“Dedicated to The Continued Education, Training and Demonstration of PEM Fuel Cell Powered Lift Trucks In Real-World Applications”

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Project ID# : ed008

“This presentation does not contain any proprietary, confidential, or otherwise restricted information.”

Overview

Timeline

- Start - 9/1/2008
- Finish - 8/31/2011
- Complete as of June 2010:
  Deployment 92% / **Education** 58%
  Overall: 72% Complete

Budget

- Total project funding
  - DOE share: $ 820,272
  - Contractor share:
    $ 385,273
- Funding Received:
  FY2008: $ 386,000
  FY2009: $ 434,272
  FY2010: $ 0

Barriers

- Barriers addressed
  A. Mixed Messages for Education
  B. Product Performance / Limited Model Availability
  C. Infrastructure cost / justification

Partners

- Hydrogenics:
  "HyPx Fuel" Cell Power Pack Manufacturer, serving as subcontractor for FCPP and providing technical support

Hydrogen Education / Deployment of Fuel Cell Powered Lift Trucks: *The LiftOne Program Objectives /Relevance*

- *To educate a broad group of stakeholders to the benefits of fuel cell and hydrogen technology* by conducting "H2 – Education Seminars", which have taken place over the past year at: a)All LiftOne branch locations; b) Selected lift truck user sites; c) Professional organizations' meetings; d) Local community colleges; e) Two participating 1st responders' facilities.
- The demonstration of *"clean energy"* through the execution of a series of six (6), one-month long deployments of 2 each hydrogen fuel cell powered lift trucks at strategically selected, large electric fleet user locations across the LiftOne territory. 5 of the 6 deployments with these major companies were completed as of mid-April, with 1 site remaining.
- *To further assist in the commercialization of fuel cell and hydrogen technology* through the longer and geographically diverse deployments in *real-world* applications. In process!

Project Approach

- The ***Education Segment*** involves day-long H_2 seminars, conducted at the various LiftOne Branches. 2-3 sessions are held per month, with an average of 12-15 attendees from companies with varying material handling fleet sizes.
- Each session has included a working fuel cell powered lift truck demo on site, a key towards attracting attendees.
- Technical information is provided for the many maintenance oriented attendees, through "hands on" inspection of the fuel cell power pack's components and a demonstration.
- The Education Segment's reach has been expanded and increased H_2 Awareness over the past year:

NACAT Annual Conference

NC Trucking Assoc. Council

BMW H_2 Fuel Cell Expo

Michelin Tire Corporate "Green Day"

American Textile Engineer's Society

Kannapolis-Concord Fire Department

Columbia, SC: "Green is Good For Business" Expo

Project Approach- Continued

- The content of the Education Session has been revised to include deployment data as it is made available, along with updated cost / value proposition data.
- Plans have been made for the H_2 Education sessions to be given through webinars conducted at major corporations with multiple locations *(i.e.…Ingersoll-Rand).*
- The ***Deployment Segment*** has included the program's 2 CAT lift trucks being put into service with the Hydrogenics "HyPX" series Fuel Cell Power Packs, and on-site Hydrogen refueling with the Air Products model HF-150 mobile fueler.
- The Deployments have involved mandatory orientation sessions for all operators and facility personnel. H_2 safety and hands on fueling instruction / operation is covered by LiftOne and Air Products. Sessions conducted for all shifts.
- Local fire departments are invited and have participated.

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Education / Deployment Milestones

Month / Year	Milestone or Go/ No-Go Decision
May - June / 09	**Milestone:** Successful execution of the first Deployment of the 2 HyPX - FCPP powered CAT® lift trucks at Stanley Tools in Concord, NC. The subsequent data analysis, post deployment review meeting with results and value proposition were conducted with the deployment site's top management.
June - December /09	**Milestone:** Continuation with the next 3 deployment sites, which included a large North Carolina Distribution Center of a major retailer; Bausch & Lomb and BMW (Both in the Greenville, SC area). The data analysis, and review meetings followed.
Feb - March / 10	**Milestone:** Execution of Deployment site # 5 - Electrolux in Anderson, SC. The trial went well, with the analysis completed and the Review Meeting scheduled for late April.
April / 10	**Go / No-Go Decision:** Delayed start of the last (6th) site - Michelin Tire in Lexington, SC. Due to production slow downs and ramping back up between mid-2009 and early 2010, Michelin had asked to be the "last" site. This deployment will not commence until late April / early May as of the time of this presentation's submission.
June / 09 - May / 10	**Milestone:** Further Development of the LiftOne H_2 Education Seminars and conducting at LiftOne Branches, the NACAT Annual Conference at Central Piedmont CC, several NC Trucking Maint. Council Meetings, American Textile Engineering Conf.. Working fuel cell powered lift truck present at each.

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Technical Accomplishments / Progress

Deployment Program

- Decent overall performance results from the 5 Deployments conducted over the past year. Some technical issues occurred, resulting from component parts failure on the Fuel Cell Power Packs. Site 2 in particular was not as successful as was hoped for.

Site # 1 - Stanley Tools - 30 days ran
* Truck / Cell #1 ran 300 hrs
* Truck / Cell #2 ran 230 hrs
* 89 kg of H2 used / 96 fuelings
* 5 minutes average fuel time
* 6.3 hrs avg run time per tank (1.6kg)
Notes: 1 defect with pump impeller
Straight forks - sideshifter application
Operators liked performance but the
heat exhaust in summer was a minus.

Site # 2 - "Company ABC" - 25 days ran
* Truck / Cell #1 ran 240 hrs
* Truck / Cell #2 ran 118 hrs
* 109 kg of H2 used / 89 fuelings
* 3.6 minutes average fuel time
* 5.3 hrs avg run time per tank (1.6kg)
Notes: Several repairs (see below)
One truck w / clamp, One with forks
Trucks ran OK, the high amp spikes
from clamp function was a factor. Heat.

- Site 2 issues were: A) water pump failure on 2 FCPP; B) pressure regulator; C) purge valve failure. D) Pump valve blade failure.

- *The designed safety mechanisms did work and shut down the FCPP. The manufacturer has redesigned the components to avoid repeats.*

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Technical Accomplishments / Progress continued

Site # 3 - Bausch & Lomb - 22 days ran
* Truck / Cell #1 ran 34 hrs
* Truck / Cell #2 ran 45 hrs
* 24 kg of H2 used / 22 fuelings
* 2.7 minutes average fuel time
* 5.3 hrs avg run time per tank (1.6kg)
Notes: No defects experienced
Straight forks - sideshifter application
The lightest application. Trucks worked
well - hours were not high.

Site # 4 - BMW - 23 days ran
* Truck / Cell #1 ran 165 hrs
* Truck / Cell #2 ran 190 hrs
* 71 kg of H2 used / 62 fuelings
* 2.6 minutes average fuel time
* 8.0 hrs avg run time per tank (1.6kg)
Notes: Best deployment of all 5
Straight forks - sideshifter application
Trucks ran great. Fantastic run time.
Trial went well…moving forward.

Site # 5 - Electrolux - 22 days ran
* Truck / Cell #1 ran 160 hrs
* Truck / Cell #2 ran 140 hrs
* 76 kg of H2 used / 73 fuelings
* 2.8 minutes average fuel time
* 6.5 hrs avg run time per tank (1.6kg)
Notes: 2 fueler issues corrected
Straight forks - sideshifter application
Another good trial with no problems.
Decent hours run. Operators liked.

Very good results from sites #4 and #5. Site #4 has a strong possibility to acquire a significant number of fuel cells and our involvement with the deployment was a critical factor for this determination.

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Technical Accomplishments / Progress continued

Education Program

In addition to the "Hydrogen 101" information presented at the LiftOne Education Seminars, the "real world" material handling application data and cost exercises proved particularly interesting to the attendees.

INFRASTRUCTURE COMPARISON / HARD LINE COSTS BATTERY vs H2 * with batt / chrg & H2 3 shift Operation - Annual / 5 year Analysis 40 trucks - Class 1 sit downs		
Assumption: 3 shifts per day / 7 days per week 10 holidays (350 days per year)		
36 / 48 V Batteries	Item Description	Hydrogen Fuel Cells
$164,000	40 Chargers @ annual rate of $ 4,100 each for the electricity	
$187,200	Cost of 3 batteries / 1 charger per truck = $ 23,400 x 40 = $ 936,000 / 5 years	
$210,000	Dedicated personnel to staff battery room & change - 1 dedicated per shift @ $70,000 per	
	person (burdened rate - low). Includes watering	
$37,500	Battery storage / charging / changing room 2,500 sq ft x $ 75 = $ 187,500 / 5 years	
$5,000	Battery changer maintenance averages $ 5,000 per year	
	Hydrogen Infrastructure: Includes all equipment for storage, compression, dispensing,	$258,000
	installation & maintenance	
	H2 supply during year: Calculated at 4 kg @ $ 7 per kg / per truck / per day = 1400 kg per year	$392,000
	per truck. 1400kg x 40 = 56,000 kg of H2 per year @ $ 7 per kg.	
$603,700	ANNUAL TOTAL	$650,000
$3,018,500	5 YEAR TOTAL	$3,250,000

Technical Progress - Equipment

CAT® Model E5000
Class I – 48v lift truck

Hydrogenics Model
HyPx1-33, Fuel Cell
Power Pack

Air Products Model
HF-150 Mobile Fueler

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Future Work

Activities For Next Fiscal Year

1. Continue with Education Seminars

- Broaden scope of attendees to include some webcast opportunities that have been discussed with companies.
- Bringing the Education Session on the road to customer sites. This would be beneficial, since the many users have already attended.

2. Continue with the Deployments (as needed)

- The 6th (and final) Deployment site was to commence by late April or early May. A review meeting would be conducted during June.

3. Publicize The Program and The Successes

- Continue to use the local media and trade publications.

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Summary

- The LiftOne Education Seminars have been comprehensive and effective in increasing hydrogen awareness among the commercial communities in the LiftOne geographic regions.
- Reaching out to users through a variety of avenues has been a solid method utilized and will continue to be over the next year.
- The course has been condensed when needed to be able to be presented in confined time slots. These have been effective.
- The cost equation to convert from batteries to fuel cells remains a major obstacle that has to be overcome.
- The LiftOne Deployments have provided excellent opportunities for several major companies in NC and SC to test the clean power fuel cells offer – while examining cost possibilities.
- Deployment Grades: **Site 1 (Stanley Tool): A** **Site 2 (Dist Center): C-**
  Site 3 (Bausch & Lomb): B **Site 4: (BMW): A**
  Site 5 (Electrolux): A
- ***Note that Site 4 is leaning toward a full fuel cell fleet – LiftOne had a role in this.***

Collaborations

Working closely with us:

- Partnering with LiftOne for this project as a subcontractor, Hydrogenics has been instrumental as manufacturer of the HyPX series Fuel Cell Power Packs used for the Deployments.
- Also, for interpreting the data and providing on site technical support when needed.
- Leading the efforts from Hydrogenics were:

  Michael Xu - Product Development Manager

  Frank Hailah - Systems Integration Technologist

  Kevin Harris - Business Development / Sales Director
- Hydrogenics has been most proactive in using not only the performance data, but the operator / user feedback positively to make product improvements.