



Hydrogen - Pathway to Clean Energy !

November 9, 2010

50+ Years of Hydrogen Experience

- World's largest merchant supplier
- H₂ production equivalent to fueling ~8 Million cars/day
- Bulk ,liquid and pipeline distribution
- More than 500 H₂ customers
- H₂ Energy projects since 1993
 - > 120 hydrogen station projects
 - > 225,000 fuelings/year
- Stations in 18 countries
- Broad IP Estate



Air Products Leadership in Hydrogen Fuel Infrastructure

- Turnkey Systems Integrator
- Have at our disposal
 - Methane conversion technologies
 - Gas clean-up technologies
 - Waste Gasification
 - Electrolysis
 - Renewables
 - Carbon capture
- Significant effort in generation R&D
 - Coal Gasification
 - Nuclear
 - Bio-technologies
- Supplier of the most cost effective molecule to the marketplace



AP Hydrogen Powers

Cars



Trucks



Vans

Buses



Scooters

Forklifts

Planes

ENF  CA^{FC} 



AP Hydrogen Powers

Submarines



Automated
Guided
Vehicles



Cell Phone
Towers



Tractors



Lighthouses

Locomotives



AP Fueling Stations

Italy



Washington , DC



India



Korea



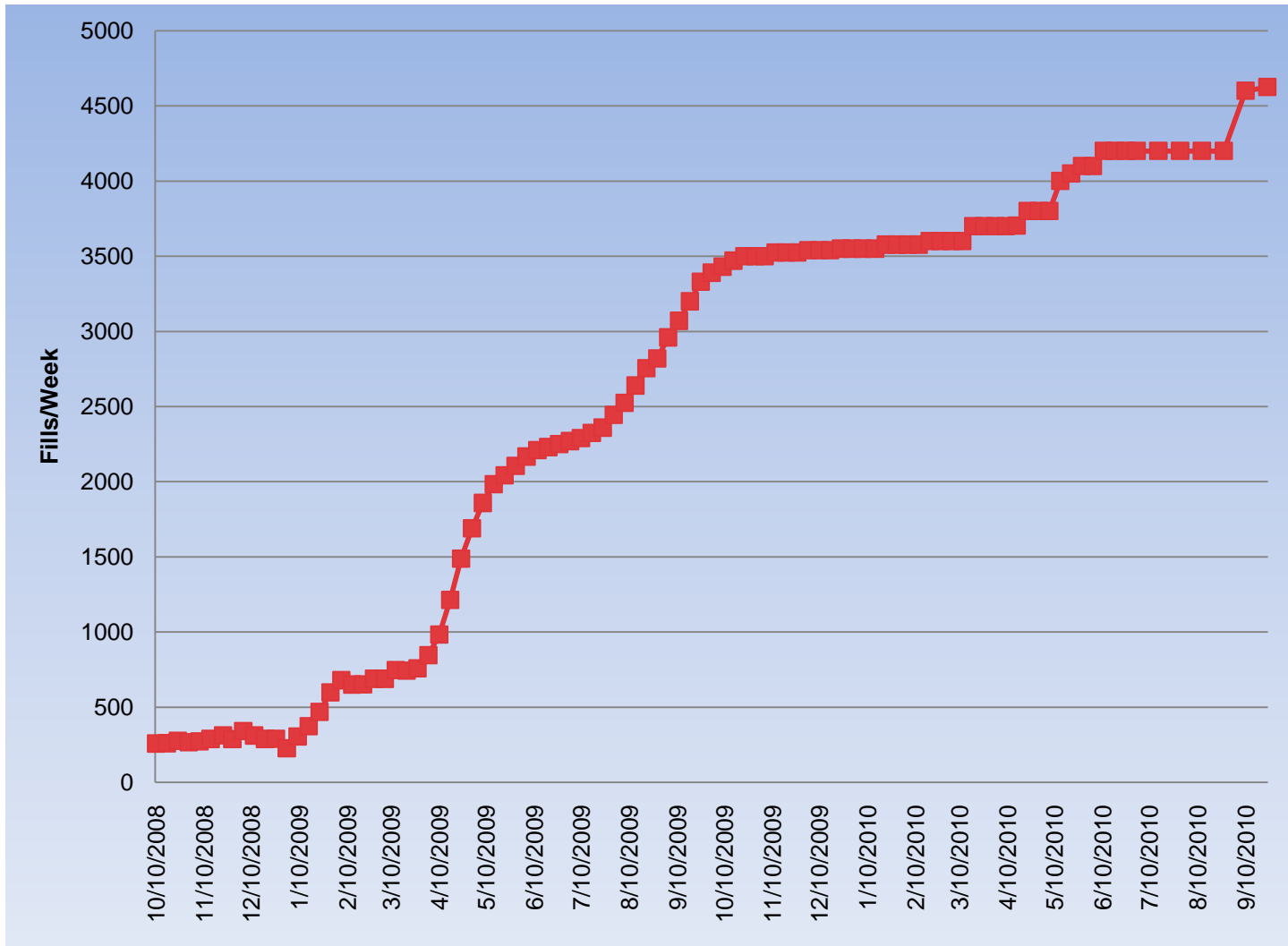
Sacramento, CA



China



Dispensers Fill Count



Infrastructure Vision

- End game is clear, transition has been difficult
- AP experience is unique
 - Several 10,000-15,000/yr fueling applications
 - Have 50-200 MH vehicles per site today
 - Very high reliability of supply
- Lessons Learned
 - Improve delivery technologies
 - Reduced maintenance costs
 - Simple, modular, expandable
 - Use existing forecourts
 - Chart a renewables pathway

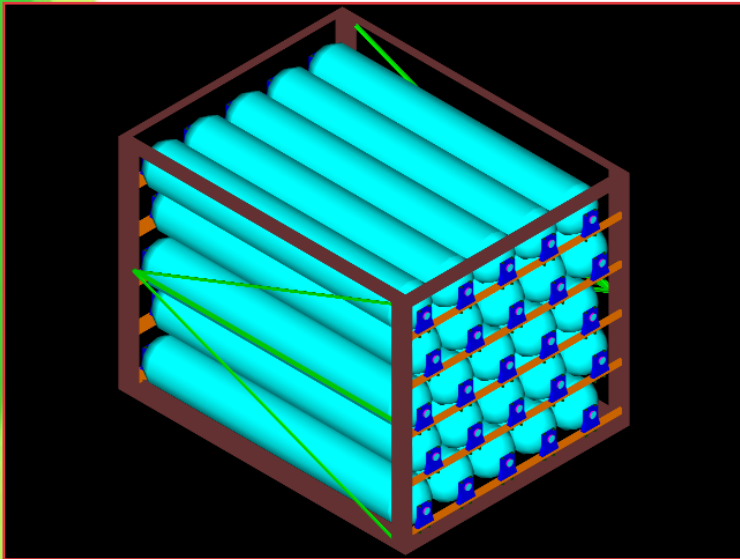
Air Products' Patented Delivery Trailer



- Liquid Hydrogen trailer capable of delivering liquid and high pressure hydrogen over 10,000 psi to a station
- Enables step-change in liquid delivery to numerous applications, lowering delivery costs

The Delivery and Station Breakthrough

HP Composite Bulk Delivery / Storage



- Enables step-change in bulk hydrogen product payload capacities, up to 2-4X .
- Enables distribution of hydrogen from all forms of distributed and renewable sources with minimum GHG emissions
- Promotes modular and expandable stations on existing gasoline forecourt.
- Potential to eliminate ONSITE COMPRESSION.
- AP Patents pending

Leveraging Sustainable Global Trends

Alt Fuel
H₂/CNG/
LNG/HCNG



Existing
Technology, New
Markets

Energy from
Waste



Renewable
Power

Carbon
Capture and
Storage



DOE Grant

BF Plus



New Partnership
and Product

Air Products Projects Capturing CO₂ from Fossil Fuel-Based Processes

- **Oxyfuel** technology for pulverized coal boilers
 - Installing proprietary CO₂ capture, purification and compression system at Vattenfall's pilot, Germany
 - Onstream 2010
- **Hydrogen** production from natural gas with CO₂ capture
 - DOE Phase II Industrial CCS Award, Port Arthur, TX
 - Onstream 2012
- CO₂ capture from **gasification**
 - Pressure-Swing Adsorption for CO₂ Capture from Sour Syngas
 - Pilot development



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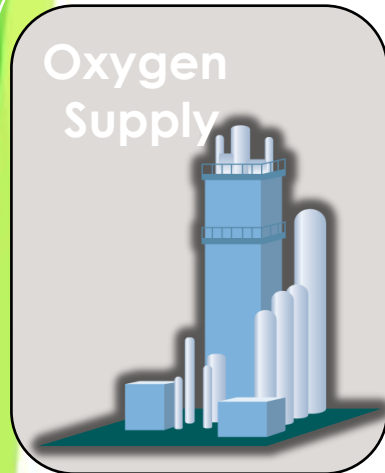
Air Products Tees Valley Renewable Energy Facility

- Proposed 49MW EfW facility using advanced gasification technology
- Currently in the planning & development stage
- Potential for:
 - Renewable electricity for up to 50,000 UK homes
 - Significant green hydrogen production
 - Diversion of 300,000 – 350,000 tonnes of non-recyclable waste from landfills



Oxyfuel Power Plant with AP Technology

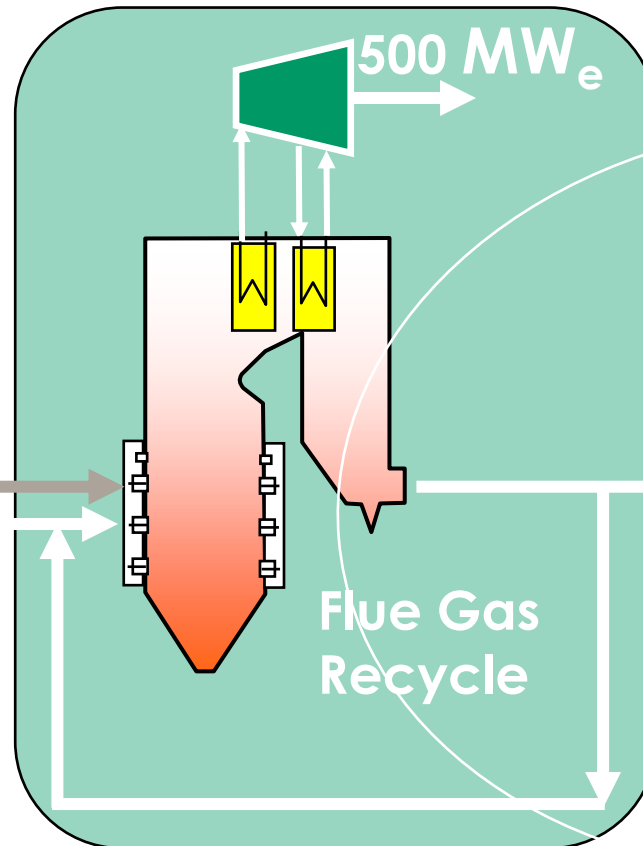
APD



Oxygen Supply

Oxygen
~10,000 tpd

Steam Boiler and Turbines

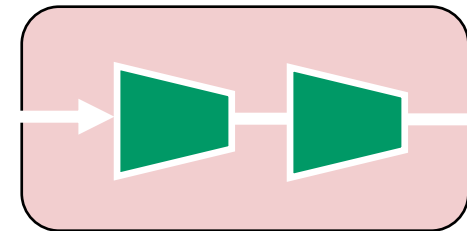


500 MW_e

Flue Gas
Recycle

CO₂ Transport
and Sequestration

CO₂ Purification
and Compression



APD Patented
Technology

Leading the Way to Commercialization



160 kW
oxyfuel rig¹



15 MW
oxyfuel
combustion
unit²



30 MW
oxyfuel
pilot plant³



100's MW
oxyfuel
demonstration³



Renfrew, Scotland



DOE Project
Host: Alstom,

Windsor, CT



Germany

¹Photo courtesy of Doosan Babcock

²Photo courtesy of Alstom Power

³Photo courtesy of Vattenfall

Renewable Hydrogen Power and Heat Generation System

Fountain Valley, CA Station

- High Temperature Fuel Cell
 - Anaerobic digestion of municipal wastewater
 - Converts sludge to electricity, hydrogen and heat
 - 100 kg/day capacity (25 cars) and 250Kw of Power
 - Host site: Orange County Sanitation District
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- Water waste from 100,000 people provide 1MW of power and 500 kg/day of Hydrogen
 - ~40,000 waste water digesters in the U.S.

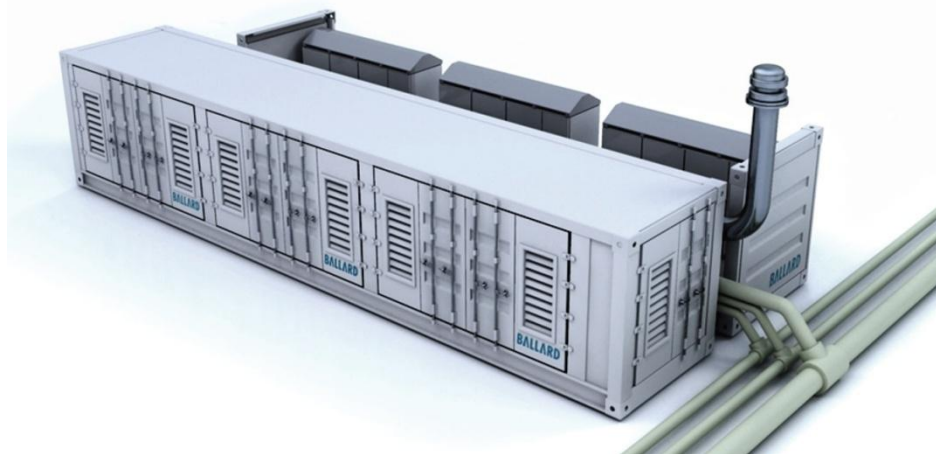


FuelCell Energy

AIR
PRODUCTS 

PEM Power Generation

- 1MW Ballard PEM fuel cell 20,000 hr life
- Torrance CA
- H₂ from Air Products pipeline
- Peak power shaving
- Scheduled start January 2012
- 75% renewable Hydrogen via biogas SMR



Hydrogen Pipeline Station, Torrance CA

- ~100 cars/ week capacity , New station retail design, H2 only.
- Hydrogen dispensed into a car at prices competitive to gasoline today.
- In start-up mode



Summary

- Rapidly growing market in complimentary market segments.
- A clean sheet approach shows that a transition strategy is achievable.
- A transition strategy can reduce early funding requirements.
- Hydrogen as a sustainable fuel can be achieved.

Thank You

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