Political Economy and the Hydrogen Revolution
ver 1.0

David G. Victor
Thomas C. Heller & Nadejda Victor

Program on Energy & Sustainable Development
http://cesp.stanford.edu/pesd
Three Topics

1. Rates of Change
2. Incumbents Fight back
3. Niche Markets
Hydrogen and Its Competitors

USA: Prices for Major Fuels and Energy Carriers, 1970-1999

1996 Dollars per GJ

- Hydrogen
- Retail Electricity (Industry prices)
- Gasoline
- Jet Fuel
- Oil
- Gas
- Coal
1. Rates of Change
Slow Evolution:
Primary Energy Systems
Evolution of Infrastructures

- Canals
- Telegraph
- Oil pipes
- Roads
- Gas pipelines
- Railroads

Million Miles

Percents of saturation

1800 1850 1900 1950 2000

1830 1850 1870 1890 1910 1930 1950 1970 1990
Causes of Slow Diffusion

• Network effects lock out early stages
  – co-location and co-evolution of infrastructures can speed diffusion
  – Niche markets are essential
• Numerous complementary innovations required
  – Infrastructure and end user
  – Organizational (e.g., methods of production)
  – Social (e.g., finance)
  – Professional (e.g., training)
• Political coalitions difficult to form
  – Trial and error; not perfect information
• Regulatory frameworks
  – Vital; yet often poisonous
2. The Empire Strikes Back
Sources of Political Power

• Determinants of Political Power
  – Value-added (jobs, dollars)
  – Concentration of Interests
  – Organization of Interests

• Concentrated, well-organized incumbents versus diffuse, hypothetic and unknown new entrants
Output of the U.S. Hydrogen Industry

[Diagram showing USA Hydrogen Production, 1971-1998]

- Hydrogen Price (96'US$ per Thousand Cubic Feet)
- USA Hydrogen Production (Trillion Cubic Feet/year)

Key dates and milestones:
- 1971
- 1974
- 1979
- 1984
- 1987
- 1991
- 1994
- 1998

- 1 Billion '96US$/year
- 0.5 Billion '96US$/year
- 0.1 Billion '96US$/year
Uses of Political Power

• Legislative and Regulatory Retaliation
  – “Red Flag Act” (1865)
    • Repealed for small vehicles (1895)
      – Automobiles (< 3 tonnes)
      – Locomotives
    • Automobile Club formed (1897)
    • Road signs (1904)

• Stigmatization
  – Edison against gas light
  – Edison against AC
Three Responses to the “Hydrogen Threat”: 1

- Electrification
  - Carbon rules likely to hit electricity hard
    - Response: carbon sequestration and possibly nuclear power
  - Eliminates carbon from electricity; allows steep reductions in industry and households through electrification
  - Transport emissions reduced, in parallel, through energy efficiency (hybrids, etc.)
  - Nothing left for hydrogen
Electrification of Industrial and Post-Industrial Societies

U.S. Primary Energy

Primary

Input to Electricity

Nonelectric Energy

million tonnes oil equivalent

0 500 1000 1500 2000 2500


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Three Responses to the “Hydrogen Threat”: 2

• Pipeline Safety
  – Will hydrogen pipelines and storage be easier to site than gas pipelines?
  – Rights-of-way available for hydrogen
    • Perhaps 1/3 of gas pipelines usable for H₂
  – BUT, will neighbors allow it?
  – Analogy: LNG sites
Three Responses to the “Hydrogen Threat”: 3

• Incumbents Get Efficient
  – Analogy: Clipper Ships vs. Steam Ships
  – OPEC’s response?
chart of crude oil prices since 1861

US dollars per barrel

World events

- Russian oil exports begin
- Sumatra production begins
- Pennsylvanian oil boom
- Discovery of Spindletop, Texas
- Fears of shortage in USA
- Growth of Venezuelan production
- East Texas field discovered
- Post-war reconstruction
- Loss of Iranian supplies
- Suez crisis
- Iranian revolution
- Yom Kippur war
- Netback pricing introduced
- Iraq invaded Kuwait

1861-1944 US average.
1945-1985 Arabian Light posted at Ras Tanura.
1986-2001 Brent spot.

bp statistical review of world energy 2002
World Oil Production: 1965-2001

Million Barrels Daily


Former Soviet Union
Russia
Non-OPEC
OPEC
Members of the $\text{H}_2$ Coalition?

- Environmentalists?
- Gas companies?
- Coal companies?
- Automobile producers?
- Electric power generators?
3. Niche Markets
Abuses and Uses
Why We Care About Niches

[Graph showing the cost of Photovoltaics (learning rate ~ 20%), Windmills (US) (learning rate ~ 20%), and Gas Turbines (US) (learning rate ~ 20%, ~10%) over time with cumulative MW installed.]
Abuses: Blind Assertions of “Learning”

Hydrogen Niches: Transportation

- Mass Market Automobiles
  - Unlikely due to “lock out”
- Fleet Vehicles
  - Cutting-edge Firms
    - CNG Experience
  - Noise-sensitive communities
    - More important than air pollution?
- Ships (Farrell et al.)
  - Professional crews; located near H₂ source; regular routes
- Aircraft
  - LH₂ properties; supersonic and hypersonic
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