Electric Vehicles & Consumers

Stanford
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20 years of hands on studies on consumers & alternative fuels at ITS

• 1988  Diesels in California
• 1989-1990 Compressed Natural Gas Vehicles in New Zealand & Canada
• 1991-1996 Electric vehicles in Calif. (interviews, surveys and test drives)
• 1996-2001 Neighborhood EVs & City Electrics (Nissan Hypermini project)
• 2002-2004 Consumers & fuel economy decisions
• 2002-2005 Fuel cell vehicles and consumers (Toyota Highlander FCHEV)
• 2003-2006 Hybrid buyers studies (Ford Escape, Prius, Highlander, Honda Insight, Civic, Accord, Nissan Altima)
• 2007-10 PHEV drivers (national survey and converted Priuses in households)
• 2009-10 BEV drivers (BMW MINI E)
• 2010-12 BEV charging behavior with ETEC/Nissan in San Diego
• 2010-13 PHEV P-ups in SF city fleets, Chrysler
• 2010-12 BEVs in Shanghai (VW)
The biggest change in automotive design is electric drive & the historical nexus of climate change and oil security/supply.
“Nobody ever made a movie about Who Killed the Methanol Vehicle”

Shannon Arvizu, Columbia PhD student doing a sociology thesis on EV social movement.
BMW MINI E program is first major EV consumer experiment in US since Nissan Hypermini & RAV 4 EV (OK Tesla as well)

- 1-year lease at >$900/mo.
- In-home charging stations (no public charging)
- Out of 550 MINI Es worldwide, 450 in US
MINI E Household Samples

Non-UCD Sample
• 189 private households in LA and NY/NJ

UCD Sample
• 54 volunteers (44 LA /10 NY/NJ)
• Largely affluent - multi-vehicle households
• 47 men / 10 women: Mostly 35-55+ (3 younger)
• 1/3 prior MINI owners; 1/2 had hybrid experience; 1/4 had EV experience
• Many car aficionados, some green buyers
Data Collection Tools

**Non-UCD Sample**
- Online survey by BMW in June 2009 (n = 189)
- Online survey by UCD in October 2009 (n = 72)
- Journal entries
- Blogs
- Facebook

**UCD Sample**
- Phone interview (June 2009)
- Online BMW survey (July 2009)
- Online UCD survey (Sept-Oct 2009)
- Diaries, activity space maps, home interviews (Aug 2009-May 2010)
- Blogs & Facebook
Topics for today

• Response to drive feel
• Response to range limits (range anxiety???)
• Response to charging times and networks
• The human machine interface
• Response to environmental attributes of EVs

And, will EVs succeed in the market despite serious shortcomings and high costs?
Almost all drivers in our studies say they like the feel and sound of electric drive

- Drive test in Pasadena
- Hypermini test in Davis
- BMW MINI E project
• 84% (48) will use MINI E on daily commute
• 72% (41) say round trip will be between 0-55 miles.
• 8 said round trip between 56 and 110 miles.
• 35% stated they will use MINI E daily
• 58% say they will use 3-6 times per week.
Most users in UCD study want more range, but say they are satisfied with 100 miles

MINI E Range by driving condition (n=41)
Maybe 3 ways to characterize drivers travel patterns and range issue in BMW study

• 100 miles of range and home based charging easily covers all travel needs (1/3 sample)

• 100 miles of range covers more than 90% of their old drive patterns (1/2 sample), some minimal adaptations, add trips to EV

• Some drive at or near 100 miles weekly, must make adaptations like careful planning, charging at work, or elimination of trips (less than 1/3 sample).
Response to range limitations: Households reallocate household trips with MINI E

Below illustrates how households change…

In Person Interview Observations:

- Before Household receives their EV, each car performs a fairly routine set of trips labeled here as Trips w-z and Trips a-d
For some households, a small portion of trips cannot be done with the MINI E Primary reasons:
- Cargo/Passenger space
- Range
However, Trips are offset from the secondary vehicle *with* the MINI E when the opportunity is available as well as *extra trips* not taken before.

Reasons for this: MINI E is “fun” to drive, environmentally motivated, cheaper operating costs.

Note: Possible bias toward driving the MINI E often because it is a limited lease period.
We’ve seen individuals **expand** their MINI E range over time. Factors impacting this include:

- Driver experience of exploring the range of their car
- Reading and hearing others experience through social networks (facebook, blogs, MINI E gatherings)
- Public Infrastructure
MINI E drivers do more trip planning much more than with gas vehicle

- Google maps used by many households to plan a long day
- Drivers learn distances to work, to store, to family
- Drivers learn terrain (hills, etc…)
- Becomes a game to many drivers (not all)
HEV energy displays and HEV influence driver behaviors and change their experience of fuel economy

- HEV owners spend lots of time looking at screen in first year
- HEV owners show researchers the screens, not the engine
- HEV owners understand and “value” their vehicle through their instruments
- HEV owners learn how fuel economy varies over speed, terrain, weather

Tai Stillwater, PhD student
New user interfaces are designed by UC Davis to explore the new fuel economy.

- **Real time cost per mile:**
- **Real-time CO2:**
- **Trip, daily and total average fuel economy**
- **Electricity & gasoline use compared over time, distance, journeys**
Eco-Driving Interface Based on the Extended Model of Goal Directed Behavior

- Goal Desires
- Attitudes & Expected Emotions
- Social Norms
- Personality Factors
- Goal Desires
- Perceived Behavioral/Goal Control (PBC)
- Roundtrip MPG+
- My Goal
- Current MPG+
- Battery Charge: 88%
- Past RTs
- Peer RTs
- This RT

< Last Mile >
MINI E Drivers develop new relationship to dashboard displays

• Watch “level of battery and miles to go.
• Some watch “regenerative display”
• Would want “integrated GPS system”
Charging at home meets most needs

• Predominantly nighttime

• Enjoyed feeling of independence, not visiting gas stations, stability of electricity rates

• Most didn’t take advantage of possible workplace charging – not sure about “rules”
Will a public charging network expand EV market?

• As we note, in many cases we find 90% of charging will probably be done at night where the vehicle is parked.

• Night-time charging brings the best benefits to power company capital and in some cases emissions.

• Drivers in Berlin don’t seem to be using public network, some result from 1990s demos (La Rochelle and Mendrisio)

• Fast charging - 80% in 20 minutes - how much does this solve limit of EVs
Environmental Attitudes among MINI E drivers in USA and Germany

- Few in UCD sample believe in climate change or have it as primary concern (very different in Berlin sample)
- In interviews, most concerned about local air quality (Los Angeles in particular)
- A few concerned about battery toxicity
- Lots of uncertainty about impact on CO2 emissions – changing source of emissions (LADWP, SCE) again Germans due to choices have better feel for emissions in power sector
- Stronger interest in fuel security than Germany
How big is market for EVs?

- In 1995, after 4 phases of studies
  - Study of EV pioneers
  - Drive test with 200 households in Pasadena comparing CNG, methanol, and EVs
  - In depth study travel behavior (with diaries) and household interview
  - Statewide survey of 550 new car buying Californians (4 staged mail out survey)
  - And these assumptions:
    - EVs available in mini-mid sized autos
    - With ranges from 60-120 miles
    - At prices not too much higher than ICE (up to 2000 more)
  - Concluded a market of around 15% of new car sales in California
Concluding conundrum……

Very positive response to EV1, MINI E, Hyper MINI.

EVs seem to result in an integrated social expressive, psychological, cultural, technical combination….

It seems that EVs in many ways are the perfect “green” product...expressive and

But EVs remain less practical and expensive..

What will happen?
Change happens: Japan’s market shifted radically last year

Prius now best selling non-K car in Japan most of 2009, Honda Insight was best selling earlier in year

March 2010 = 37,000

30,000

Date: JADA