NUVERA FUEL CELLS

Hydrogen and fuel cell technical advisory committee meeting

May 9, 2012

Presented by: Prabhu Rao, VP Commercial Operations

Nuvera Fuel Cells
129 Concord Rd. Bldg 1
Billerica, MA 01821

Agenda

- The Journey
  - Lessons Learned
- Current Focus
- Challenges and Opportunities

Company Introduction

- Nuvera Fuel Cells is a global leader in the development and advancement of multi-fuel processing and fuel cell technology
- Operations in US and EU
  - R&D
  - Low Volume Manufacturing
  - Sales & Service
- Total 120,000 sq. ft.
- 132 employees (127 in US)
  - >100 high skilled engineers (88 in US)
- Wholly owned by Hess

Billerica, MA (USA)

Milan, Italy (EU)

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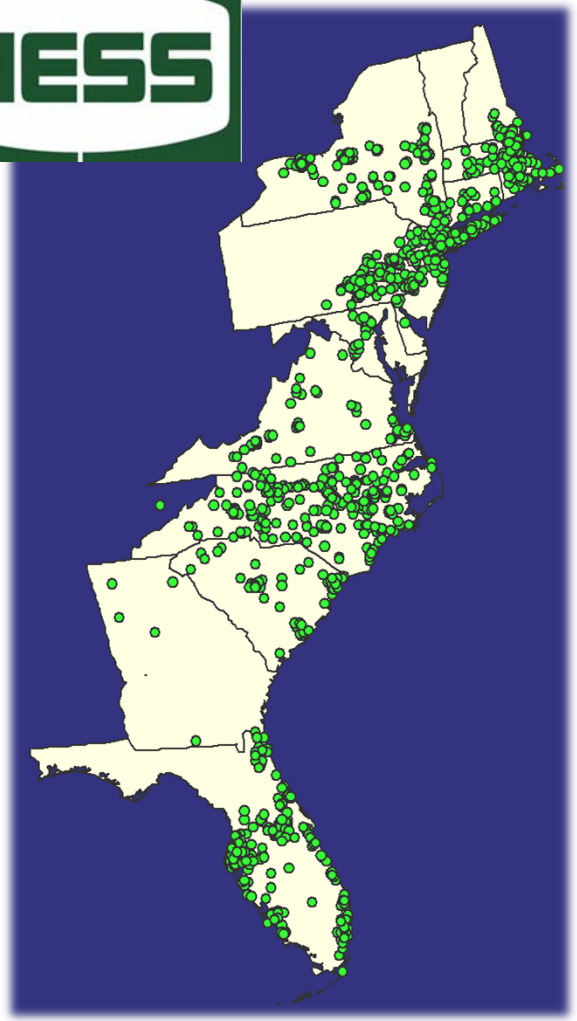
Nuvera Fuel Cells, Billerica, USA is ISO 9001: 2008 certified

US Refueling Opportunity



Hess station network (1400 stations)
>95% Corporate Owned & Operated

Covers #1, 4 & 5 rated sub-regions identified as early FCEV adopters locales (NREL 2006) and >30% U.S. Population

1) New York—Northern NJ—Long Island
2) Los Angeles—Riverside—Orange County
3) San Francisco—Oakland—San Jose
4) Boston—Worcester—Lawrence
5) Philadelphia—Wilmington—Atlantic City
12) Hartford
19) Providence—Fall River—Warwick
20) Rochester

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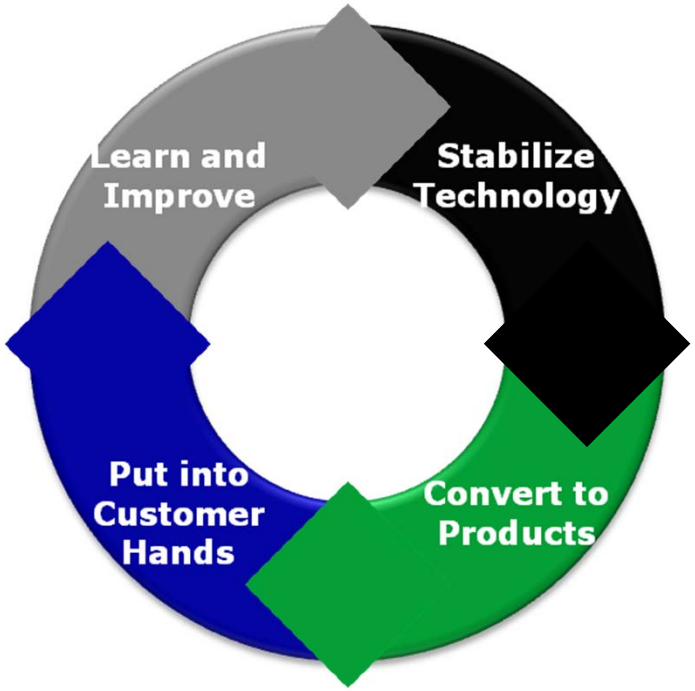
Development cycles of learning



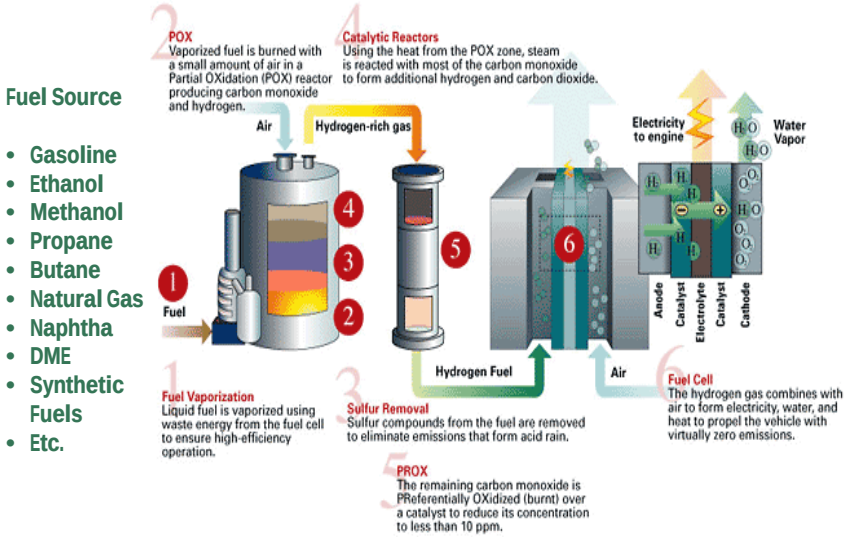
ENABLE

- Technology Development
- Product Development
- Key Suppliers Engagement
- Manufacturing Process Development
- Customer/User Focus

Technological Milestone

Nuvera conducted the world's first successful demonstration of converting gasoline to electricity with a fuel cell.

1997



Nuvera 50 kW_e Multi-Fuel Processor, LANL 10kW_e PROX, Plug Power 500 W_e PEM Test Setup

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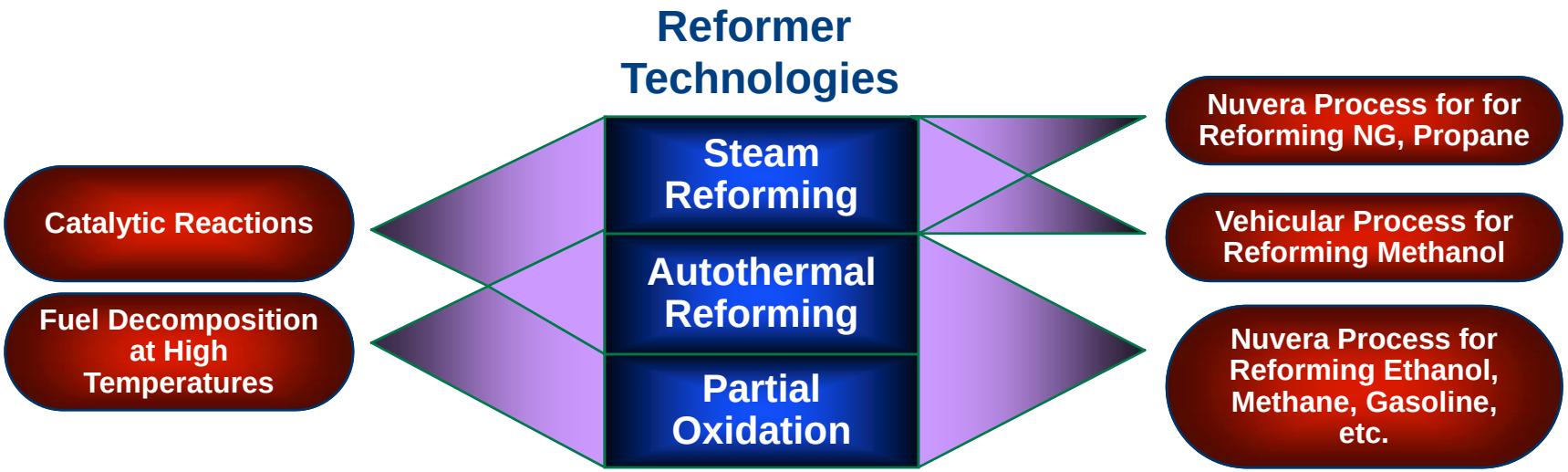
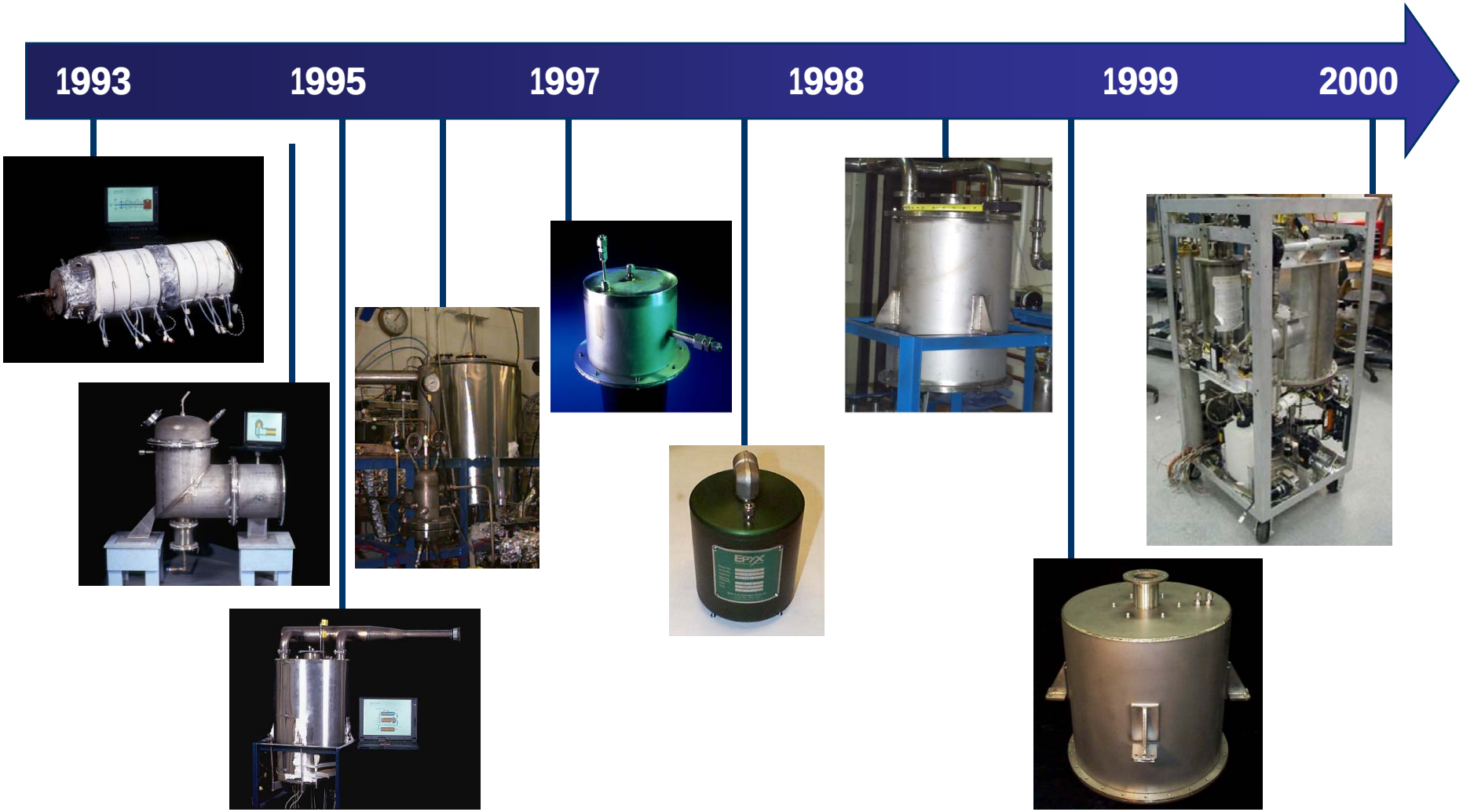
Fuel Processing Technology

Hydrogen Production Options

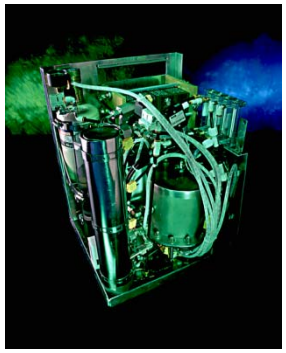


These technologies are used in large-scale, dedicated H2/CO facilities, and increasingly in smaller on-site/on-board applications.

Early Successes: Fuel Processors 1993 – 2000



Early Successes: Systems: 1998 – 2000



300W Propane FCPS

30 Nm3/h 99.99% Pure Hydrogen Generator

1 kW Propane/NG FCPS

1 kW Propane FCPS

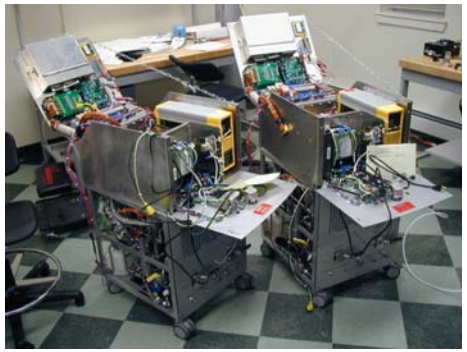
5 kW Endurance FCPS

5 kW NG ATR FP

50 kW Gasoline FP

10 kW Gasoline FP

5 kW NG FCPS



2 x 1kW H2 FCPSs

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Lessons learned: Avanti

- ✓ Global Partnerships
- ✓ Customer Req'ts
- ✓ Cyclic SMR's
- ✓ Durable XDS fuel cell
- ✓ Champion Efficiency
- ✓ Aggressive Cost-outs
- ✓ Supervisory Controls
- ✓ ECU Development
- ✓ Cost of Reliability

2	5	5	**Deployments**
16%	22%	>30%	**NetAC Eff'y (HHV)**
1.00	0.42	0.16	**Normalized Cost**
PowerStream Circa 2001	Avanti GEN1.2 Circa 2003	Avanti GEN3.0 Circa 2005	**Product Offering**

Hydrogen Generation History

On-Board

STAR™, gen 1
2000

STAR™, gen 3
2007

CHP

PowerStream™, gen 1
2001

Avanti™, gen 4
2006

Hydrogen

First Hydrogen Generator
1998

PowerTap™, GEN I
2005

PowerTap™, GEN II
2009 - Present

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Nuvera Fuel Cells, Billerica, USA is ISO 9001: 2008 certified

The Nuvera Difference – Stack Technology

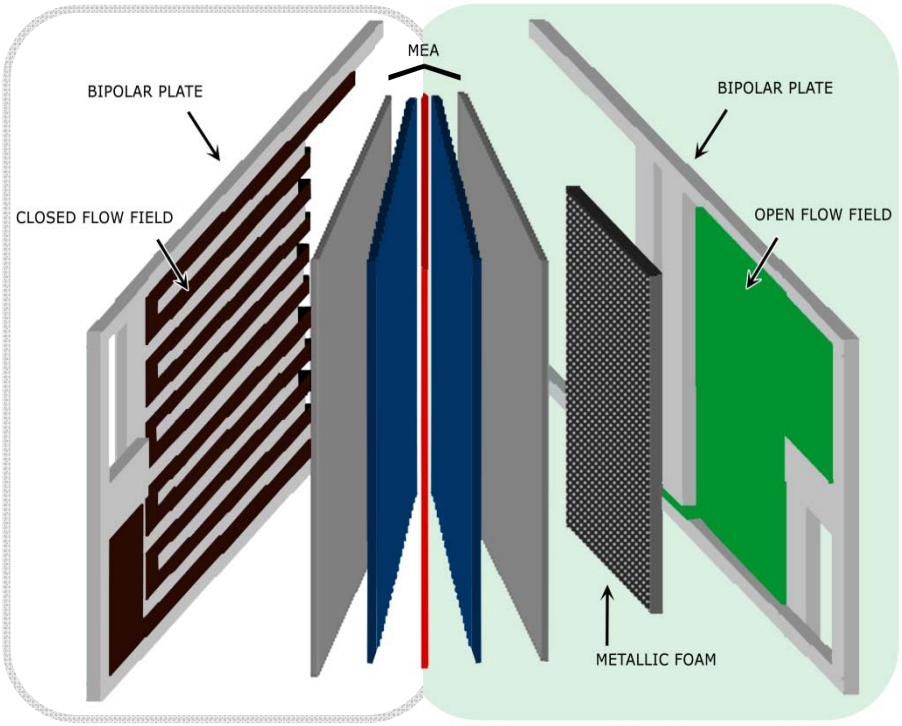
Our Competitor

Third Party Stack Technology
Limited control over stack design

Graphite Plates
Less durable over lifecycle

Closed Channel-Land Flow Field
Sensitive to temperature extremes

Cooling Cell
Adds complexity to balance-of-plant



Conventional Stack

The Nuvera Technology Difference

Our Stack

Nuvera Stack Technology
Nuvera is in full control of stack design and is focused on continuous improvement

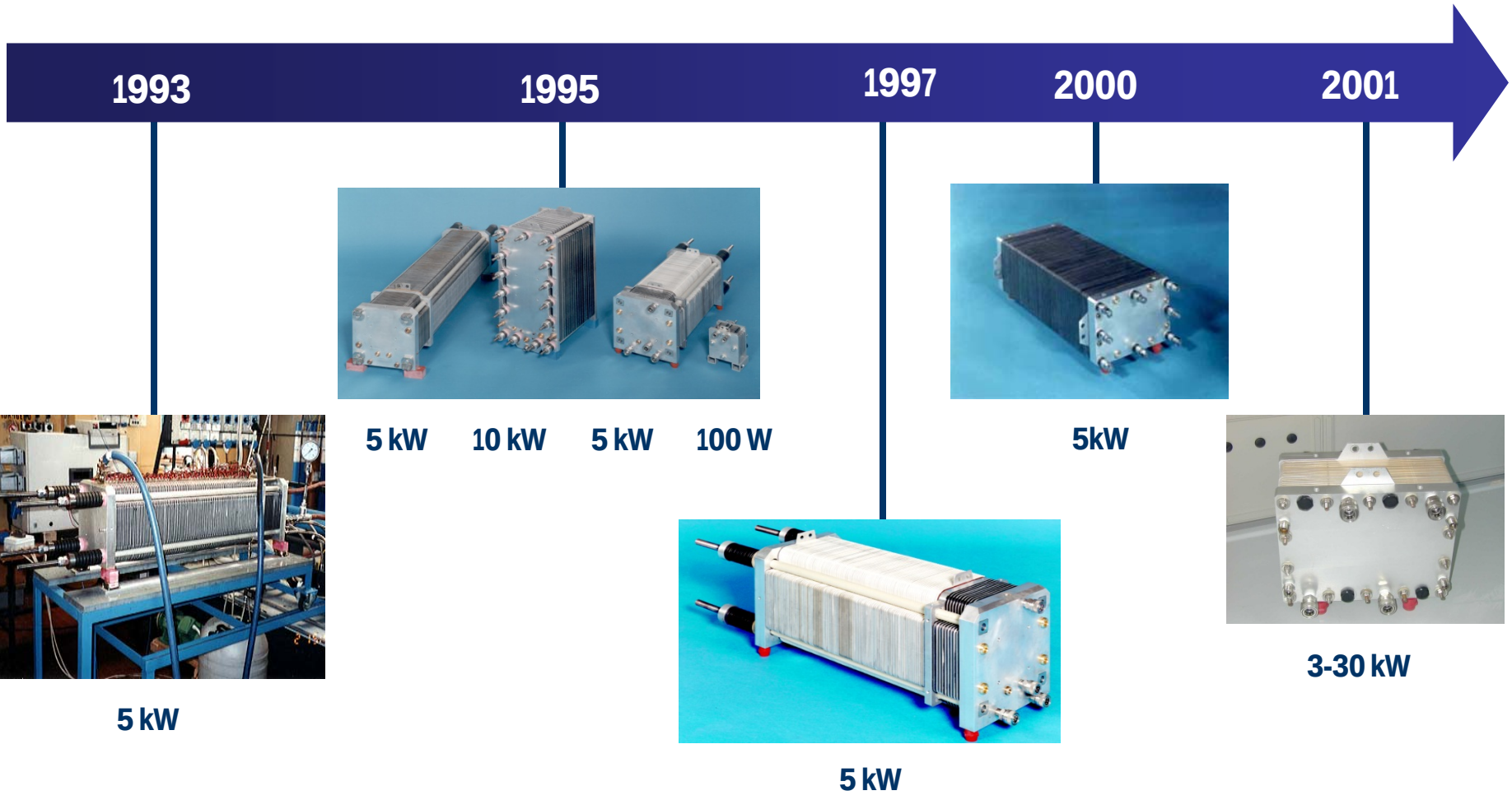
Metallic Bi-Polar Plates
Durable, reliable, and cost-effective

Open Flow Field
Increases the active area of each cell MEA

Cathode Water Injection
Simplified balance-of-plant reduces on-going costs

Early Successes: Fuel Cells: 1993 – 2001

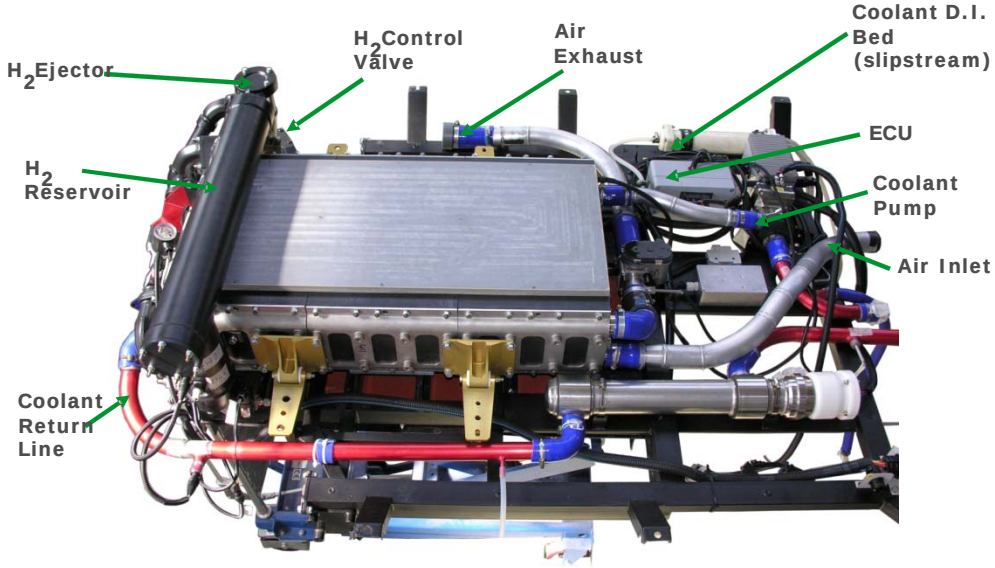
Residential MicroPower fuel cell stack example



Advanced PEMFC Engines

Nuvera has been working with automotive OEMs for over 10 years

- Metallic architecture since 1993
- Patented open flowfield
- 8 MW produced in 7 generations
- High durability and low cost



Fiat Seicento
Elettra 7kw RE, 2000

Fiat Seicento
50kw FCEV, 2003

Fiat Panda
80kw FCEV, 2006

Alfa Romeo Mito
80kw FCEV, 2010

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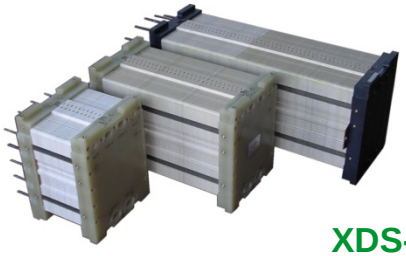
PEMFC Stack Design Convergence

Industrial

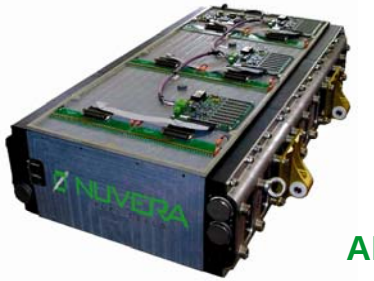


XDS-900

- High durability
- 3 generations of hybrid motive FC systems
- Commercial stage

Broad range of industrial vehicle platforms

Automotive/Aerospace



ANDROMEDA

- High power density
- 9 car installations
- R & D stage

ORION

- Single architecture
- All mobility markets

Range Extender – BEV

Engine – PEMFC EV

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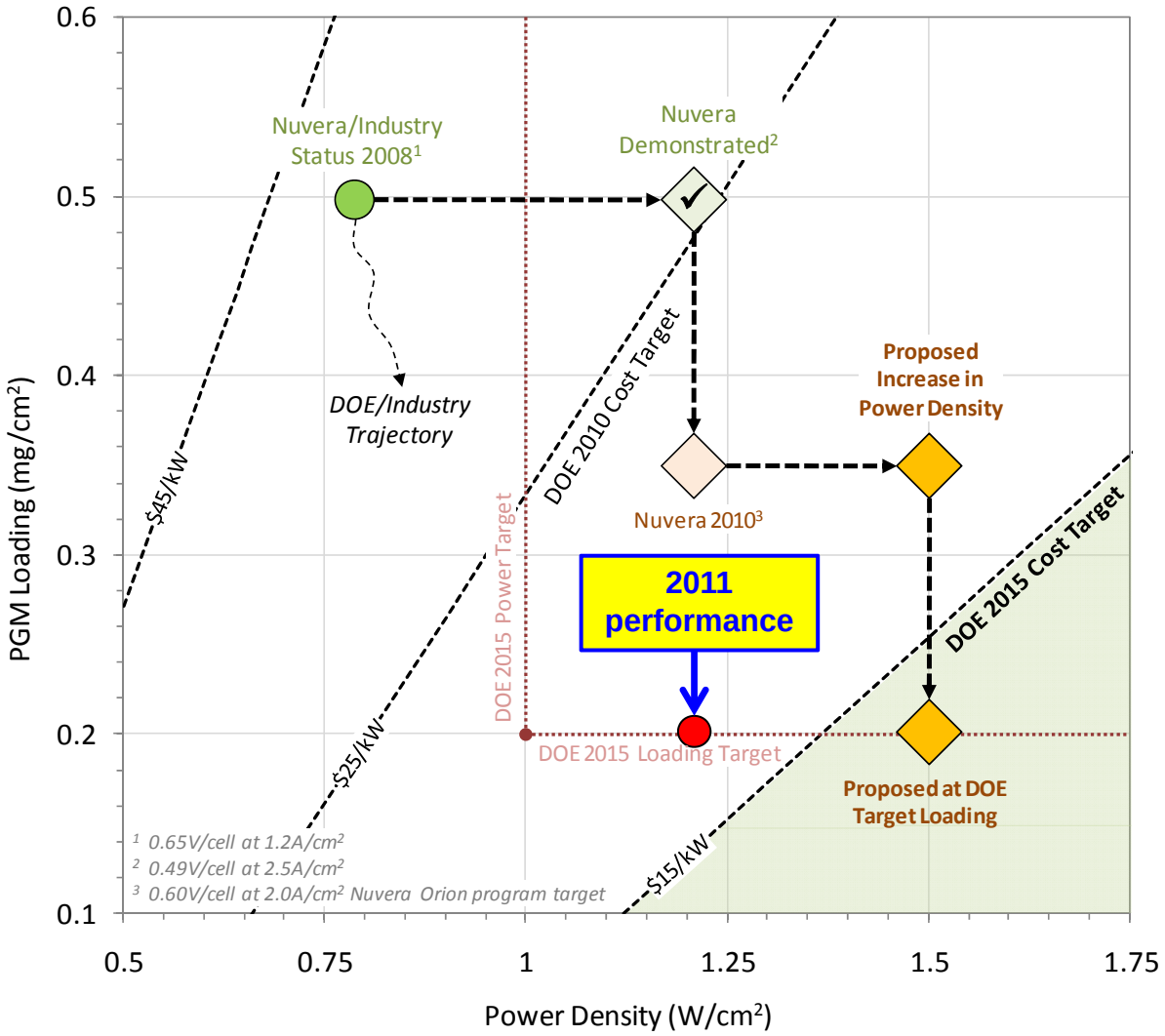
Cost Roadmap (2008)



Objective:
End up in the shaded region.

↓

Enable Cost

Prove Durability	Increase Efficiency
SPIRE	**AURORA**

Nuvera is uniquely positioned to push the envelope of cost-competitiveness.

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Nuvera - Market applications

Light Duty EV & Range Extender

Fuel Cell Forklifts

Ground Support Equipment

Industrial Mobility

Truck APU & Reefer

Fuel Cell Tractors

Transportation

Fuel Cell Bus

Fuel Cell Vehicle

Aerospace APU

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Total Power Solution

PowerEdge™
Motive Power Solution

- Direct Replacement of Forklift Lead-Acid Battery

PowerTap™
Hydrogen Supply Chain

- On-Site Hydrogen Generation, Storage, and Compression

An integrated productivity enhancement system for material handling

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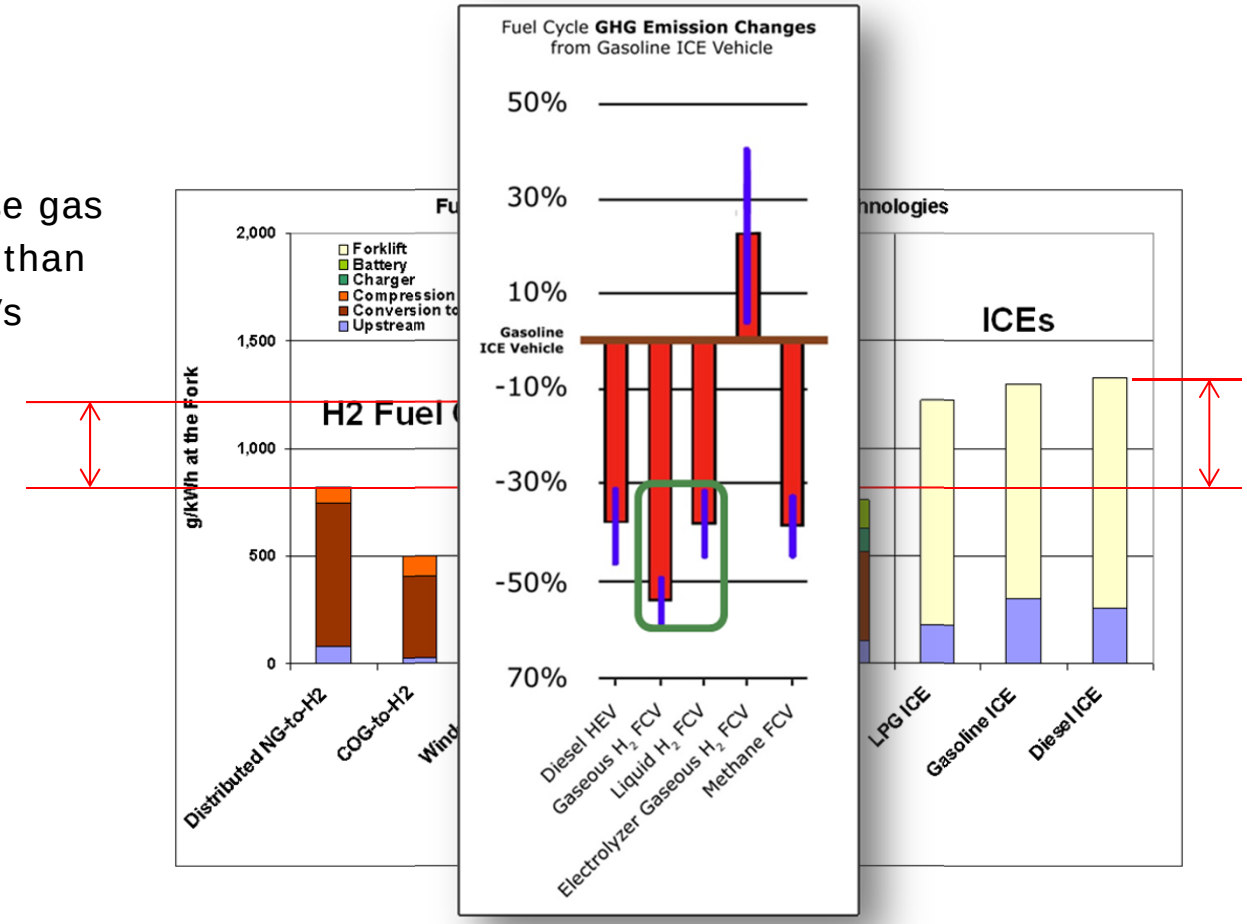
Reducing Carbon Footprint

33% less greenhouse gas emissions than battery EVs



Comparison of well-to-wheel GHG Emission Pathways.
Source: ANL, M. Wang, 2002

34-42% less greenhouse gas emissions than propane, gasoline, or diesel IC trucks

Source:
Full Fuel Cycle Comparison of Forklift Propulsion Systems,
Center for Transportation Research, Argonne National Laboratory, October 2008.

Nuvera On-Site Experience

Nuvera's PowerTap is serving customers in multiple markets

Market	Material Handling
Customer	HEB San Antonio, TX
Statistics	**22 months** on site **11,500 hours** **6,000 kg H2** delivered **99.995%** purity **> 99.5%** availability of H2 at pump

Market	Merchant Hydrogen
Customer	Sacramento, CA
Statistics	**7 months** on site **3,300 hours** **5,800 kg H2** delivered **99.9995% (UHP)** purity **Consistent generation of UHP Hydrogen at customer site**

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Relative Scaling (Material Handling vs. Automotive)

Application	H2 Generator Peak Rating (kgH2/day)	H2 Generator Peak Rating (scfh)	Average H2 Refueling Station Production Capacity[1,2] (kg/day)	Maximum Vehicle Refuels per Day[3,4]	Average No. of FCV's Supported[4]	PTH 1X Storage Bank Scale Factor[6]	Maximum Class II Forklift Trucks Supported[2,7,8]
Small Community Station	56	~1000	38	10	92	1	13
Small-Medium Community Station	112	~2000	76	20	184	2	25
Medium-Large Community Station	280	~5000	189	50	461	5	64
Large Community Station	560	~10,000	379	100	921	9	127
Small Public Service Station	920	~16,000	622	164	1514	15	209
DOE Target Public Service Station	1500	~27,000	1014	267	2468	25	341

1. Assumes 69% Capacity Factor to account for seasonal & daily fluctuations in demand

2. Assumes 98% Station Availability (22days/yr with one 8-hr shift of service)

3. Assumes 80% Fuel Tank Oppurtunity Refills

4. Assumes 80-miles/gge FCV, 380-mile range & 12000-miles/year

5. Assumes 58% H2 gas utilization factor for cascade storage

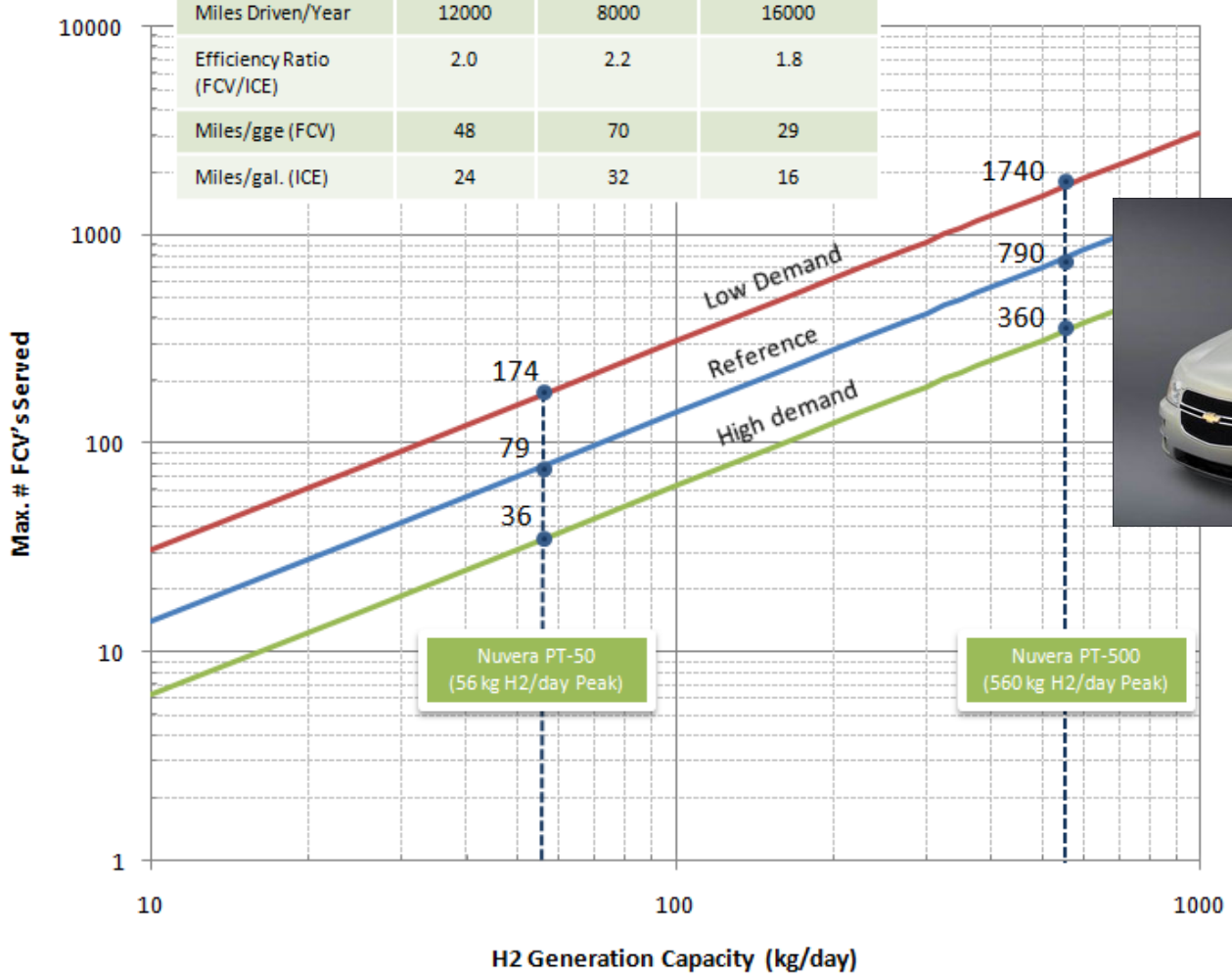
6. Assumes 6500psig Cascade Storage, 3 Banks, 27 11-gal ASME cylinders, 20C ambient

7. Assumes 95% Capacity Factor for Material Handling

8. Assumes 1000Ah, 80% Discharge, 3 shift, 6 day/wk, 50 week/yr operation; RP = 52%effy

PowerTap Single Station Service Capability

Case -->	Reference	Low Demand	High Demand
Miles Driven/Year	12000	8000	16000
Efficiency Ratio (FCV/ICE)	2.0	2.2	1.8
Miles/gge (FCV)	48	70	29
Miles/gal. (ICE)	24	32	16



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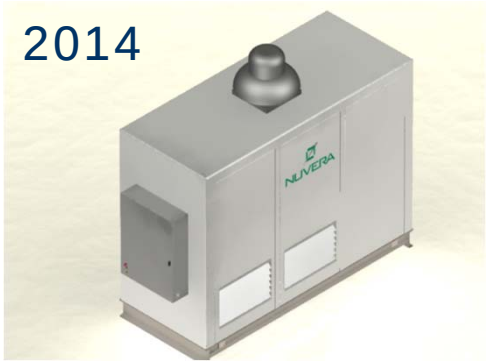
PowerTap Product Suite

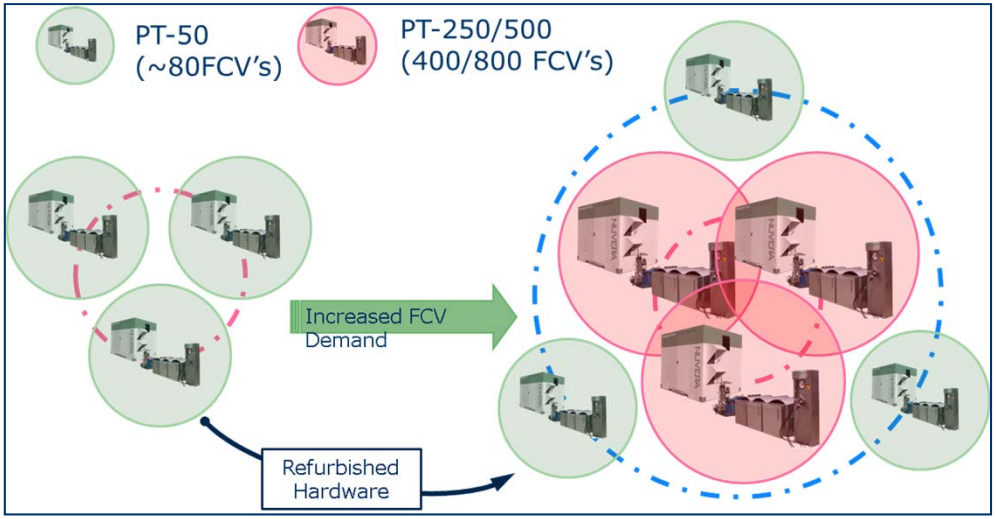
2010

PTG-50
(12’ L x 4’ W x 9’ H)

2014

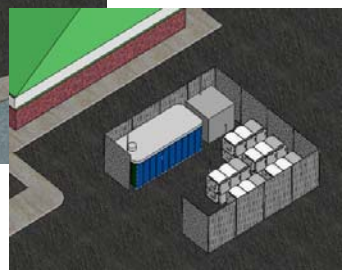


PTG-250
(12’ L x 6’ W x 9’ H)



PT-50

PT-500



Site layout courtesy of Hess Safety Harbor, FL

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PowerTap Retail Automotive (2015)

Nuvera PowerTap™ GENIII+ Hydrogen Generator Appliance
125-250kg/day Ultra-High Purity Grade H_2 Capacity, 800-bar Output
Target Footprint Dimensions: 12'Lx6'W

Summary

- Nuvera is focused on creating foundational technologies that can provide product opportunities in many markets
  - Possible due to capabilities of the team, funding source and strategic view
- We will be focused on being a hydrogen provider for low volume applications (50-2500 kg/day)
  - Industrial mobility
  - Transportation
  - Merchant
- Leverage our high power density stack technology to partner with OEM's or integrators in many markets
- Mainly focused on North American and European Markets in the near term extending to Asia next.