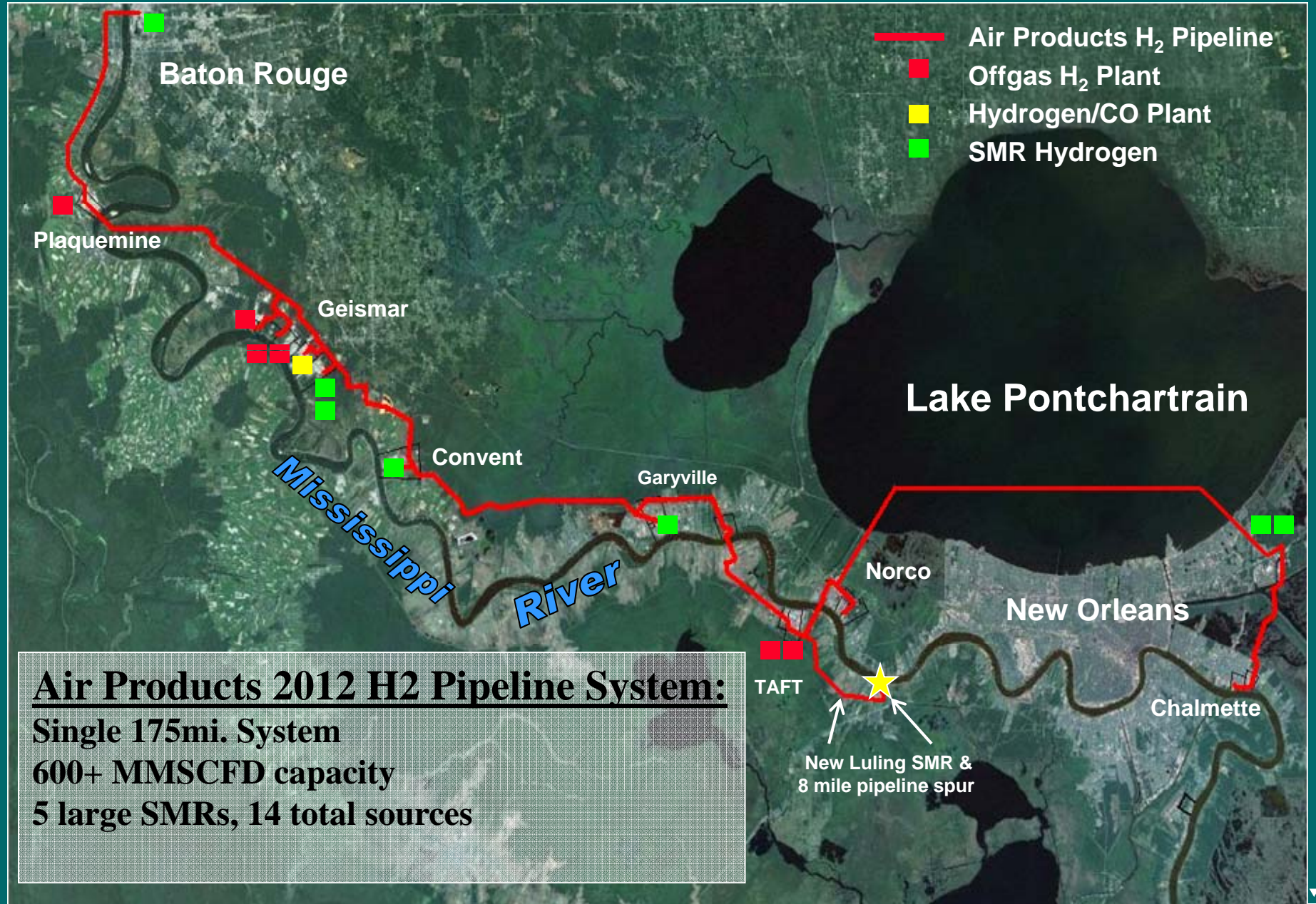




**AIR**  
**PRODUCTS** 

Hydrogen Energy Systems



**Air Products 2012 H<sub>2</sub> Pipeline System:**  
 Single 175mi. System  
 600+ MMSCFD capacity  
 5 large SMRs, 14 total sources



# Air Products' Leadership in Hydrogen Fuel Infrastructure

- **World's largest producer of merchant hydrogen ~50% share**
  - > 40 years of experience
  - 90% used at source
  - 8% piped to point of use
  - $\text{CH}_4 + 2\text{H}_2\text{O} + \text{heat} \rightarrow 4\text{H}_2 + \text{CO}_2$
- **Active in fueling since 1993**
  - Over 100 hydrogen stations
  - Over 100 dispensers
  - 350 and 700 bar pressure
  - Approaching 200,000 fuelings
  - In 16 countries



# How is Hydrogen Used?

- **Hydrogen is used to produce glass, steel, foods, pharmaceuticals and electronics.**
  - **Approximately 1,000 customers purchase hydrogen in the US and Canada for industrial use.**
- **Hydrogen is also used in hydrogenation, hydrotreating, hydrocracking, and other industrial applications in the petrochemical and refining industries.**
- **Hydrogen is used in fuel cells to produce electric power.**
- **Hydrogen is now being used more frequently for motive power (cars, vans, buses, forklifts, boats, planes, etc.) through either:**
  - **Internal combustion or**
  - **Fuel cells**

# 3 Applications for hydrogen “fueling”:

- **Internal Combustion Hydrogen**
  - Utilizing H<sub>2</sub> in a traditional (modified) 4 stroke combustion engine
- **Hydrogen-Compressed-Natural-Gas (“HCNG”)**
  - Blending pure H<sub>2</sub> with NG to lower NOX in NG-fueled vehicles
- **Pure H<sub>2</sub> used as fuel source for fuel-cell vehicles (electric vehicle)**
  - Pure H<sub>2</sub> used in Proton Exchange Membrane fuel cell to produce electricity

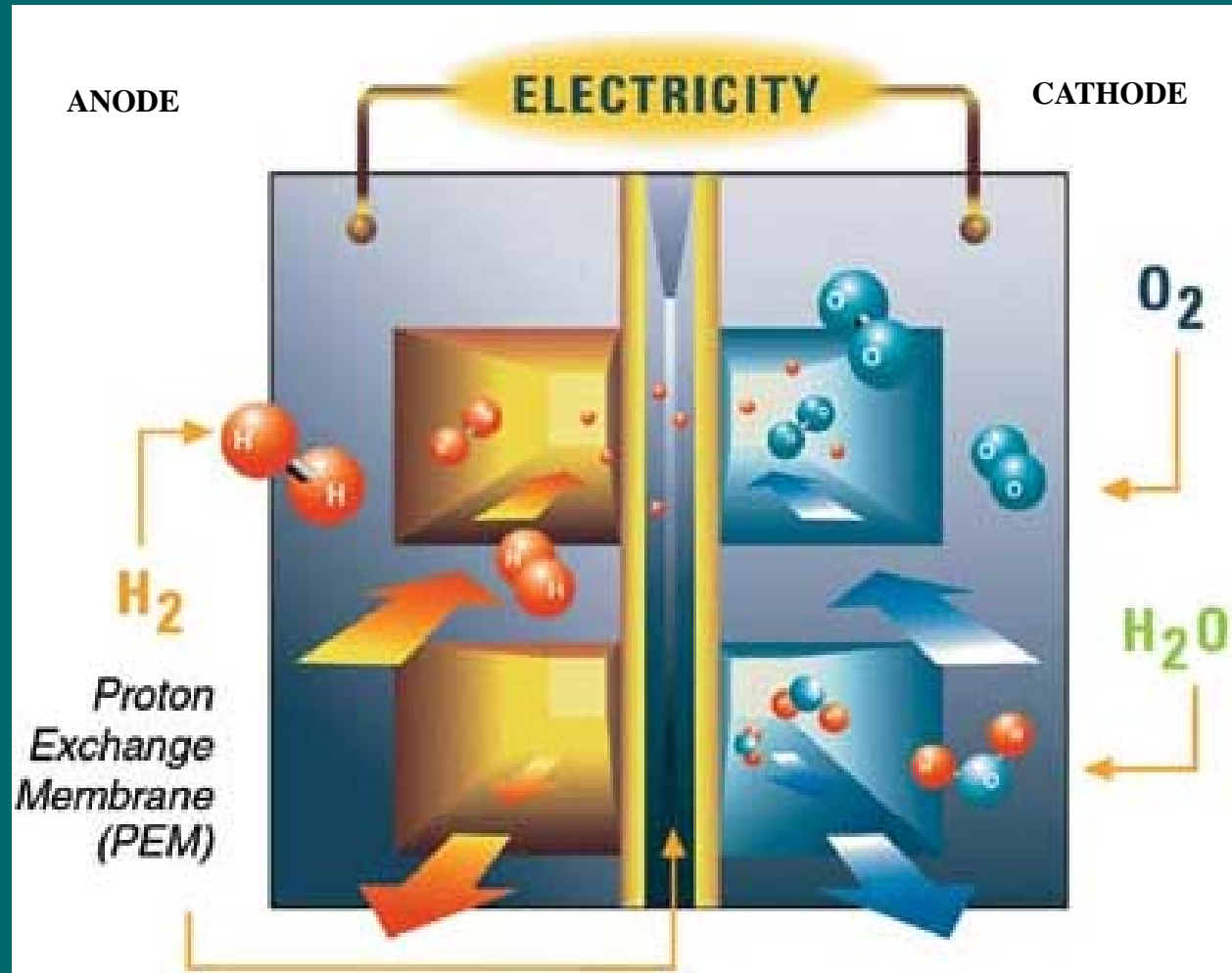
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# HCNG

- **HCNG is now accepted as an alternative fuel in order to reduce NOx & HC emissions**
  - NOx reduced by up to 50%
- **Primary approaches:**
  - Run low level blends on existing engines
  - Run 20% blend on modified engines
  - Run 30% blend on specially designed engine
- **HCNG vehicles expected to roll-out sooner than fuel cell vehicles**
  - Technology is “here” today
  - Can be applied to Mass Transit Fleets
  - Can make immediate impact on emissions reductions
- **Natural fit for regions already invested in CNG vehicles**

# Fuel Cell Technology



Fuel Cells create a DC electrical power circuit caused by the movement of electrons between anode and cathode in a PEM

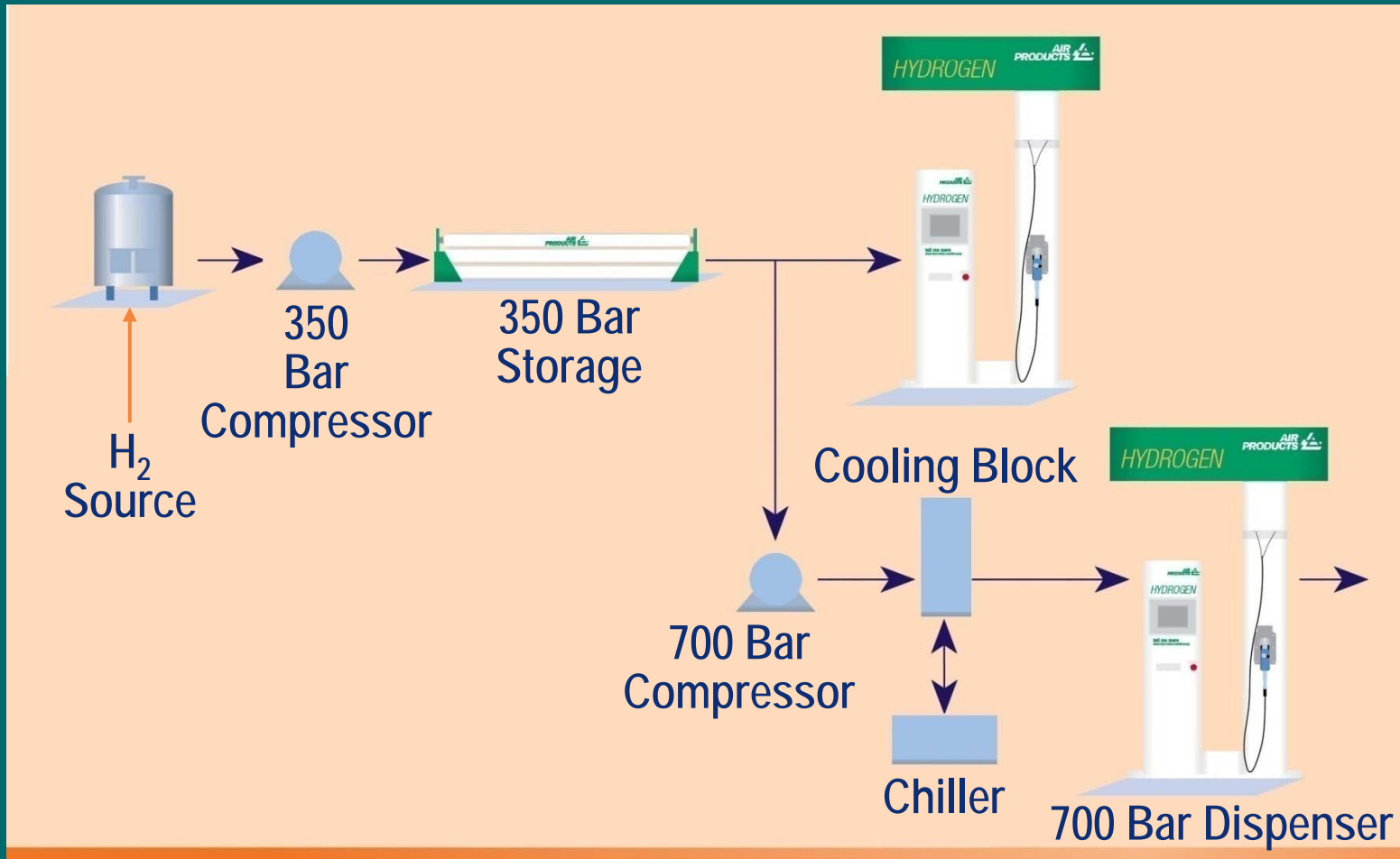
# The Cars







# Hydrogen— Fuel of the Future, Today! Typical System



# Air Products Allentown Corporate Offices





# Customer Projects





# Retail Fueling

BP - Singapore

Shell Hydrogen  
Washington DC

IOC - India



# BP - SMUD





# Fuel Cells for Materials Handling

## How are fuel cells used for materials handling?

- Complete fuel cell engine in a box
- Direct replacements for industrial batteries in motive power equipment



## What do the fuel cell power packs do?

- Replace batteries permanently
- Converts hydrogen gas to direct current (DC) power
- Refueled in 1 to 2 minutes by self-service dispensers
- Provides constant power 24/7 – eliminates battery droop
- Runs 2 times as long as a battery
- Produces no emissions except clean water and heat



# Typical Fuel Cell power packs

Class I



Class II



Class III





# Fuel Cell Savings in Materials Handling

## ■ Lower Labor Costs

- Eliminate labor associated with battery changes
- Eliminate travel to and from battery room
- Eliminate corralling (traffic jams) problems

## ■ Increase Productivity

- More product moved with less labor
- Trucks run at full speed 24x7

## ■ Reclaim Warehouse Space

- Reuse battery room to expand operations
- Save up to \$1.5 million in construction costs

## ■ Improve Employee Relations

- Improve morale & standardize operator performance
- Improve health and safety standards



# Sysco Houston



Thank you

tell me more

[www.airproducts.com/H2energy](http://www.airproducts.com/H2energy)