



## Meeting the Needs of Hydrogen Infrastructure Financial and Sustainability Analysis

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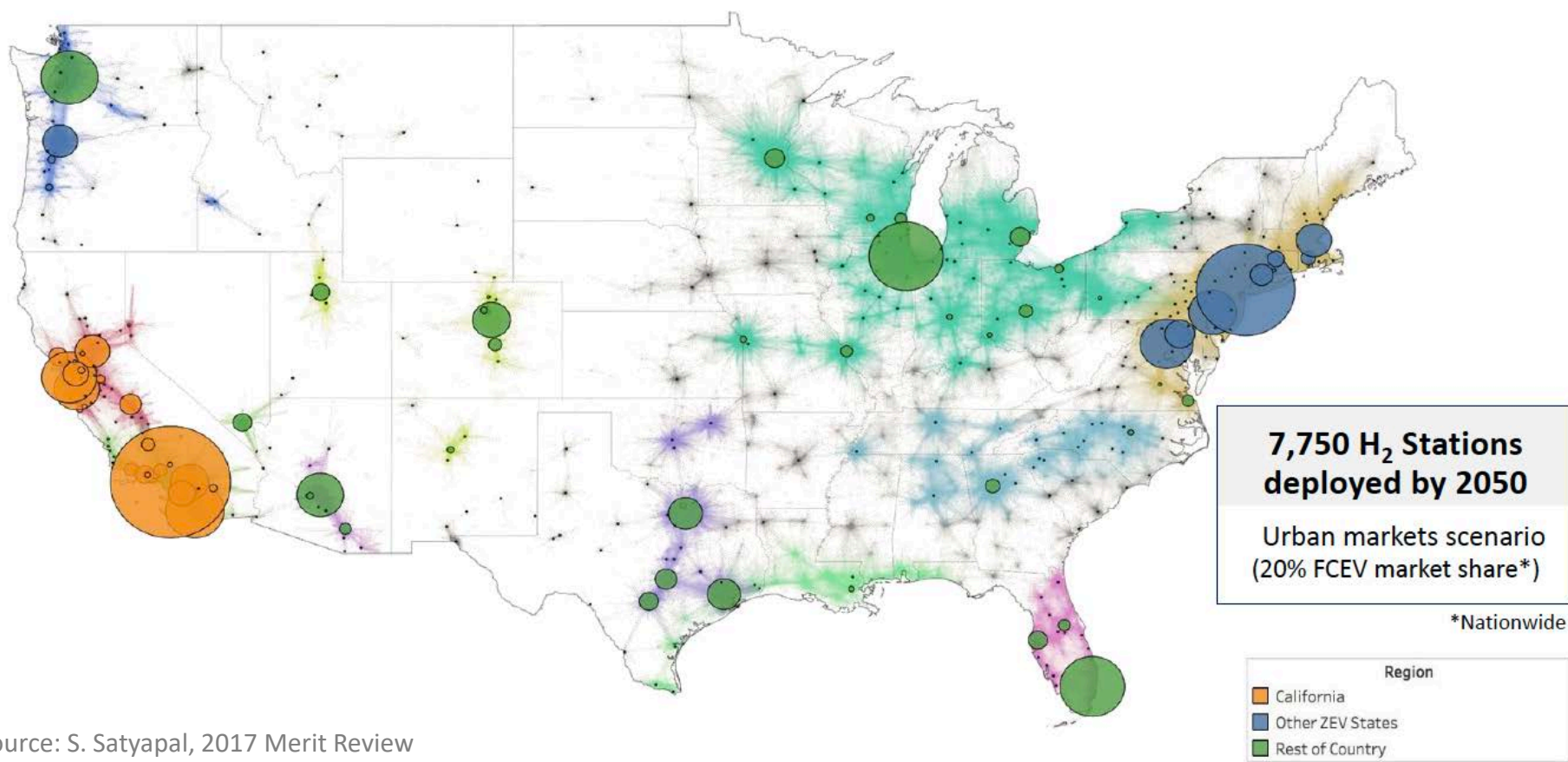
NREL/PR-5400-70244

# Presentation Overview

- H2USA's National Hydrogen Scenarios
- Financial analysis of stations (H2FAST & SERA)
- Regional Sustainability Analysis (GREET & HyReS)

# H2USA's National Hydrogen Scenarios

- FCEV demand ramps up in all major U.S. cities, at different rates and in different regions for each scenario.
- Map below is for least-aggressive scenario (by 2050)

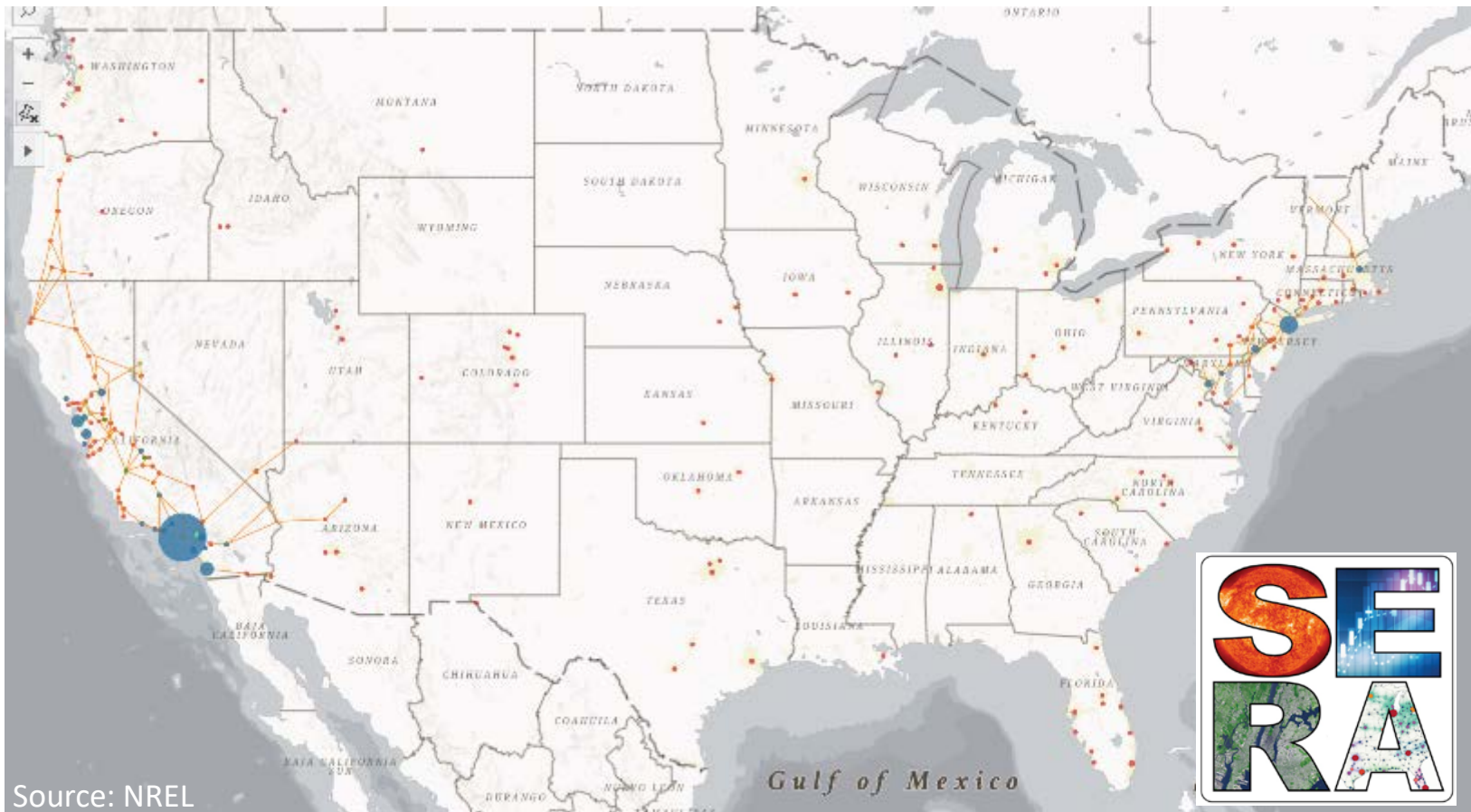


Source: S. Satyapal, 2017 Merit Review

[https://www.hydrogen.energy.gov/pdfs/review17/01\\_satyapal\\_plenary\\_2017\\_amr.pdf](https://www.hydrogen.energy.gov/pdfs/review17/01_satyapal_plenary_2017_amr.pdf)

# Optimal hydrogen supply pathways (networks)

- SERA identifies optimal least-cost production and delivery pathways for demand in all cities
- Supply networks can serve multiple cities



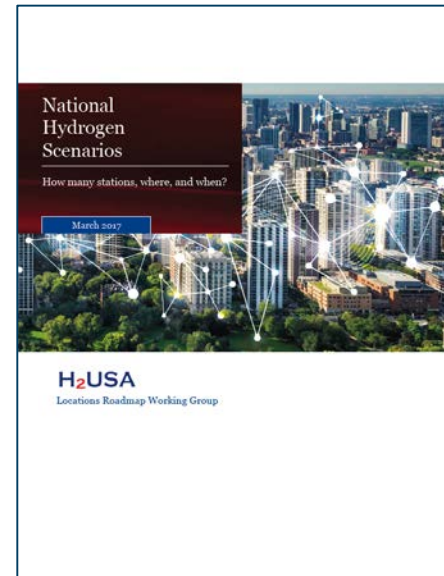


# National Hydrogen Infrastructure Simulations

*The Scenario Evaluation and Regionalization Analysis (SERA) Model*



- The SERA model has been used to simulate cost-optimal hydrogen infrastructure development scenarios to satisfy FCEV demand.
- H2USA's National Hydrogen Scenarios report relies upon SERA to estimate the number, size, and location of retail stations needed for strong FCEV market growth out to 2035.



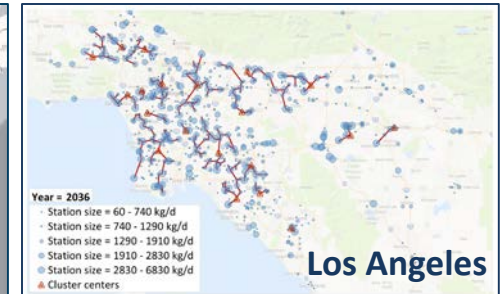
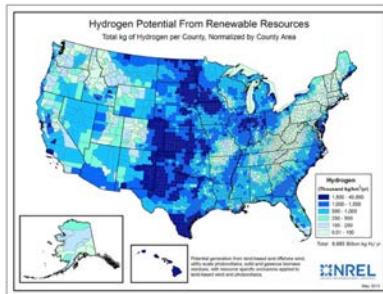
**National Hydrogen Scenarios:**  
How Many Stations,  
Where and  
When?

Energy Resources

Hydrogen Production

Storage & Delivery

Retail Station Networks

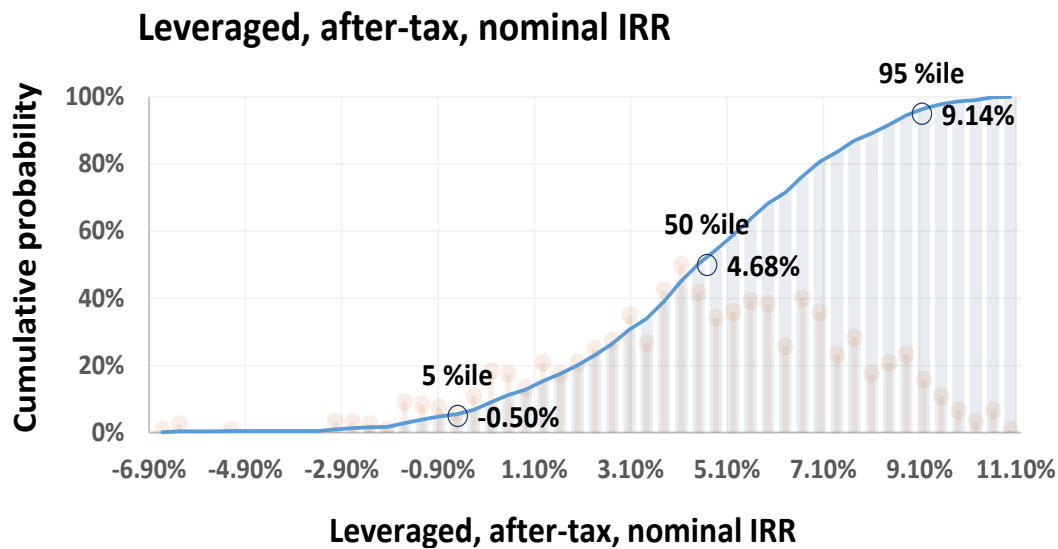


*The SERA model simulates detailed geospatial least-cost supply pathways for FCEV markets*

# H2FAST spreadsheet model allows for range of uncertain input variables and computes outputs as uncertainty ranges

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)	\$	
Estimated break-even leveraged price (\$/kg)	\$ 12.45	\$ 10.28	\$	

Click to select distribution to plot



**H2FAST**

Station Inputs

Scenario Inputs

Financing Inputs

Download Results Spreadsheet

- Model does uncertainty analysis
- Most input values can be varied
- Results reflect uncertainty ranges

<https://www.nrel.gov/hydrogen/h2fast/>



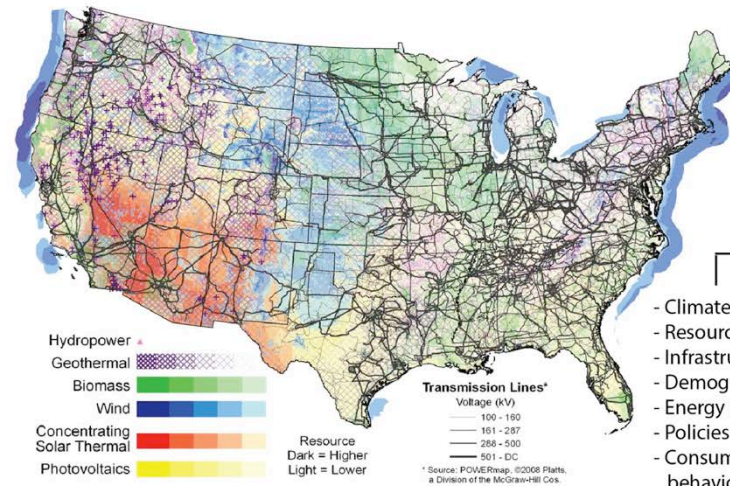
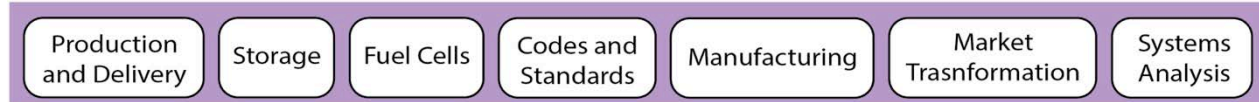


# HyReS Framework identifies regional trends

- The **Hydrogen Regional Sustainability (HyReS)** framework develops detailed regional metrics based upon parameters from **the Argonne GREET model**.
- Spatially explicit supply chain components, accounting for resource geography and component cost and performance

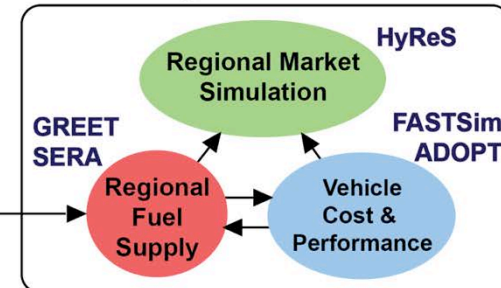


## Fuel Cell Technologies Office Targets

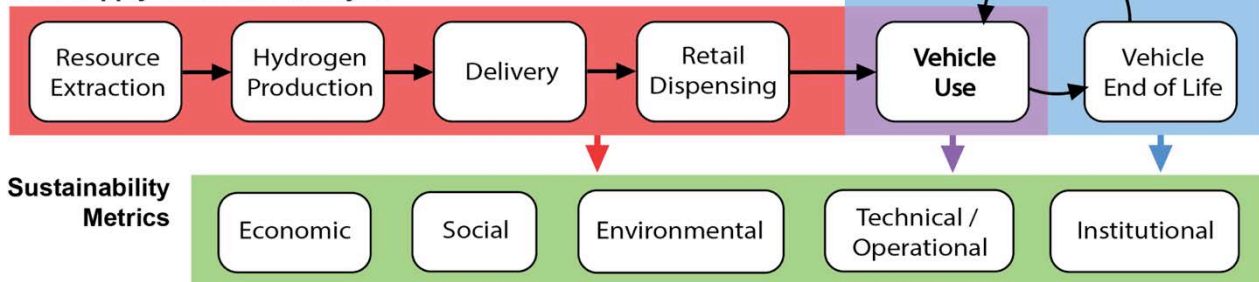


- Climate
- Resources
- Infrastructure
- Demographics
- Energy prices
- Policies
- Consumer behavior

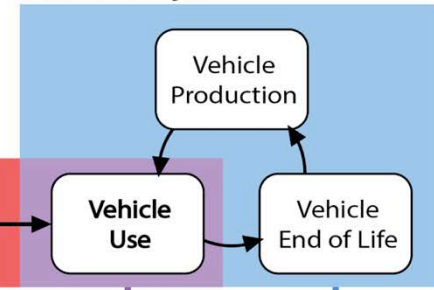
## Integrated Scenarios



## Fuel Supply Chain and Lifecycle



## Vehicle Lifecycle



The HyReS framework identifies optimal hydrogen supply chains considering spatially- and temporally-based constraints and aspects of sustainability



# Future Work: Complete integration of SERA / HyReS / ADOPT Market Simulation Capabilities

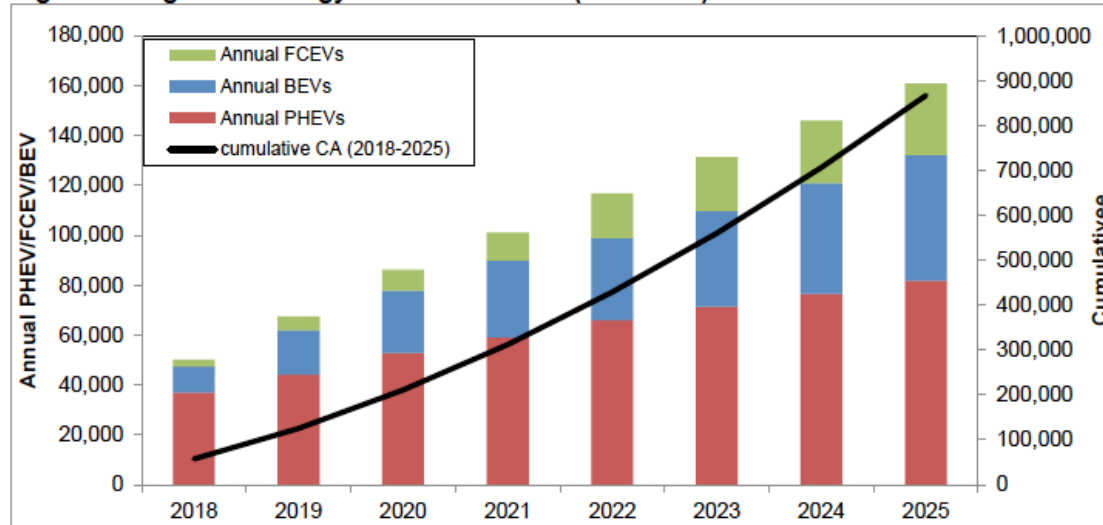
## Relevance of sustainability in market growth

- California state policies will accelerate adoption of FCEVs, BEVs, and PHEVs
- HyReS will be fully integrated with the vehicle adoption capabilities of ADOPT and hydrogen supply and financing capabilities of SERA/H2FAST
- HyReS will then be able to inform broader discussions about sustainability impacts of specific state and federal policy mechanisms

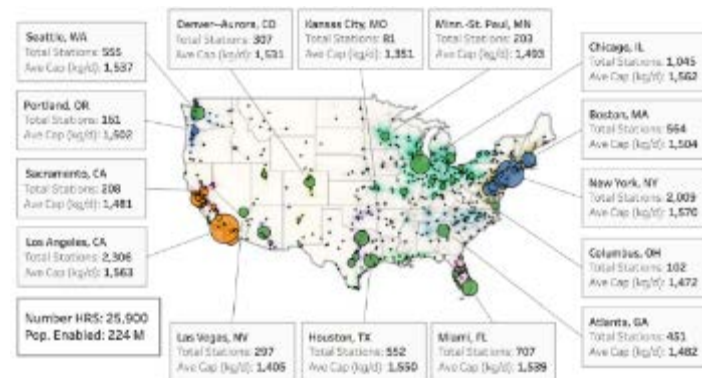
# H<sub>2</sub>USA

Market simulation capabilities will enable HyReS to contribute to broader discussions around ZEV adoption

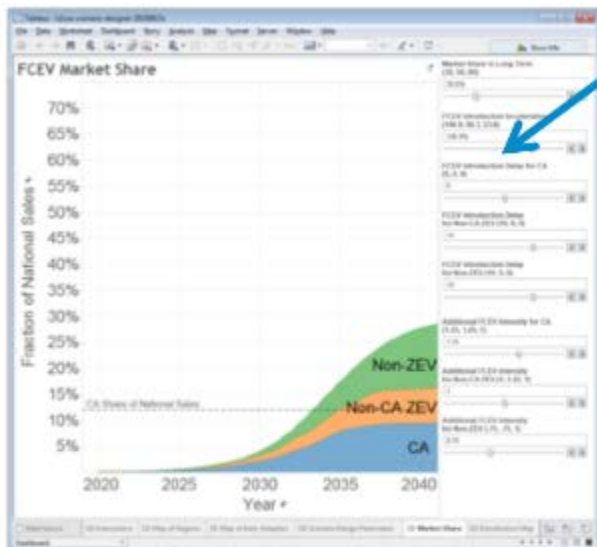
Figure 7 - High-Technology Scenario Results (California)



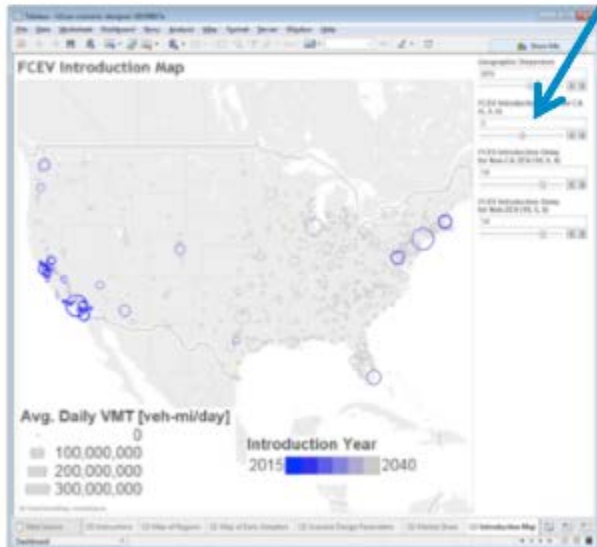
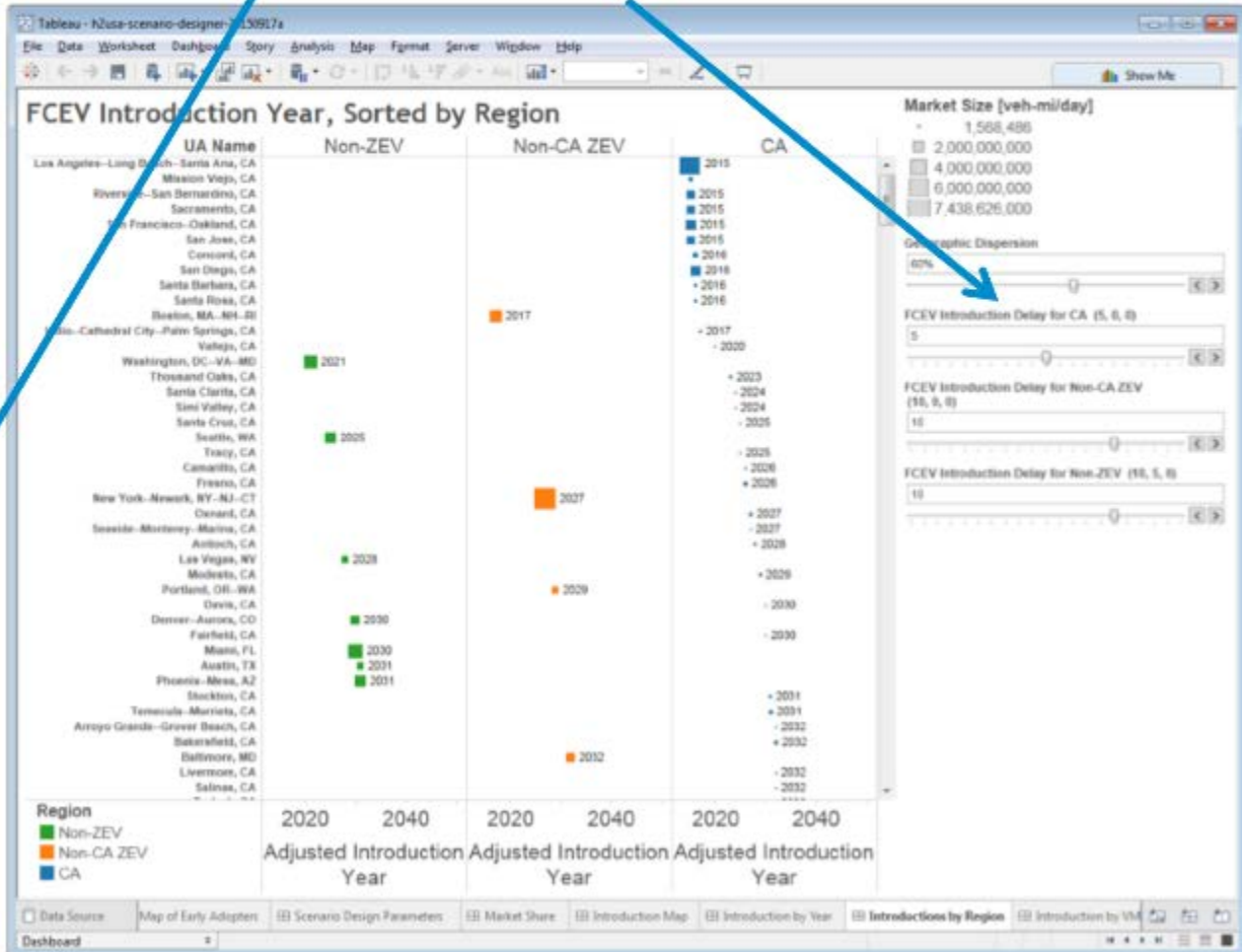
<https://www.arb.ca.gov/msprog/zevprog/zevprog.htm>



# How will these results be made available to stakeholders?



*Users manipulate sliders and other widgets to change scenarios' aggressiveness, regional sequencing, and urban clustering.*



Source: B. Bush 2016 AMR Presentation ([https://www.hydrogen.energy.gov/pdfs/review16/sa061\\_melaina\\_2016\\_o.pdf](https://www.hydrogen.energy.gov/pdfs/review16/sa061_melaina_2016_o.pdf))

# Summary

- H2USA's National Scenarios report provides three regionally articulated FCEV market rollout scenarios
- The H2FAST model can be used to examine finances for individual stations, supply chains, or entire regional networks
- The HyReS framework builds up the Argonne GREET model to develop regional sustainability metrics
- Results from these integrated models will be made available through a scenario data portal.

# Questions?

Contact Information

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