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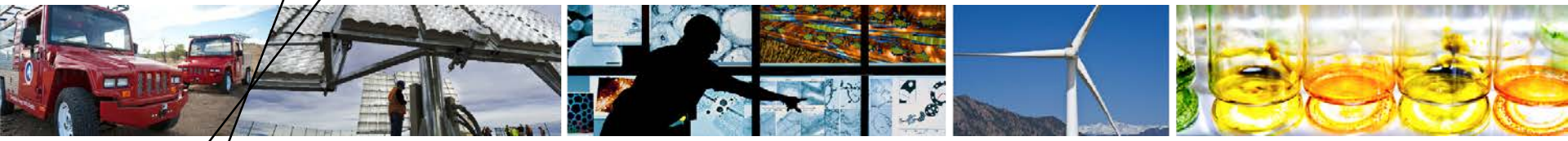
Hydrogen Infrastructure Expansion: Consumer Demand and Cost-Reduction Potential



Hydrogen Infrastructure Investment Forum—
Palo Alto, California

Dr. Marc Melaina
Senior Engineer

April 16, 2014

NREL/PR-5400-61966

Presentation Overview

- **How much do consumers value hydrogen station availability?**
- **How much will station costs decline with volume?**
- **What kind of market growth is needed to ensure station cost reductions (and adequate return on investment, or ROI)?**

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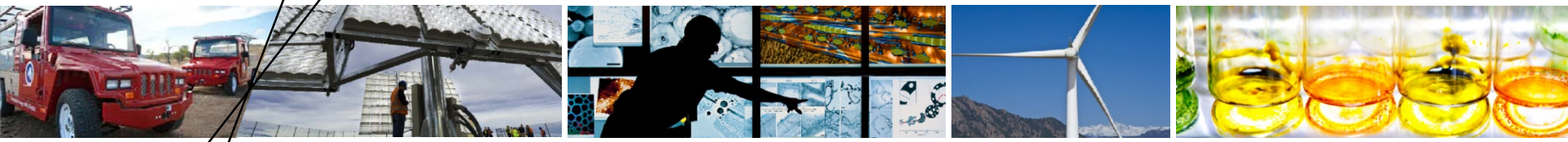


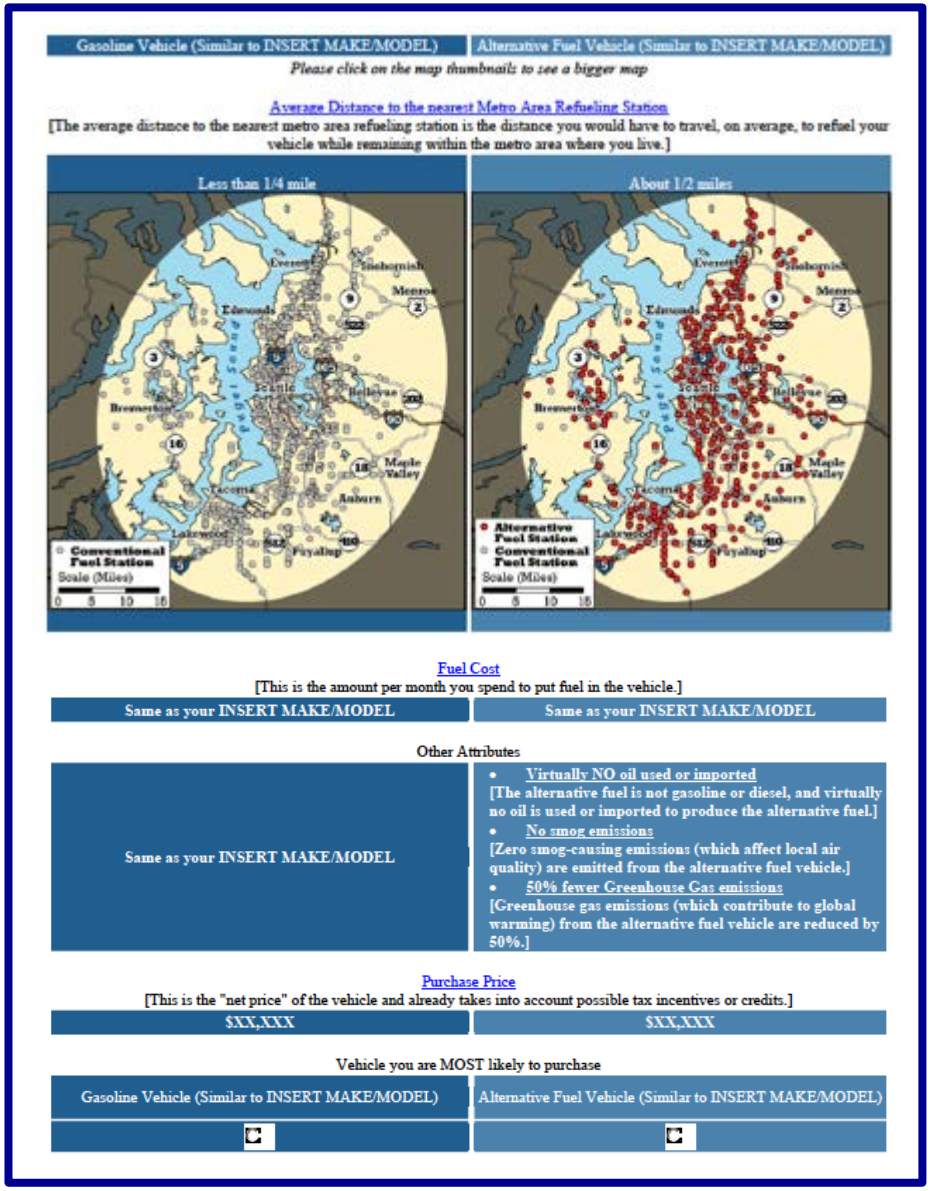
How much do consumers value hydrogen station availability?

Discrete Choice Consumer Survey

- **Received ~500 responses from each city:**
  - Los Angeles, CA
  - Atlanta, GA
  - Minneapolis, MN
  - Seattle, WA

- **Two choices:**
  1. Conventional vehicle
  2. "Alt fuel" vehicle

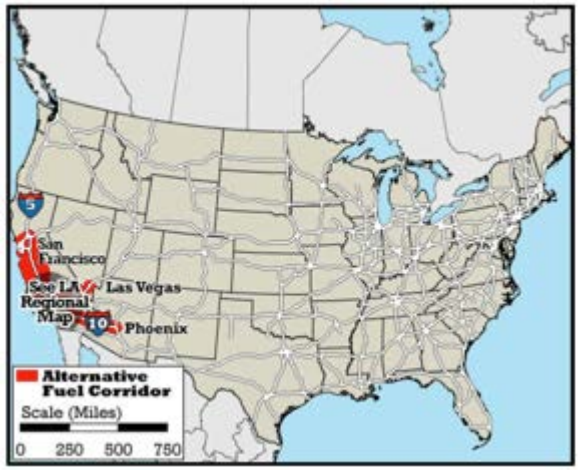
Results are a "vehicle price equivalent" penalty against the price of a vehicle during the purchase decision.

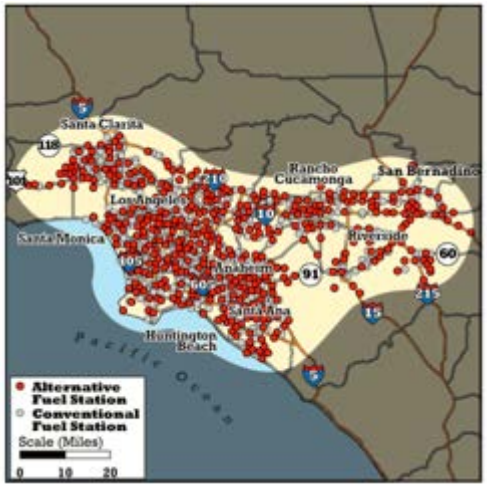


Visual Maps Were Used to Convey Availability

Discrete choice algorithm varies coverage variables among 10 choices

Local	Regional	Interstate

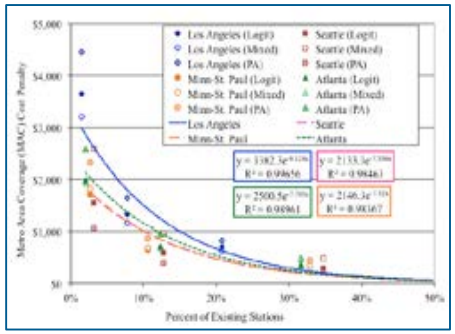


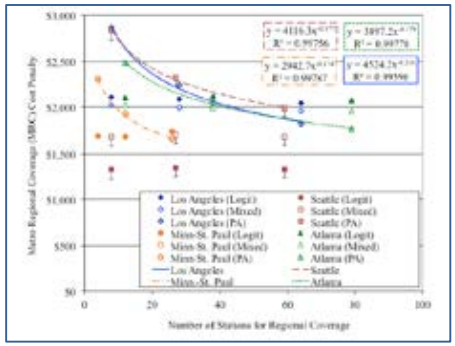


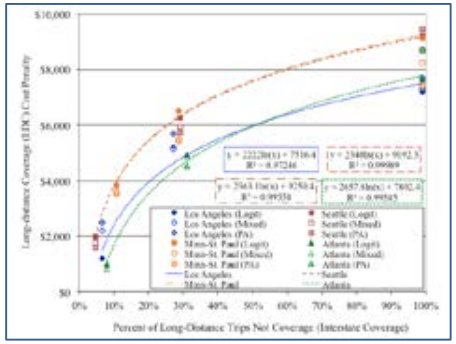
Results Suggest Value of Stations to Consumers

Results

- Lack of stations at the **local** and **regional** level can incur a penalty of $4,000–$6,000 against the vehicle price.
- Lack of stations along **interstates** between major cities (500+ miles) can also incur a penalty of $4,000–$6,000.







- ***Sufficient station availability may be comparable to an approximate $5,000–$10,000 per vehicle price reduction.***
- ***Analytic "cost-of-time" models suggest much lower penalties.***

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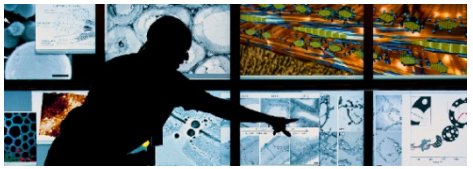
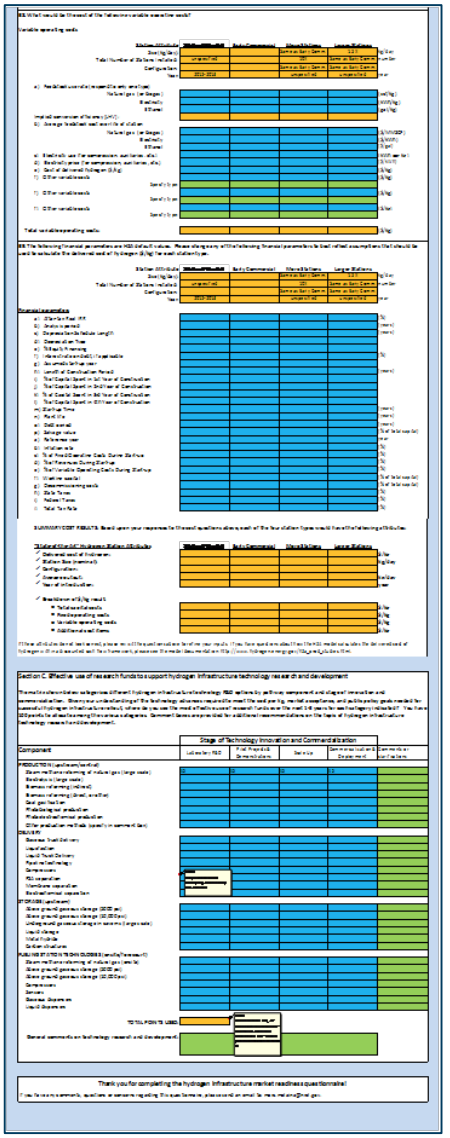


How much will station costs decline with volume?

Quantitative Results from the Hydrogen Station Cost Calculator (HSCC)

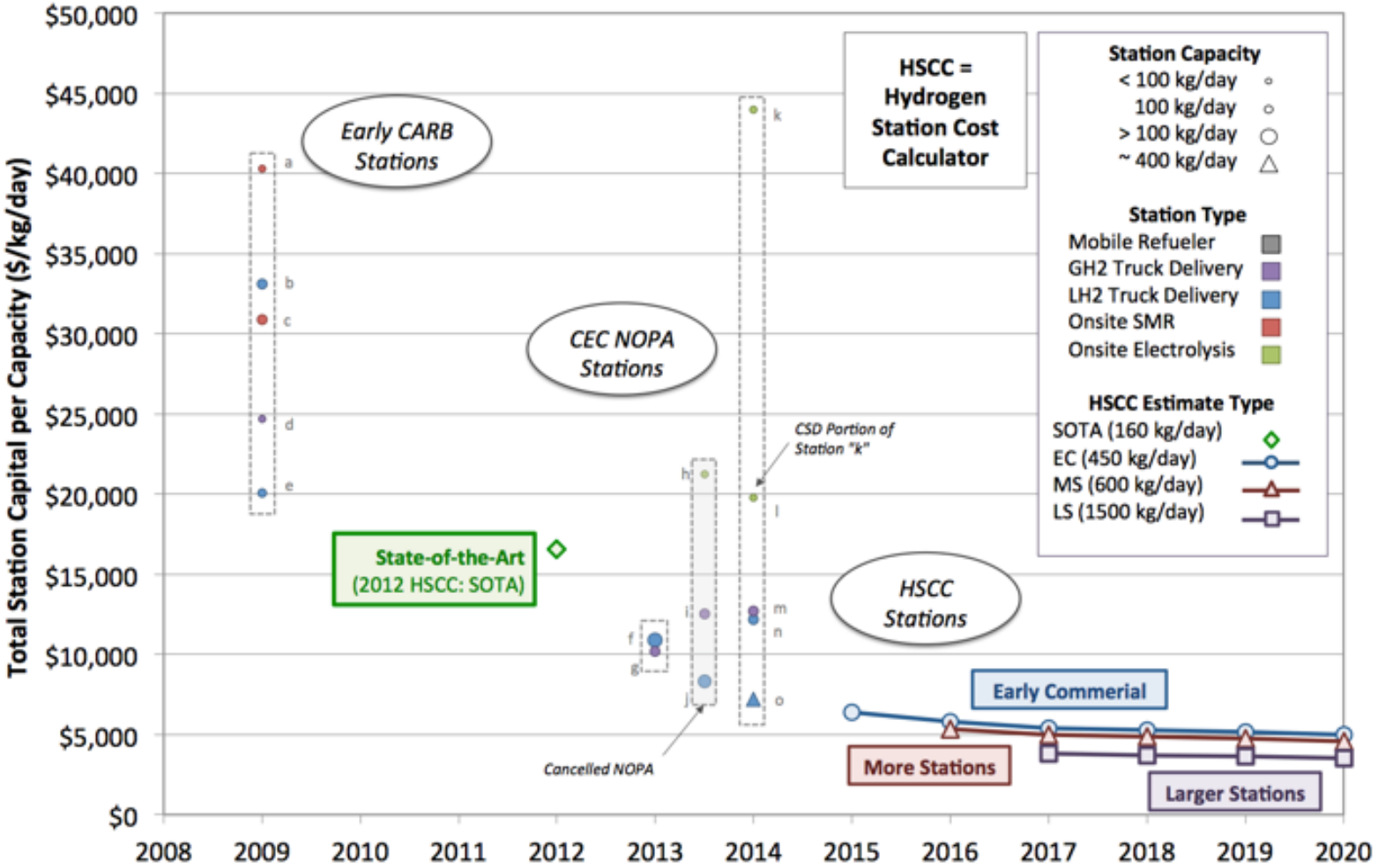
- **HSCC was administered anonymously by IDC Energy Insights.**
- **Results were analyzed by NREL staff to develop a generic station cost equation:**
  - **Economies of scale** (station size)
  - **Industry experience** (cumulative installed capacity)
- **Results for state-of-the-art costs and three future costs**

HSCC Screenshot



Quantitative Results: Capita per Capacity ($/kg/d)

Survey results and recent Energy Commission Awards suggest a 70% reduction in station capital costs by 2017–2020.



It's Not Only Volume: Qualitative Workshop Results Indicate "How" to Pursue Cost-Reduction Opportunities

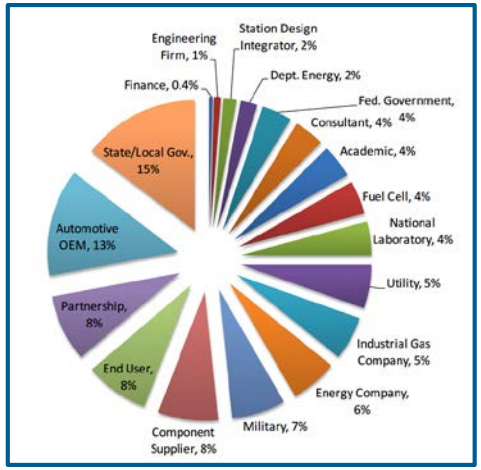
Cost-Reduction Opportunities

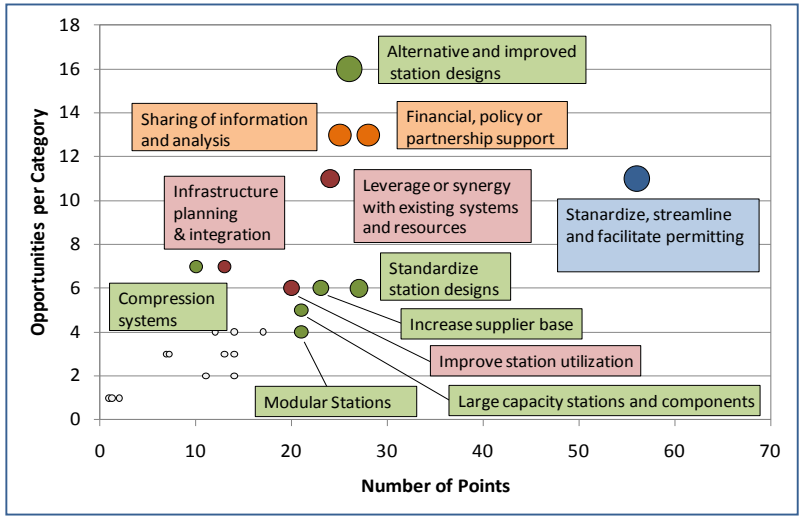
1. Expand and enhance supply chains for production of high-performance, lower cost parts
2. Reduce cost of hydrogen compression
3. Develop high-pressure hydrogen delivery and storage components
4. Harmonize/standardize dispensing equipment specifications
5. Develop "type of approvals" for use in permitting
6. Improve information and training available to safety and code officials
7. Develop methods for planning station rollouts and sharing early market information

Full report:
http://www.nrel.gov/docs/fy13osti/56412.pdf

Prioritizing Opportunities

Market Readiness Workshop, Feb. 2011





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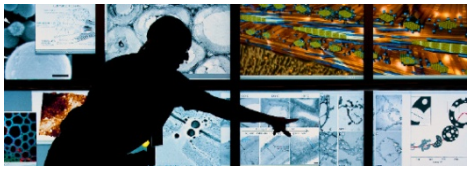
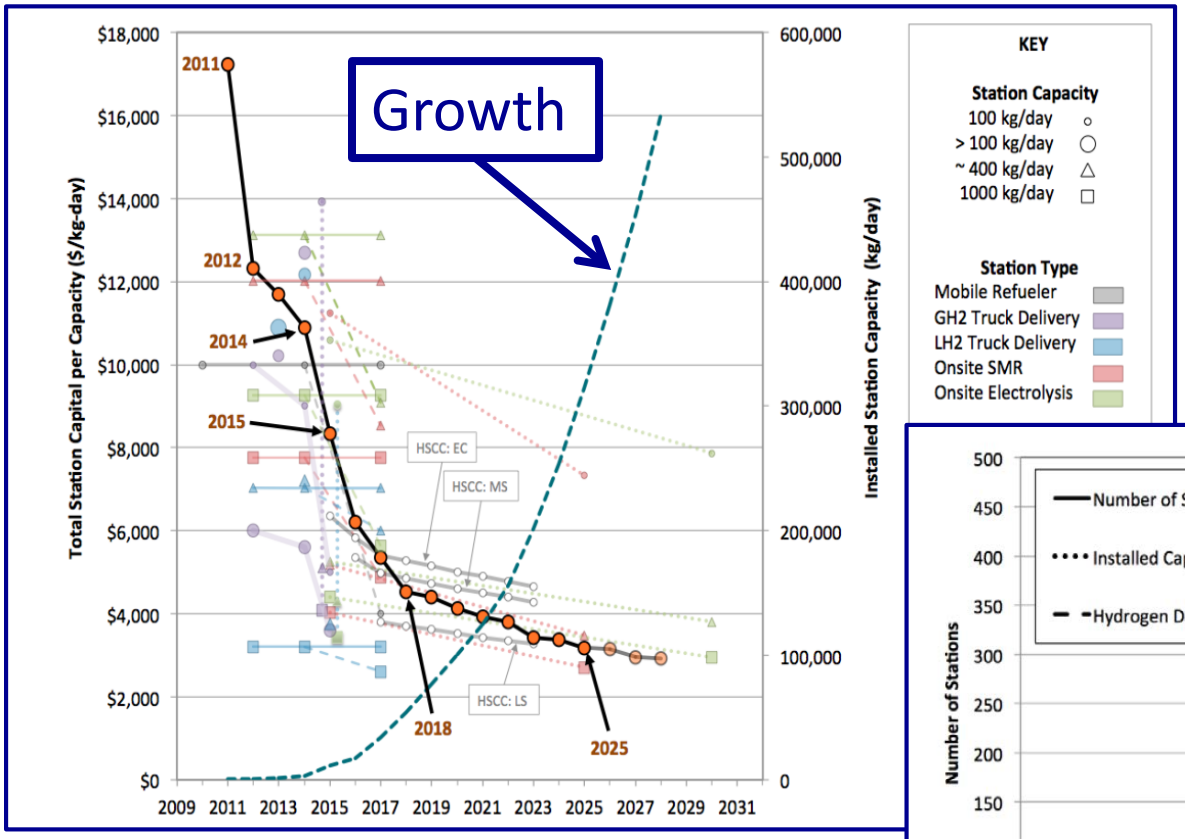


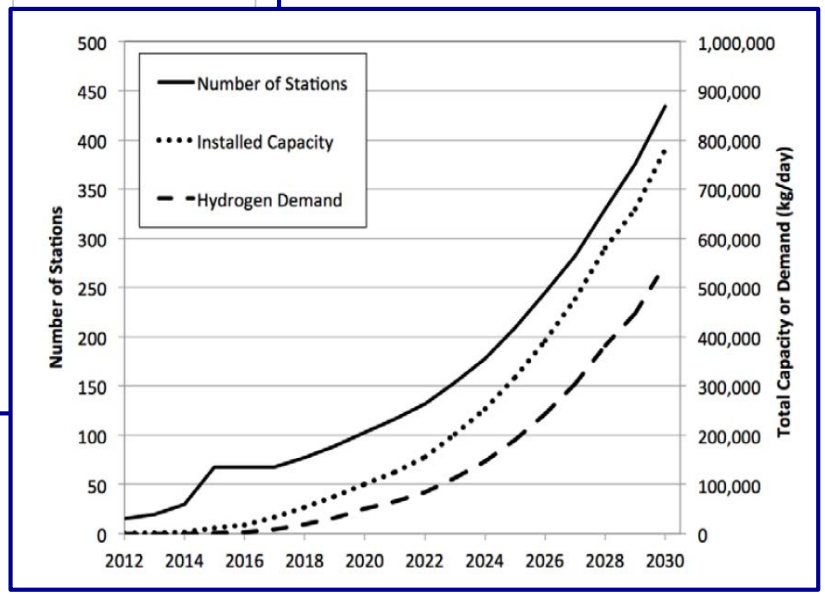
What kind of market growth is needed to ensure station cost reductions (and adequate ROI)?

Approximately 400,000–800,000 FCEVs Needed by ~2025–2030 to Achieve Cost-Reduction Opportunities

Slower growth would result in lower ROI.



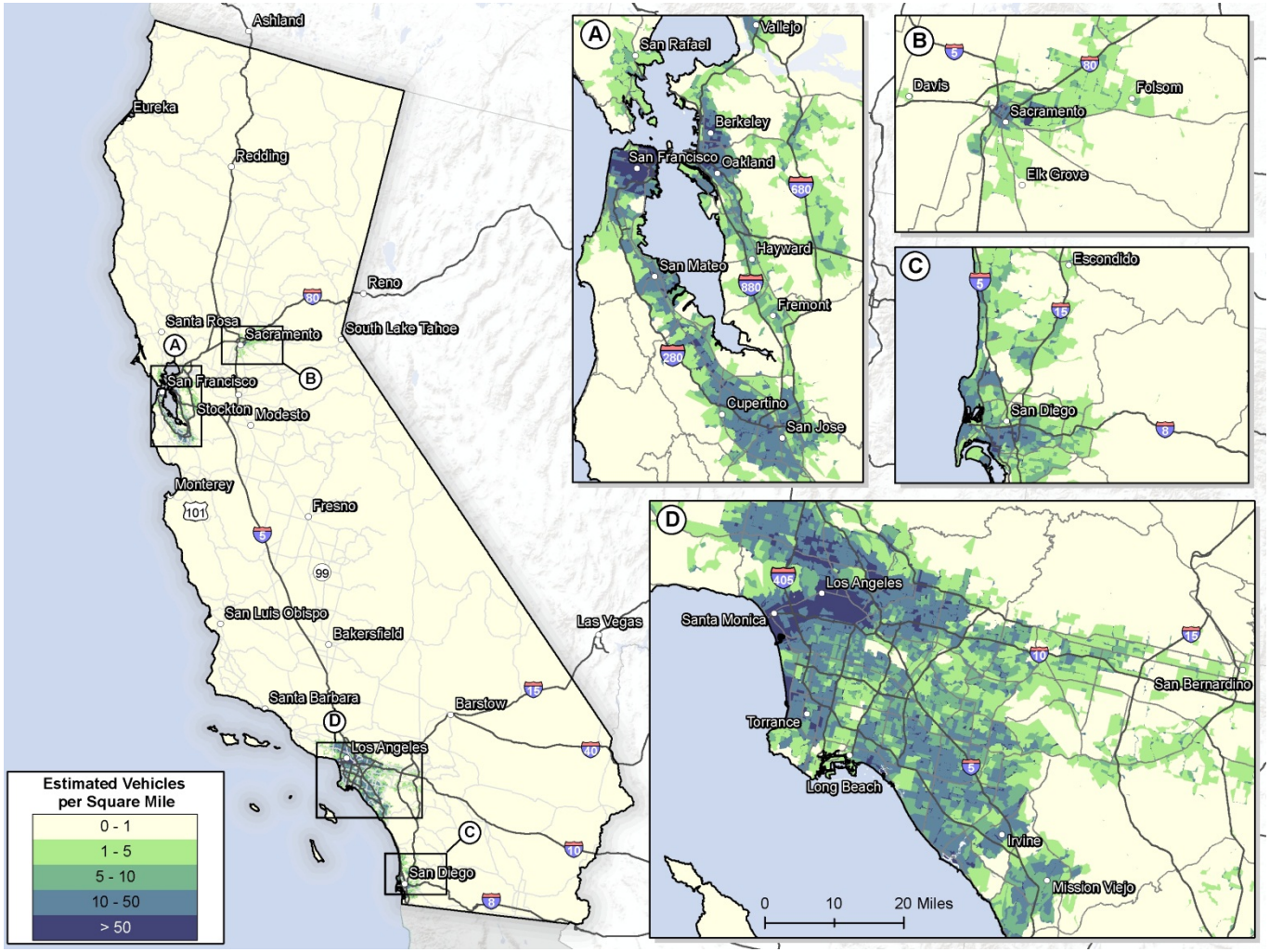
Comparing HSCC results to other estimates



Assumed demand scenario

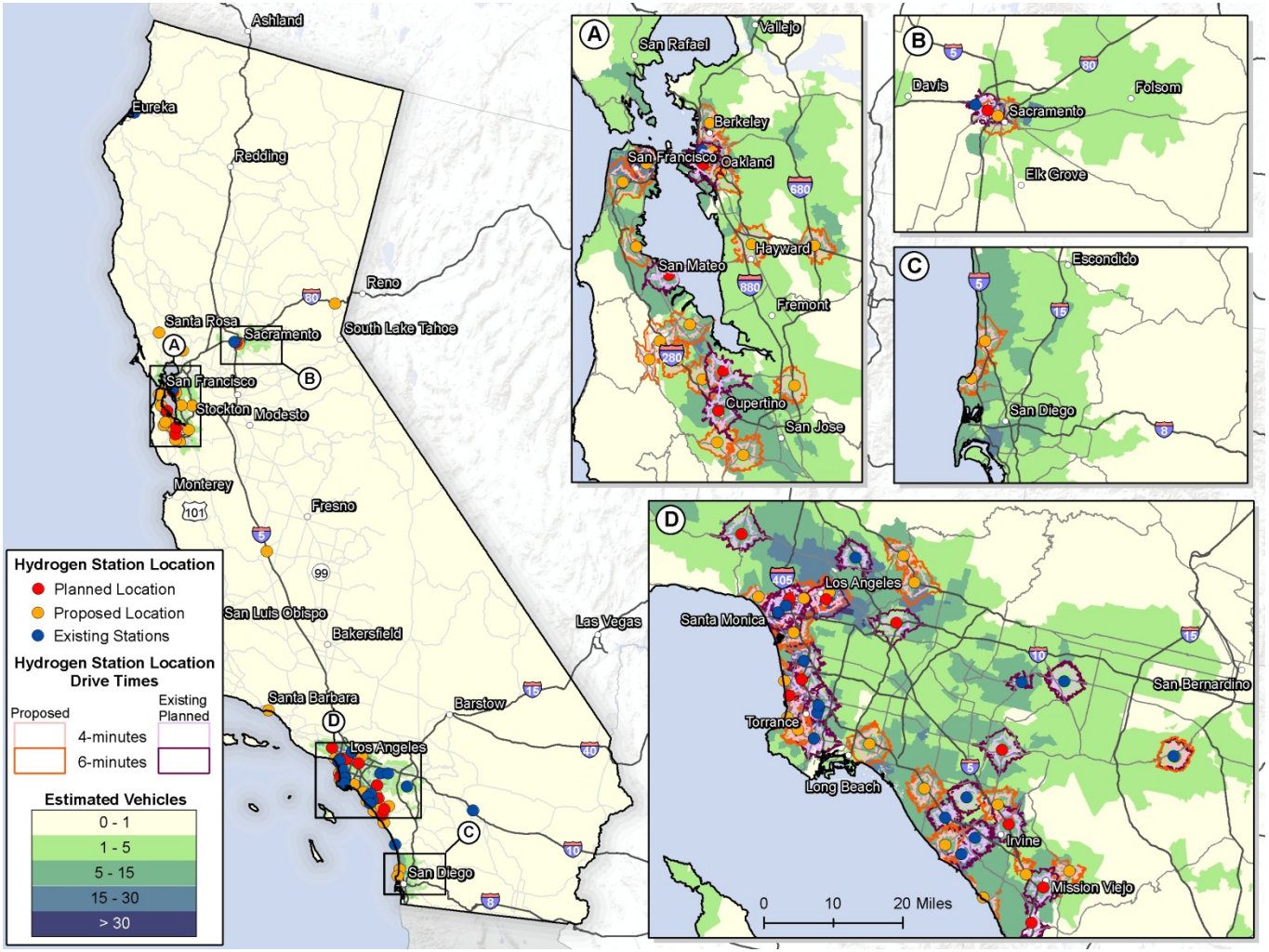
Cluster Strategy Focuses on High-Density Areas of Likely Early Adopters

Early Adopter Metric (EAM)

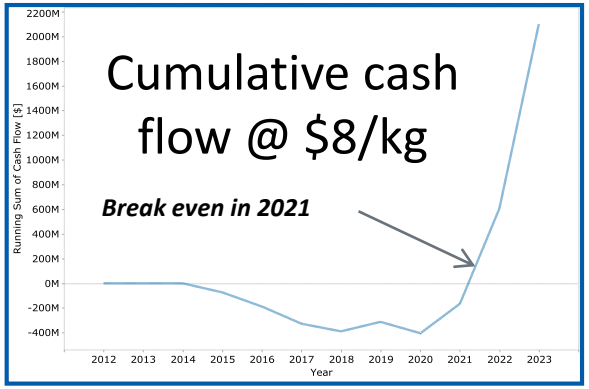


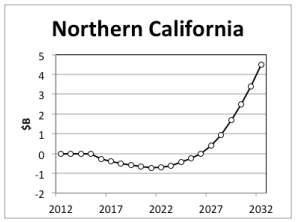
Cluster Strategy Focuses on High-Density Areas of Likely Early Adopters

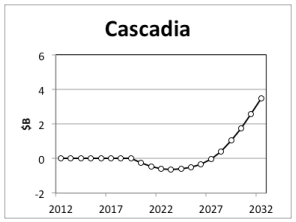
Existing, Planned, and Proposed Station Locations

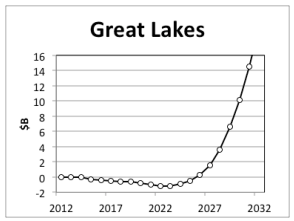


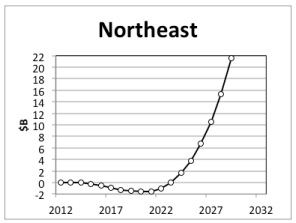
How Do Cash Flows Resolve Locally and Regionally?

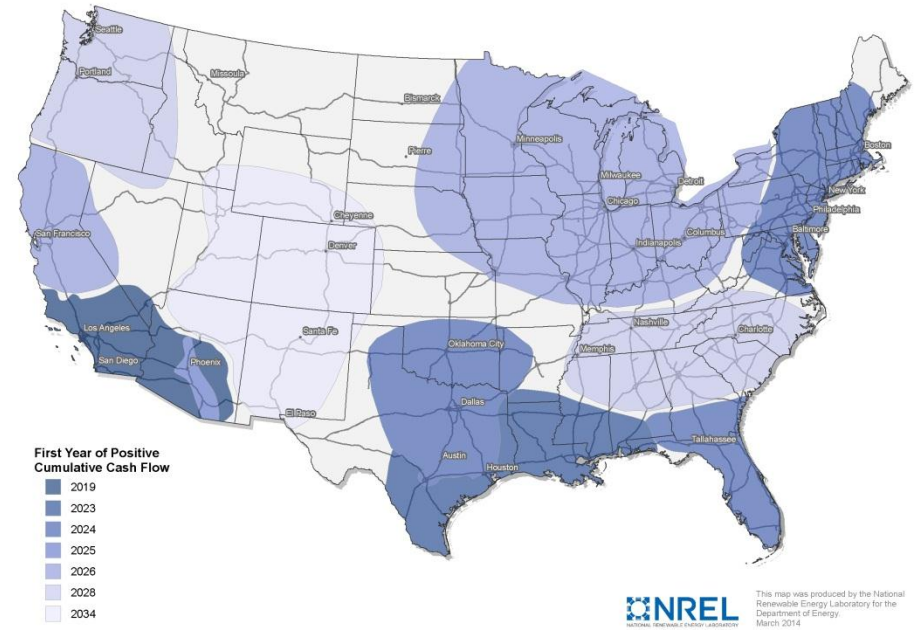




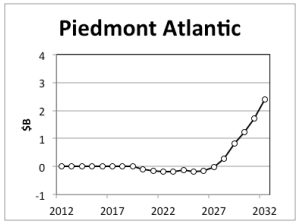


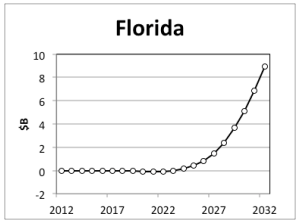


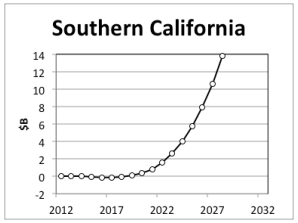


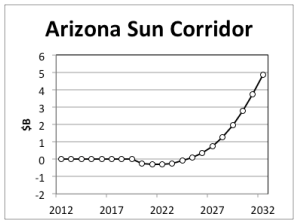


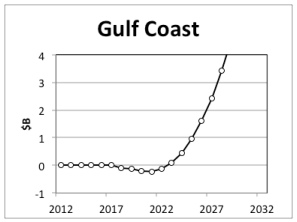
Conceptual and example results only

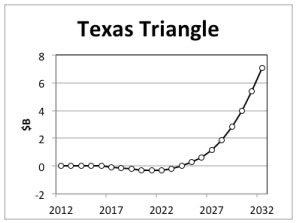


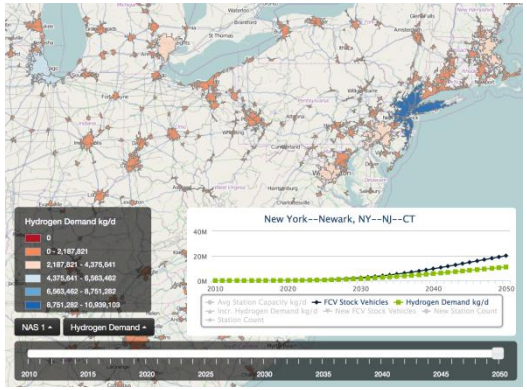












Interactive visualization tool is in development

Regions are based on America 2050 Map: www.america2050.org

Summary of Key Points

- **Station availability is critical to consumer choice and therefore market success.**
- **With volume, station capital cost reductions may be on the order of 70% below current costs.**
- **Volumes (demand) required are on the order of 400,000 to 800,000 FCEVs deployed by 2025–2030.**

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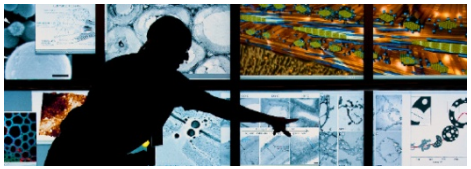
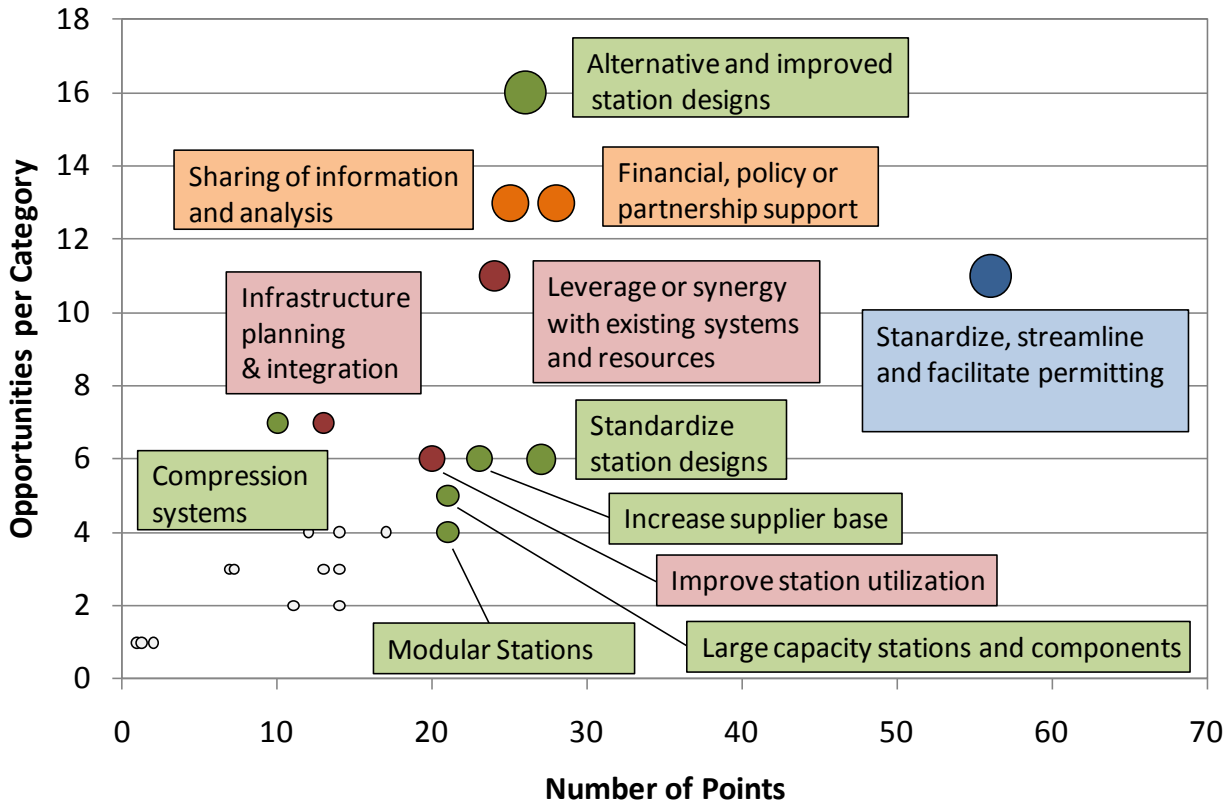


Questions?

Characterization of Cost-Reduction Opportunity Priorities

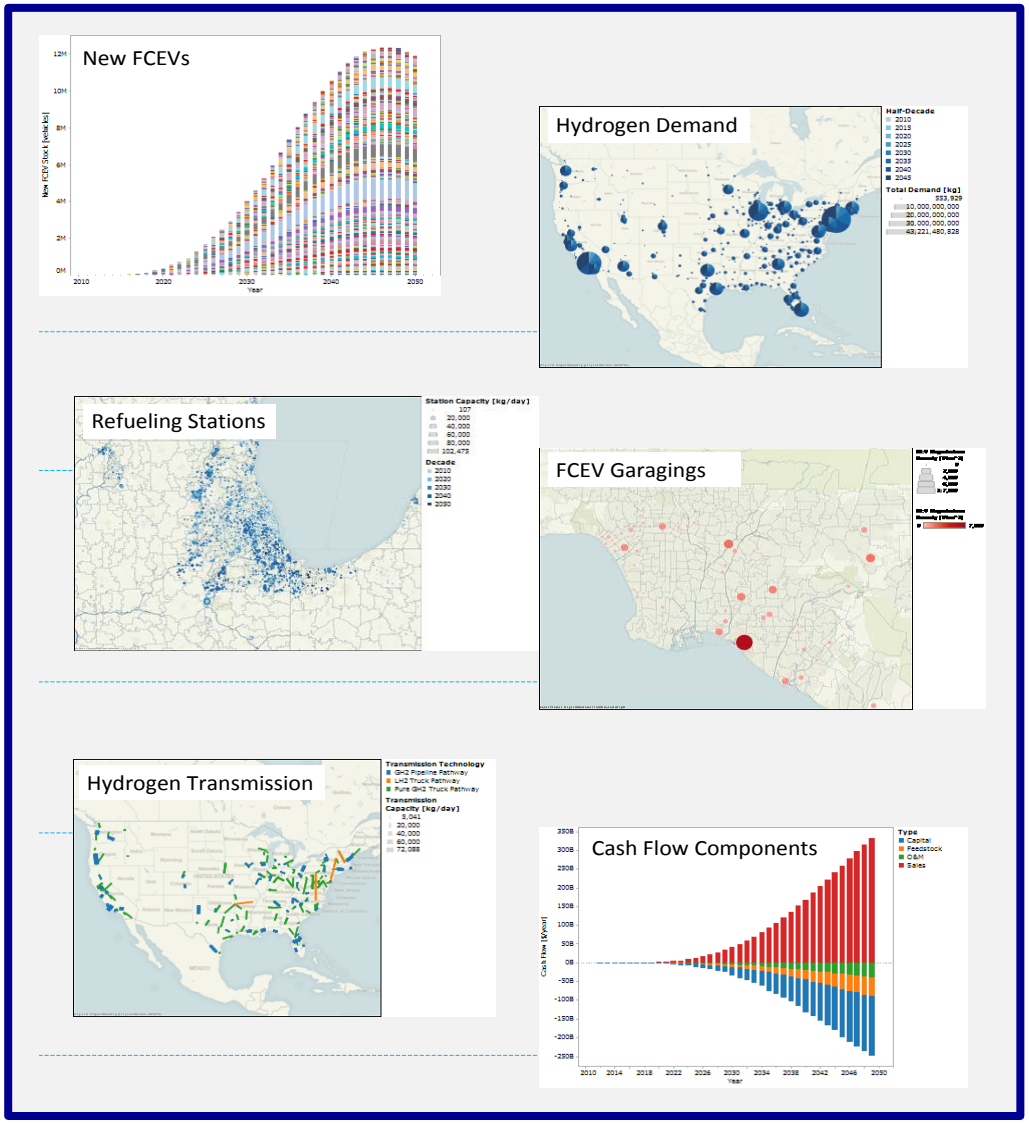
Opportunities clustered and ranked according to workshop attendee votes on priorities



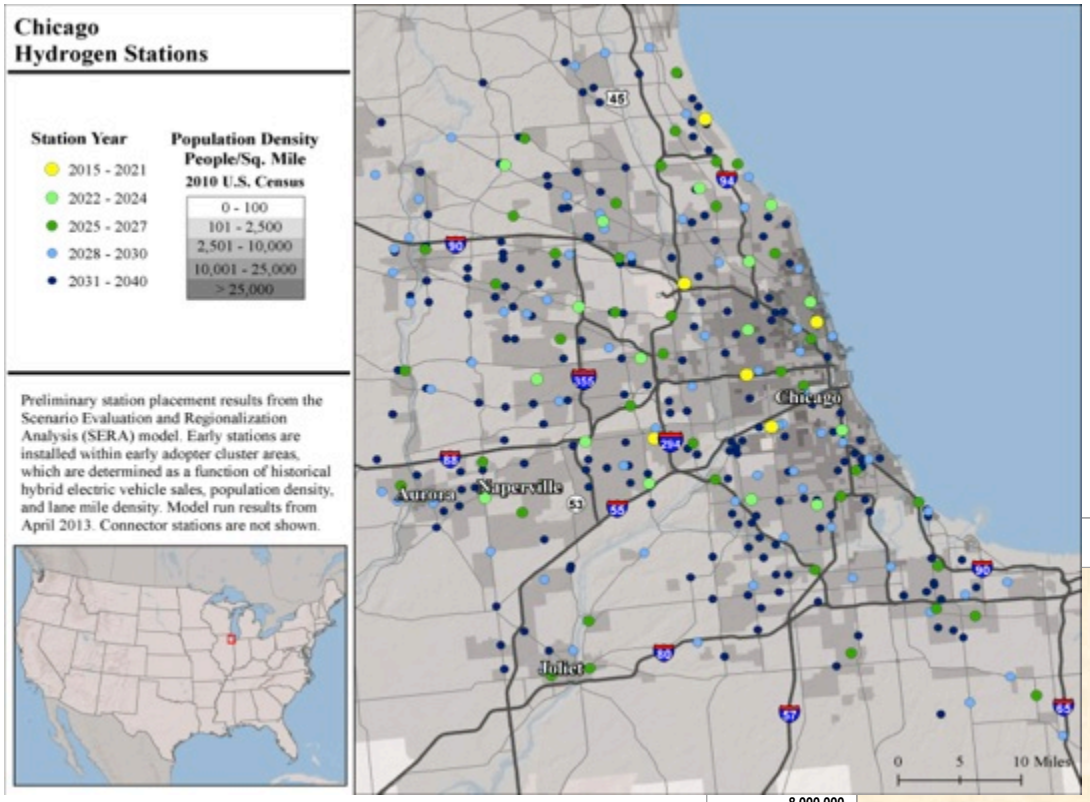
1) Station designs, 2), Streamlining of the permitting process, 3) Systems planning and analysis

Infrastructure Expansion Models Have Both Technical Detail and Financial Analysis Capability

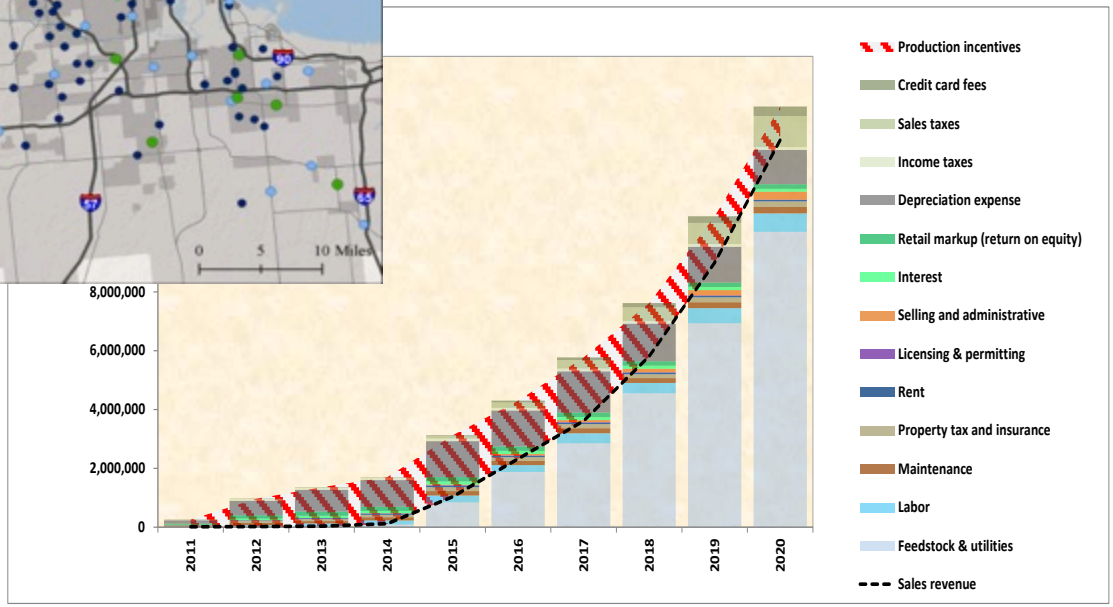
- Costs developed with "bottom-up" estimates at the component level, validated with real projects (CEC) and expert surveys
- Detailed spatial and temporal modeling across hydrogen supply chain
- Early adopter consumer data (demographics, etc.)



Station Placement Algorithm and Detailed Financial Toolkit



Early stations placed near early adopter clusters and network expansion to provide coverage



Detailed financial breakdown, including influence of incentives

HCC Results Are Consistent With U.S. DOE Models and Estimate from the UC–Davis Rollout Study

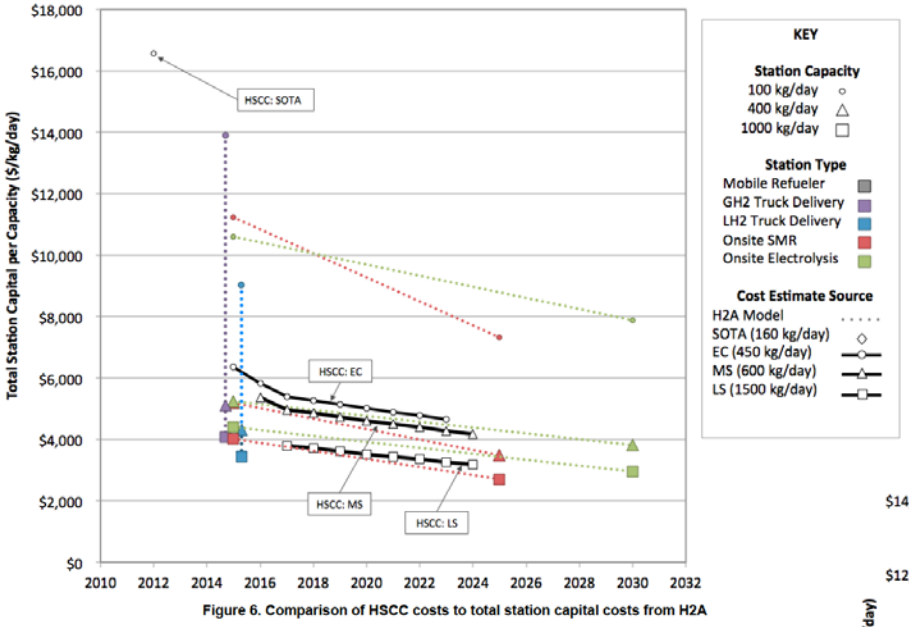


Figure 6. Comparison of HSCC costs to total station capital costs from H2A

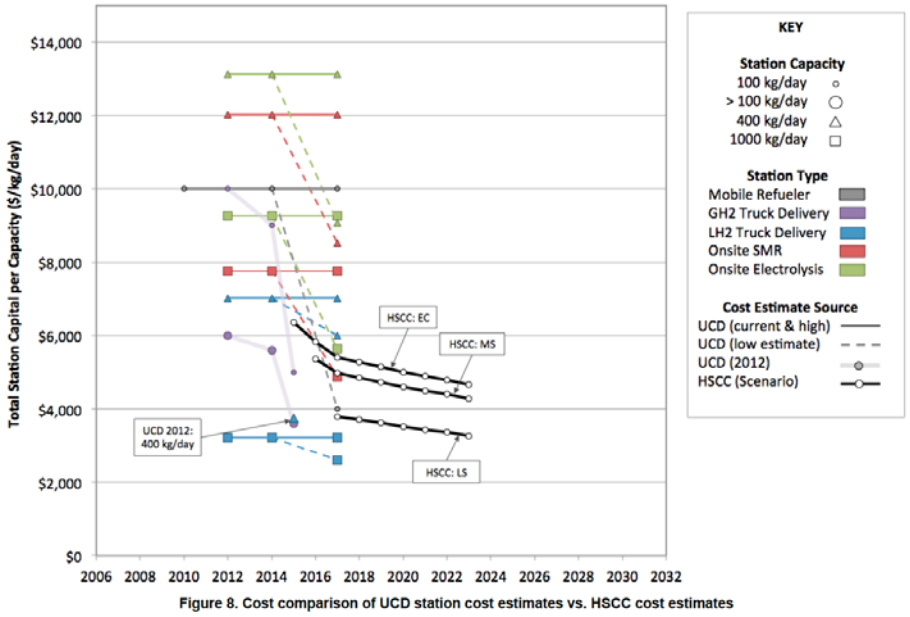


Figure 8. Cost comparison of UCD station cost estimates vs. HSCC cost estimates