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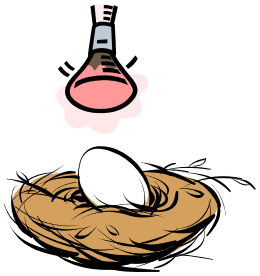
Hydrogen Industrial Trucks

DOE Hydrogen Technical Advisory Committee

Aaron Harris Oct 2010

Nurturing Products to the Market



- Fuel Cell and hydrogen generator development initiatives.
- Research studies to evaluate, predict possible impact of technology.
- Policy activities to coordinate support

Development

- Sponsored projects to prove technology in applications

Demonstration

- Research to troubleshoot roadblocks
- Industry advocacy to coordinate industry partners (standardize)

- Incentivized market to promote commercial sales
- Research to advance and ensure safety
- Industry groups assume responsibility for standards

Deployment

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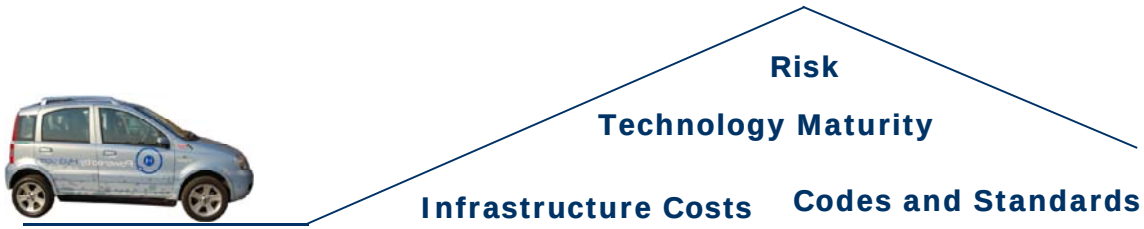
Meeting the Goals

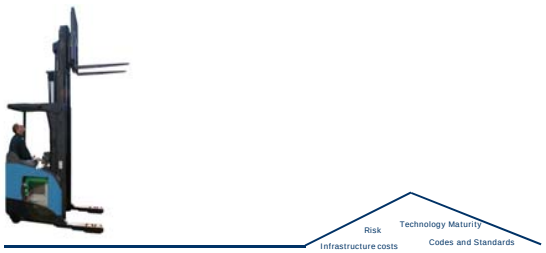
2002 National Hydrogen Energy Roadmap Goal:

"Coordinate 4 industrial segments (Production, Delivery, Storage, Application) as one system"



Keys to Success:

- Captured Fleets
- Field Experience
- Simplified Infrastructure



What is the hydrogen industrial truck market?

Captured Fleets – 1 warehouse = 10's – 100's vehicles

Field Experience – High volume warehouses run 24/7

Simplified Infrastructure - Single storage feeds multiple refueling sites

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Experience in Code and Standards

If codes and standards development relies on **experience**…
then industrial truck markets provide substantial experience.

Automotive Hydrogen Use

- 70-90 Million new cars/year
- 4-7 kg storage , 300 miles/fill, 1-2 fills/week…
- 8-10 kg per week per vehicle
- 0.5 - 1 kg/day
- **300-500 kg in 25 year life**
- Current US Vehicle Fleet: 300-400 vehicles

Industrial Truck Hydrogen Use

- 0.2 Million new industrial trucks/year
- 1-2 kg storage, 15-20 fills/week…
- 40 kg per week per vehicle
- 3-4 kg/day
- **4000 – 6000 kg in 10 year life**
- Current US Vehicle Fleet: 1000+ vehicles

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‘Niche’ to ‘Broad’ Market Comparison

Similarities

Engineering Development - fuel cell/battery hybrid vehicle systems, high-pressure hydrogen storage, regenerative braking, “Fuel Cell Range Extenders”

Safety - storage vessel performance, leak detection strategies, impact detection strategies, refueling

Codes and Standards Gaps – end of life control, aftermarket, consumer product vs. industrial use

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Differences

Engineering Development - weight, tank size and pressure, power requirements, vehicle integration, indoor fueling

Safety – driver training, regulatory agency

Codes and Standards Gaps – use type 1 tanks, indoor refueling standards

Hydrogen Warehouse

Hydrogen meets the end-user's goals:

- Increase productivity
- Optimize floor space
- Optimize energy costs
- Improved corporate image

Proven fuel cell advantages:

- Refueling vs. Recharging
- Replace indoor battery charger with outdoor On-Site generation and storage
- On-Site Generation = on-demand generation
- "Green", Retail brand names associated with national energy/security policies

Component Introduction

1. Onsite Hydrogen Generation
2. Outdoor Compression and High Pressure Storage
3. Indoor Dispensing
4. Battery replacement in existing electric forklifts

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Current Status (Published Docs in bold)

Industrial Vehicle

Forklift
NFPA 505
UL 583
UL 2267
(Integrated FC system)

Indoor Dispenser

Dispenser
NFPA 52
HGV 4.3
HPIT 2

Indoor
Refueling Guidelines
NFPA 52
HPIT 2

Fuel Cell Power System
UL 2267

Fuel Cell Power System
(Battery Replacement)

350 Bar Fueling Receptacle/Nozzle Pair
SAE J2600

Dispenser Component Standards
Hose – HGV 4.2
Breakaway – HGV 4.4
Priority and Sequencing – HGV 4.5
Manual Valves – HGV 4.6
Automated Valves - HGV 4.7

Fuel Cell System Components
Energy Storage – Batteries, Ultra-Caps
Regenerative Braking Dissipation
H2 Detectors/ Proof of Ventilation
Fuel Cell Stack and BOP

Hydrogen Pressure System
SAE J2919

Hydrogen Pressure System Components
CSA HPIT 1
- Cylinders, valves, fittings, tubing

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Defining the Gaps

Overall Assumptions

- No one would want to put a steel tank on a vehicle
  - Forklifts use batteries as the counterweight
    - Therefore steel tanks are feasible
  - Steel tanks: low tech, low cost, fast fill w/o strict temp compensation
- Niche markets will not grow faster than automotive
  - Current deployments: 200 - Cars 1000 - Forklifts
- Refueling cycles are not a concern
  - Cars = 1800 cycles in 20 years Forklift = 10,000 cycles in 10 years
- Refueling standards are sufficient for all markets
  - Indoor Fueling
  - Use of the same nozzle/receptacle

Defining the Gaps

Specific Gaps

- No available tank standard sufficient for the application
  - UL 2267 - 2006 – 4 tank standards referenced:
    - ASME BPVC Section VIII
    - DOT - subsequently interpreted as DOT 3AA
    - NGV2 – no HGV2 at publication
    - ISO 11119-1
  - Cycle fatigue phenomena and high cycle use application
- UL2267 – removable cylinders allowed
- UL 2267 - No link to component level or refueling standards
- HGV2 only applies to on-road vehicles
- NFPA 52/HGV 4.3 - Insufficient guidelines for safe dispenser function

Addressing the Gaps

Industrial Vehicle

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Acknowledge the Support Network

Consider, in 1 year…

- Testing programs at National Lab coordinated with Industry
- Changes affecting approximately ~15 documents
- Coordinating various entities to generate those documents:
  - Fuel Cell Companies
  - Industrial Truck OEMs
  - Industrial Gas Suppliers
  - Code Development Organizations
  - Department of Energy
  - National Laboratories

How did we get here…

- Identified Gaps through DOE sponsored pool of experts (HIPOC)
- Discussed in DOE sponsored monthly coordinating call (USFCCSC)
- Continued planning through USFCC as a DOE contractor (USFCC)
- Identified need for testing, supported by DOE (H2 Safety Panel)
- Test Planning (DOE, Sandia, Plug, Nuvera, Norris, CSA)
- Ongoing Standards development (UL2267, CSA–HPIT1, SAE J2919)

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Open Technical Items

Counting Fill Cycles

- Cyclic fatigue concerns requires close monitoring of fill cycles on each tank

Decommissioning Tanks At End of Life

- Regulation and the aftermarket

Cylinder Handling

- Design and manufacture only as good as the installation

Escapee Scenario

- Use of SAE J2600 Nozzle/Receptacle for two separately regulated markets
- Forklift refueled at retail gas station
- Car refueled at warehouse or industrial truck fleet fueling station

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Open Market Items

Codes and Standards Harmony and Implementation

- Harmony - UL 583, UL 2267 and NFPA 505
- Implementation – Comprehensive revision to UL2267 to reflect industry standards
- Implementation – Interpretation issues with “new” separation distance tables in NFPA

Government Policy / Codes and Standards Interaction

- Regulatory Parent Agencies and Involvement
    - Industrial Trucks – OSHA – Dept of Labor
    - Automotive - FMVSS – Dept of Transportation

Certification and Customer Confidence

-Hurdle for small companies to pursue certification of not yet proven product

- Certification path not yet clearly defined
- Difficult for customers to trust uncertified products
- Less diverse customer base (not as many enthusiasts)
- Customers need gentle nudge to field new technology

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