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Hydrogen Industrial Trucks

Component and System Qualification Workshop

Outline

- What is the industrial truck application today?
- What are the codes and standards associated with the market?
- The decision to certify a product
- How to influence that decision
- Open Administrative Items
- Open Technical Items
- Open Market Items

Industrial Applications

- **Fork trucks**
- Utility Vehicle
- Airport “Tug”
- Ice Resurfacer

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 (Steam Reformer)
2. Outdoor Compression and High Pressure Storage
3. Indoor Dispensing
4. Battery replacement in existing electric forklifts

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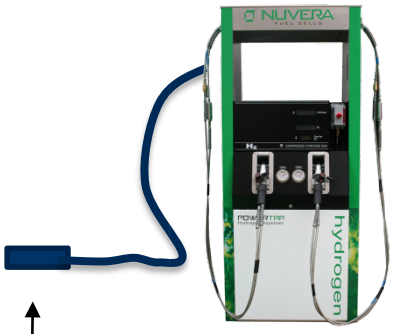
Current Code and Standards

(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

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

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

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Current Code and Standards

(Published Docs in bold)

SMR-Onsite Generation
ISO 16110-1
FC-1
SPADE – Nuvera Approach

Compression and Plumbing
ASME B31.3, B31.12
CGA PS-21, H5.5

Storage
ASME B&PVC

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Certify or Demonstrate?

Egg Approach

- Show my potential through demonstration of early products first

- Let customers demand certification

Chicken Approach

- Make the investment now to certify knowing that my customers will need it

- Certify now to avoid missed opportunities when the market expands

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Keeping the bar high

The height of the hurdle is set:

- Safety standards cannot be compromised to lower the costs

The ground level is set:

– We can only build equipment with the technology and components available today

How can we make the runners:

- Enter the race ?
  - motivation; is there increased value of certification?
- Use less effort ?
  - lower costs
- Jump with confidence ?
  - high probability of success

How do we keep the race fair?

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Open Administrative Items

Codes and Standards Harmony and Implementation

- Harmony - UL 583, UL 2267 and NFPA 505
- Harmony – Indoor Refueling - Int'l Fire Code, NFPA 52, NFPA 2, UL2267
- Implementation – Component and Sub-system level standards – CSA HPIT1, SAE J2919
- Implementation – Design criteria for tanks in addition to performance based tests (similar to ASME Article KD-10)
- Implementation – Comprehensive revision to UL2267 to reflect industry standards

Safety Codes and Standards Enforcement

- Regulatory Parent Agencies and Involvement
  - Industrial Trucks – OSHA – Dept of Labor
  - Automotive - FMVSS – Dept of Transportation
- Education of Fire Officials on:
  - H2 Powered Industrial Trucks
  - Indoor Refueling
  - H2 Storage Location

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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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Industrial Forklift Truck Market: Shapes and Sizes

- Forklifts and their battery packs come in all shapes and sizes
- Integrators must design multiple products and hence use multiple H_2 cylinder sizes to design the platform of products

Class 1

Class 2

Class 3

Open Market Items

Certification and Customer Confidence

- Certification path agreement? HPIT1 -> J2919 -> 2267?

- 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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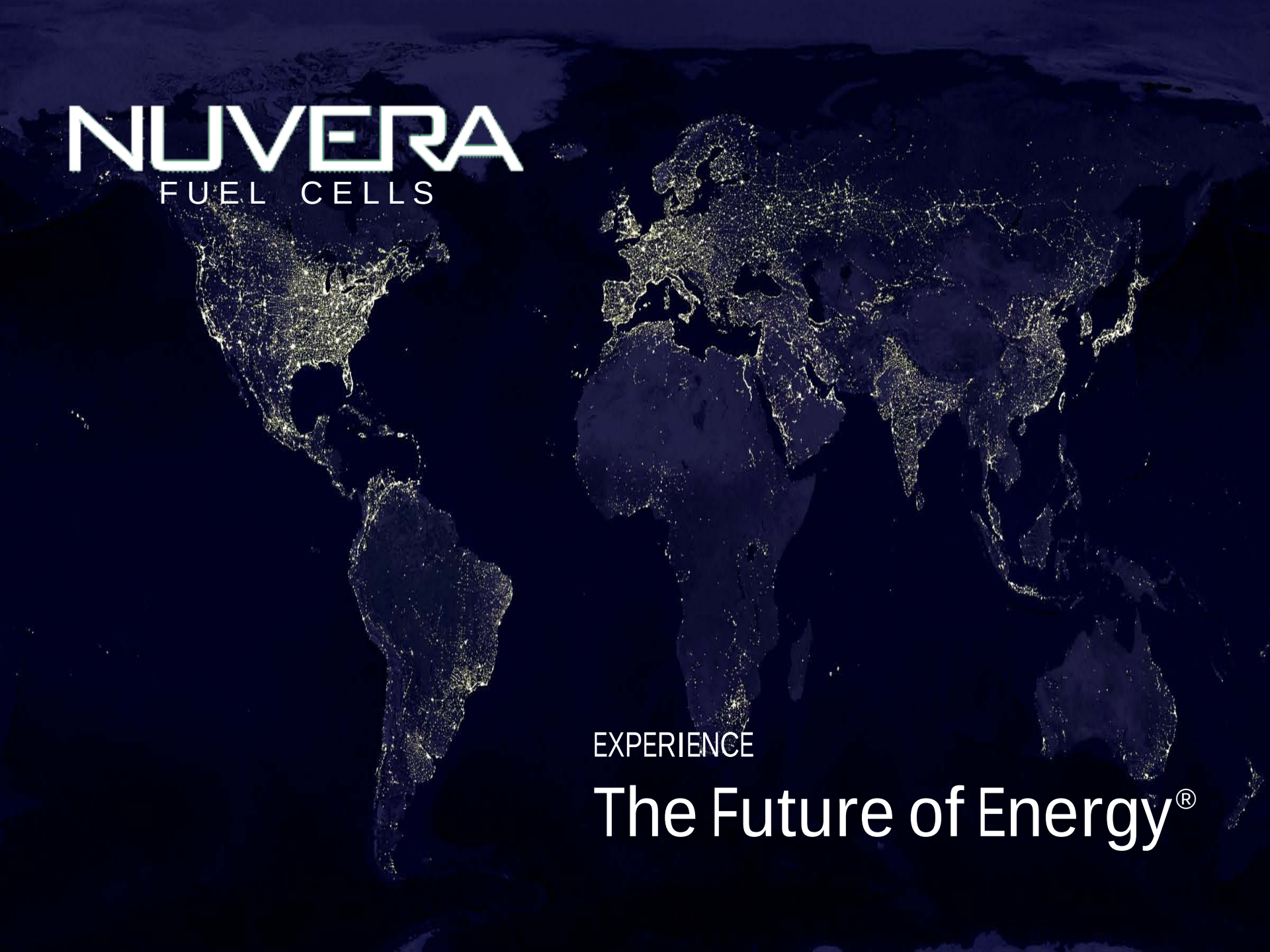
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