DOE Hydrogen Program

Lessons Learned for Fueling Infrastructure

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Project ID #: AN9

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Overview

Timeline

Project start date:
January 2008
Project end date:
July 2008
Percent complete: 40%

Budget

Total project funding
$320 K (DOE)
Funding received in FY07
none
Funding for FY08
$320 K (DOE)

Barriers

Systems Analysis
A. Future Market Behavior:
"Another major issue is the hydrogen supply, vehicle supply, and the demand for vehicles and hydrogen are all dependent and linked."

Hydrogen Production
"Reduce the cost of hydrogen to $2.00-$3.00/gge (delivered) at the pump."
(Depends upon rollout strategy.)

Partners

Subcontractor: Energetics
Project lead: Marc Melaina, NREL

Objectives

- To collect and articulate lessons learned from past experiences that can improve future decisions related to hydrogen fueling infrastructure development
- Experiences to draw upon:
  - Ethanol, natural gas and other alt fuels for vehicles
  - Success with CNG vehicles in Argentina
  - Early development of the natural gas pipeline infrastructure
  - Recent expansions of gasoline station networks in key urban areas

Milestones

"Complete a "lessons learned" study of the development of other infrastructures which apply to hydrogen fuel and vehicles."

Systems Analysis Milestone #4 (2007 MYPP, p. 4-14)

Project Milestones:	(mo-yr)
– Complete draft of workshop proceedings	4-08
– Draft report on lessons from CNG in Argentina	6-08
– Draft report on lessons from early natural gas	7-08
– Draft report on spatial distribution of gas stations	7-08

Approach

Four Tasks

(1) Conduct a facilitated 1-day expert workshop

- Focus: AFV lessons for hydrogen refueling infrastructure
- April 3rd, 2008. Sacramento, California
- 13 speakers, 73 registered attendees

(2) Collect empirical data on success with NGVs in Argentina

- Collect detailed information on this success story
- Data sources: reports, publications, surveys and interviews

(3) Analogies to early natural gas infrastructure development

- Focus on installation of pipeline systems

(4) Spatial evolution of urban gasoline stations

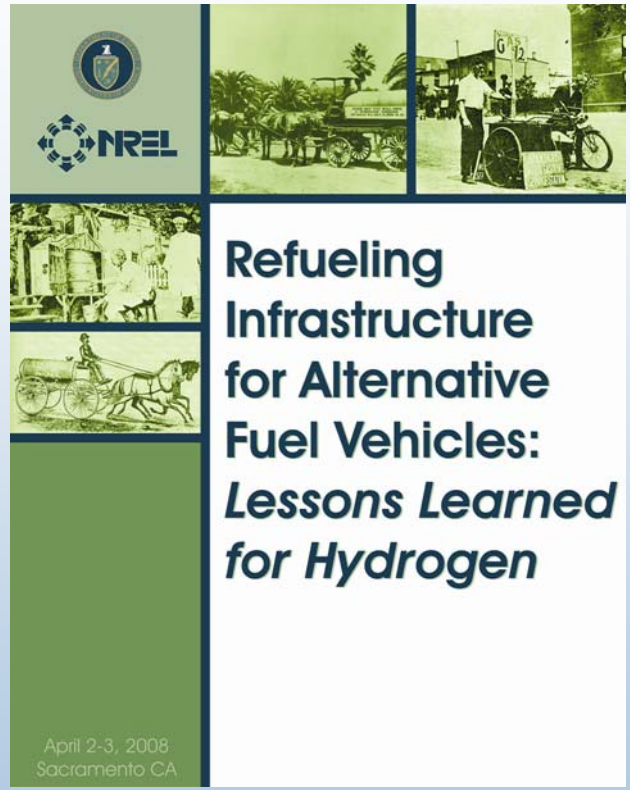
- Examine network expansion in response to population growth

Task 1 Results: Expert Workshop Presentations

- **Speaker Presentations**

  Three panels with short presentations

  - **Panel 1: Lessons from AFV Experience**
    - Marc Melaina, NREL
    - Stephe Yborra, NGV America
    - Joan Ogden, UC Davis
  - **Panel 2: Lessons from H2 Station Demonstration Projects**
    - Puneet Verma, Chevron
    - Dean Fry, BP
    - Analisa Bevan, CARB
  - **Panel 3: Innovation and Coordination**
    - Tim Gerlach, ALAMN
    - Britta Gross, GM
    - Catherine Dunwoody, CaFCP
    - Ulrich Buenger, LBST



Goal of presentations was to raise issues and stimulate discussion

Task 1 Approach: Collecting Expert Feedback from Breakout Groups

- **Facilitated Breakout Groups**

  What lessons have we learned about AFV refueling infrastructure, and how do we apply this knowledge going forward to do better with hydrogen?

  - Attendees were split into three groups
  - Each group met in two breakout sessions (morning and afternoon)
  - Prioritized actions and strategies in breakout session #1
  - Drilled down into top 5 priority items in breakout session #2
  - Reporter from each group reported back to plenary

Discussion among attendees during a breakout group

From left:
Catherine Dunwoody, CaFCP
Nicole Barber, Chevron
Jonathan Weinert, Chevron

Task 1 Results: Expert Feedback from First Breakout Session

Focus Questions #1:

- *What lessons are absolutely critical to pay attention to as we launch hydrogen refueling infrastructure efforts? What pitfalls must be avoided?*

Key Lessons Learned

Focus Questions #2:

- *Building on what we have learned from past efforts, what actions or strategies can we take to address these challenges over the next 10-20 years?*
  - *These were prioritized through a voting process*

Prioritizing Actions & Strategies

Task 1 Results: Drilling Down into Priority Actions and Strategies

Priority Actions & Strategies (examples)

- Coordinated national plan for hydrogen development
- Hydrogen co-production stations
- R&D on hydrogen stations
- Create same or better consumer experience as with gasoline
- Government sharing/limiting of liability
- Incentives for hydrogen
- Measured overbuilding of infrastructure
- Discover consumer wants and needs
- Government to evaluate and document station development costs
- Establish short and long-term commitments to H2 tech. development

Mark Ruth (NREL) reporting his group's drill down results to the plenary session.

Task 1 Results: Workshop captured discussions among a diverse and unique collection experts

Examples of discussion points

- Vehicle designs have shorter turnover times than station designs
- Just focusing on California will not build sufficient nationwide political support
- There is limited technical expertise for building H2 stations – this is a significant bottleneck to future station rollout plans
- 2010 is yesterday when we're talking about stations that take 2-3 years to install
- Large oil companies have little incentive to install stations
- The walkman doesn't look like the ipod: why do hydrogen stations have to look like gas stations?

Task 1 Results: Workshop Proceedings

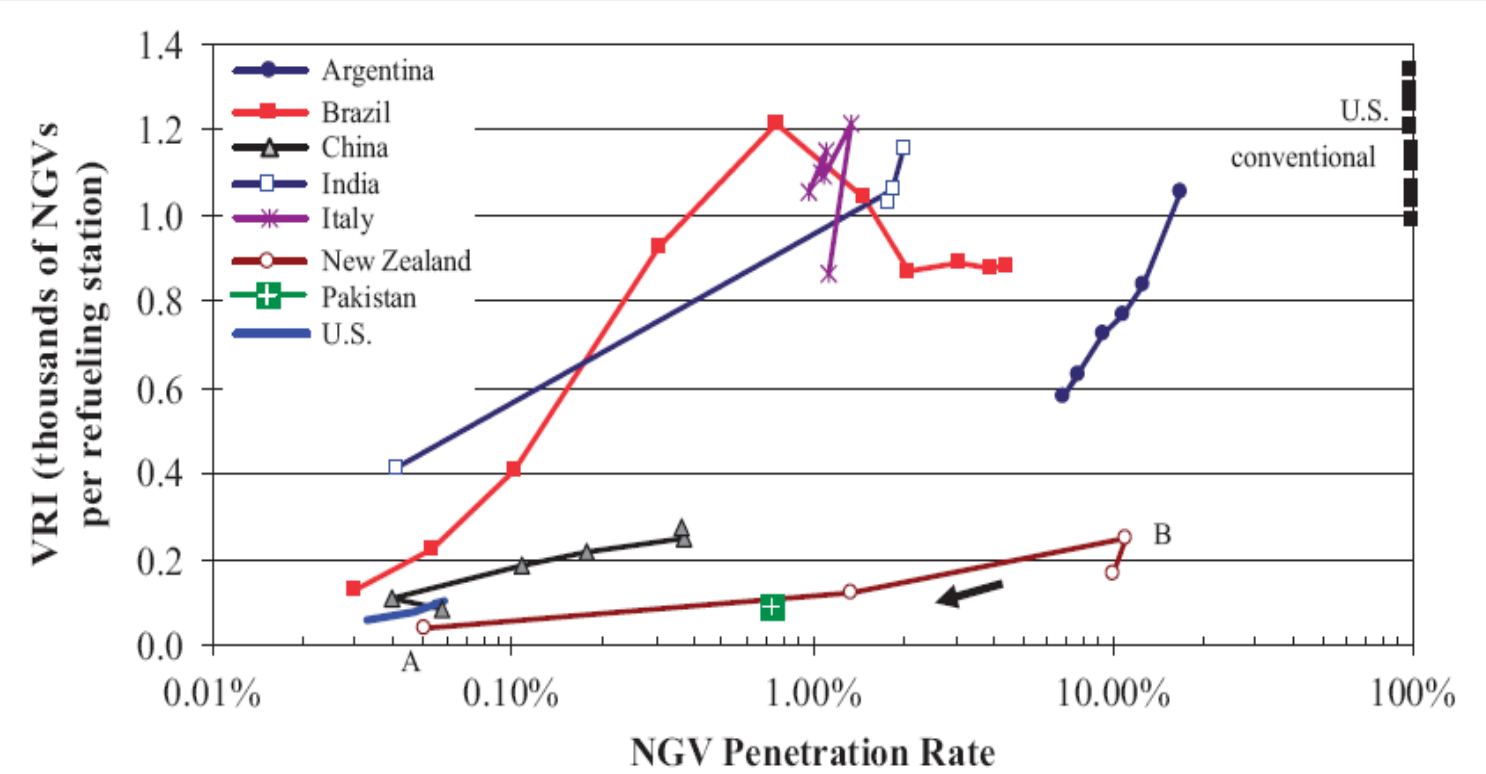
Using the proceedings as a means of acquiring additional feedback

- A draft of the workshop proceedings will be distributed to all attendees
- Attendees will have an opportunity to provide additional feedback to supplement the final workshop proceedings
- Final proceedings will be published as an NREL report

Graphic design provided by Energetics

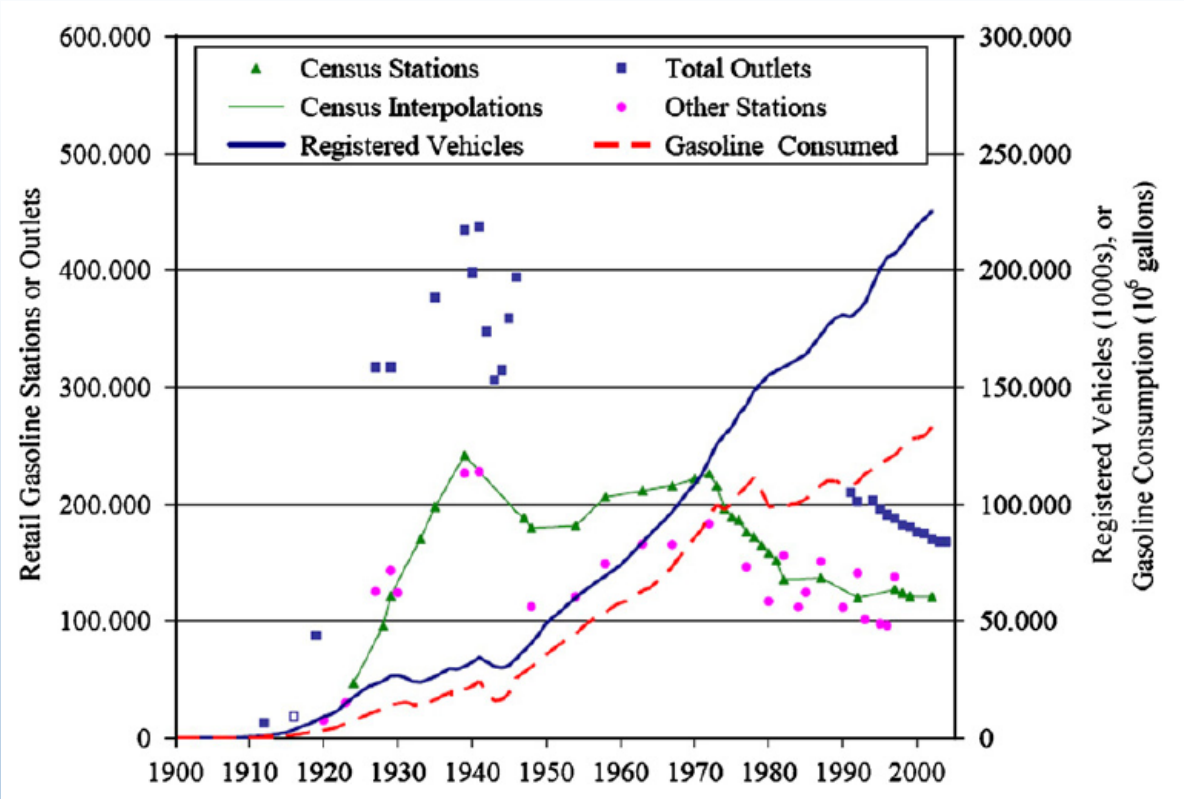
Task 2 Progress: Collecting empirical data on the successful introduction of NGVs in Argentina

- Status: Subcontractor proposal is being reviewed
- Data will be collected onsite, in Argentina, through surveys, interviews and compilation of available public literature



Yeh 2007, Energy Policy

Task 3 Progress: Literature review has begun on lessons from early NG industry



Research approach will resemble study of early gasoline industry

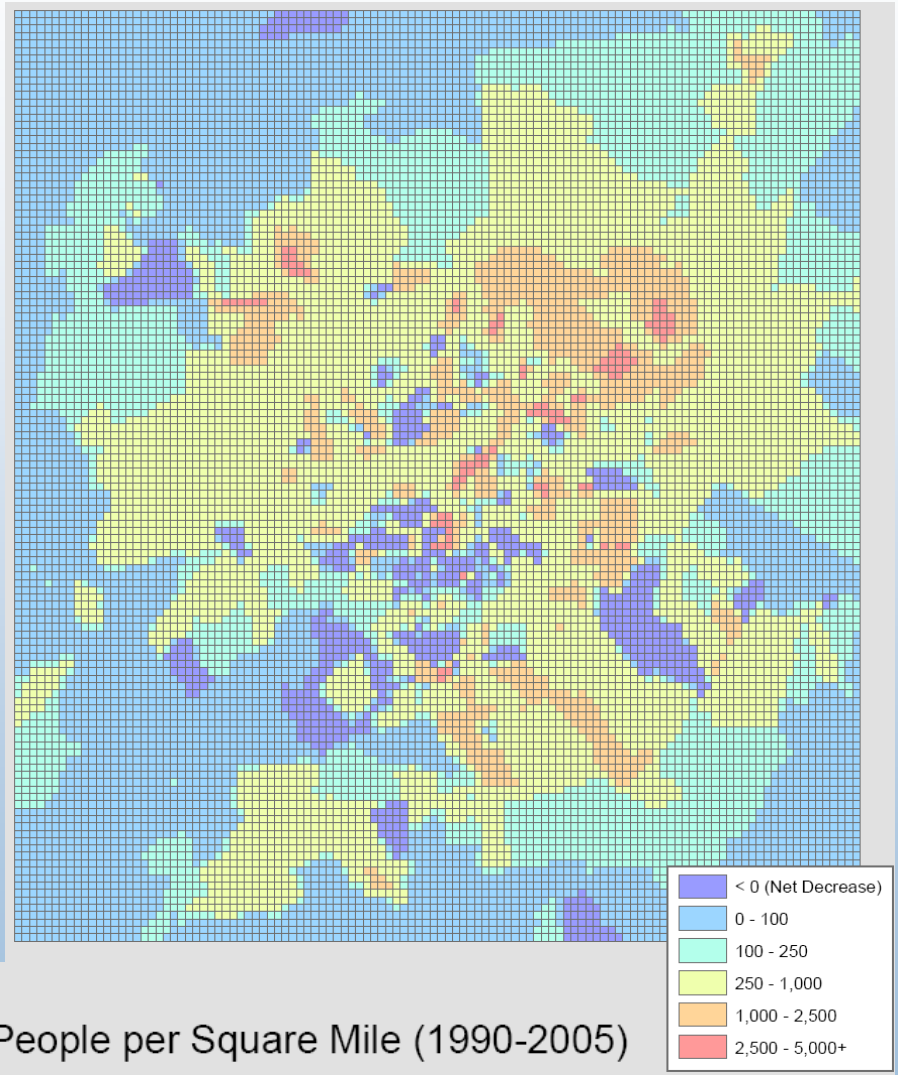
(Melaina, 2007, Energy Policy, 35: 4919-4934)

- "Non-station" methods preceded stations around 1900-1920:
  - Cans and barrels
  - Home refueling outfits
  - Hand carts
  - Curb pumps
- 10s of thousands of non-station outlets were in place ~1910

Task 4 Progress: Preliminary analysis of spatial gasoline station data has begun

Initial Research Questions

- How has the density of stations (stations/km2) changed in response to population changes?
- How has the density of gasoline demand (liters/km^2) changed in response to population changes?
- How do these trends vary among different areas within cities?
- Can common trends be identified among different cities?



Atlanta
Population Change in People per Square Mile (1990-2005)

Future Work

- Future Lessons Learned workshops (if desirable and/or funded by DOE) may focus on experiences with particular fuels:
  - Natural gas vehicle
  - Ethanol vehicles
- Alternatively, workshops may focus on other topics:
  - Adoption of new vehicle technologies
  - Energy transitions
  - Experiences with Clean Cities or other AFV programs
- Future lessons learned studies may:
  - Draw comparisons between early hydrogen and electricity infrastructures
  - Examine other international case studies (e.g., CNG in New Zealand or Italy)

Summary

- A variety of lessons learned from past experiences are being examined to gain a better understanding of current and future decisions facing hydrogen infrastructure development

The Lessons Learned Expert Workshop (April 3rd, 2008)

- Results from the Expert Workshop demonstrate both commonalities and differences among various stakeholders in terms of lessons learned and priorities for future actions
  - Different stakeholders learn different things from lessons learned from past experiences with AFVs
  - Past lessons can provide a common reference for discussing issues facing hydrogen today

Progress is being made on 3 additional tasks:

- Proposal to study NGVs in Argentina is being reviewed
- Literature review of early natural gas pipelines has begun
- Spatial analysis of gasoline station dynamics has begun