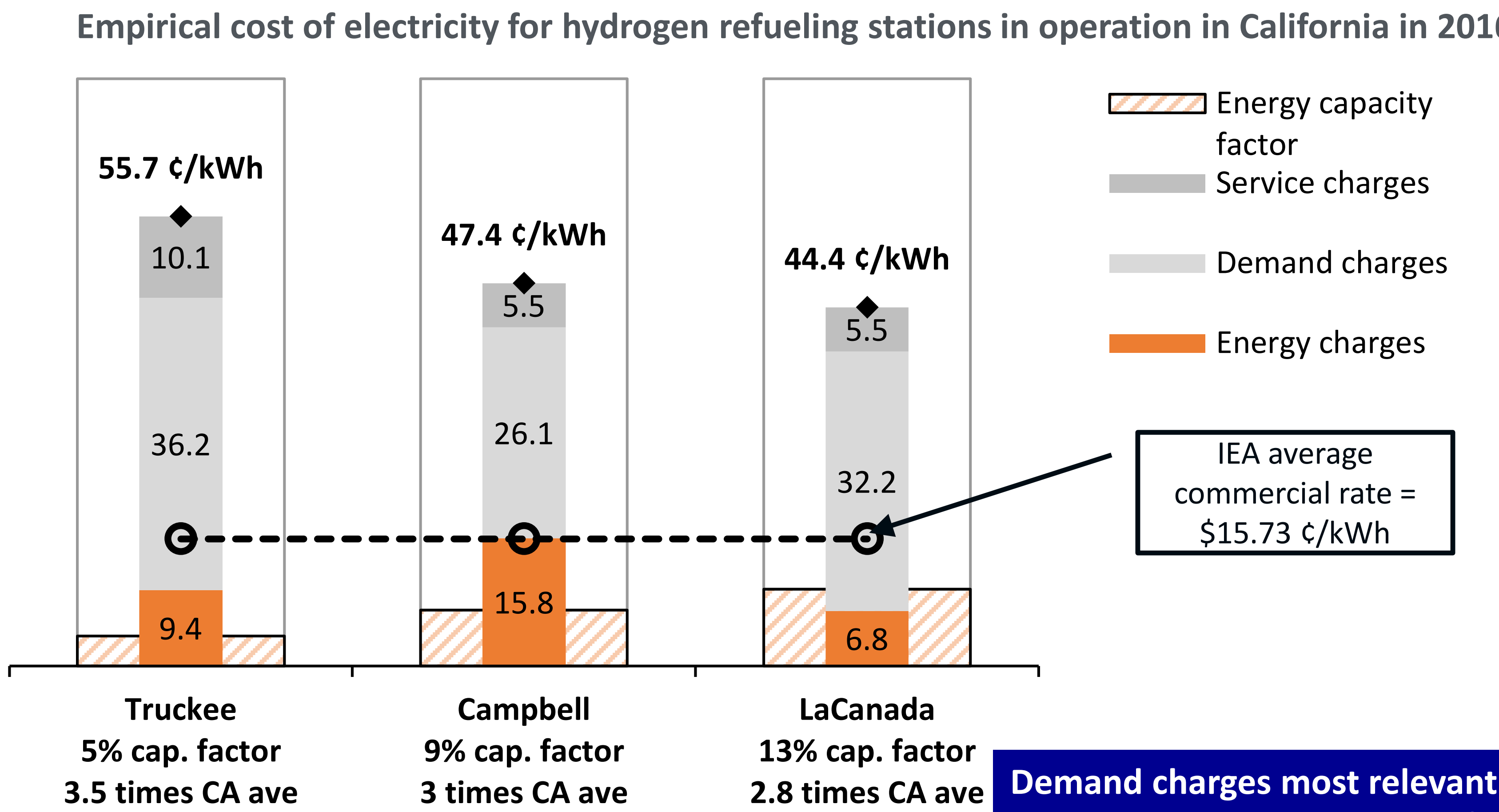


Stations use electricity at peak daily rate times

Use profile source: Joint Agency Staff Report on Assembly Bill 8: 2016 Assessment of Time and Cost Needed to Attain 100 Hydrogen Refueling Stations in California, http://www.energy.ca.gov/2017publications/CEC-600-2017-002/CEC-600-2017-002.pdf

Rate structure source: First Element Electricity bills, with permission of Tim Brown, COO

Model was used for retail stations analysis



Demand charges most relevant at low station utilization (@10 kWh/kg = ~$5/kg)

Maximum demand charges are incurred even at minimal utilization

Demand charges should be treated as a fixed operating cost

Utility bills source: First Element Electricity bills, with permission of Tim Brown, COO

Collaboration

Model development contributors

- H_2USA Investment and Finance Working Group (IFWG) – provided requirements and review
- Bill MacLeod (Hyundai Motor Group) – provided requirements and review
- Sanjeeva Senanayake (Welford Energy) – provided review and methodology guidance
- Mike Curry, MBA (Curry & Co.) – provided requirements and review
- Mike Levy, MBA (Aaquis) – provided requirements
- Remy Garderet (Energy Independence Now) – provided model review

State and federal government

- H_2USA Investment and Finance Working Group (IFWG) – provided requirements and review
- California Energy Commission – provided review and model utilization
- Tyson Eckerle (California Governor's Office) – provided model review and incentive framework

Federal laboratory and university

- Ricardo Bracho, MBA and Michael Elchinger, MBA (NREL) – compliance with accounting and finance standards
- Jeff Grover, DBA (CEO, Grover Group Inc.) – line-by-line model review and validation

Proposed future work

Apply modeling methodology to explore National and regional scenarios

- H_2USA, CEC, Northeast, Hawaii

Increase model integration with SERA

- Integrate hydrogen production scenarios
- Evaluate transitions to renewable hydrogen

Implement additional features

- Additional fixed operating costs (e.g., demand charges)
- More detailed demand ramp-up specifications
- Ability to provide custom feedstock and retail price profiles

Ongoing maintenance and support

- Support custom analysis and user base requests
- Produce model updates as needed

Any proposed future work is subject to change based on funding levels

Summary

Relevance

- Examine FCEV markets and financial strategies to support infrastructure expansion nationally
- Provide convenient detailed infrastructure financial analysis to facilitate investments in hydrogen

Approach

- Use GAAP financial calculations with extensive modeling inputs and outputs
- Include detailed risk analysis to project ranges of financial outcomes

Accomplishments

- H2FAST was incorporated into SERA model
- National scenarios show variable transition to un-incentivized financial profitability for different states
- H2FAST was used to evaluate real-world installations
- Early station operation demand charges were found to be big cost factors

Collaboration

- Model and framework leverages stakeholder
  - Department of Energy Fuel Cell Technologies Office, H2USA, California Energy Commission
- Model is thoroughly reviewed by internal and external reviewers

Proposed future work

- H2FAST scenarios will be further refined to reflect more financial factors for National scenarios
- New H2FAST features, such as fixed operating costs reflective of real-world experience

Questions?

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Technical Back-Up Slides

H2FAST webinar recording 2017

Recording of DOE-sponsored H2FAST webinar:

https://energy.gov/eere/fuelcells/downloads/hydrogen-financial-analysis-scenario-tool-h2fast-model-summary-and

H2FAST Excel version URL:

http://www.nrel.gov/hydrogen/h2fast/

H2FAST documentation URL:

http://www.nrel.gov/hydrogen/h2fast/documentation.html