



Add Praxair to your refinery  
and get more out of it.

 **PRAXAIR**  
*Making our planet more productive™*

# Praxair + Growth

## Large Scale Hydrogen Storage in Salt Caverns

Ram Watwe

Renewable Resources for Fuel Cells - Workshop

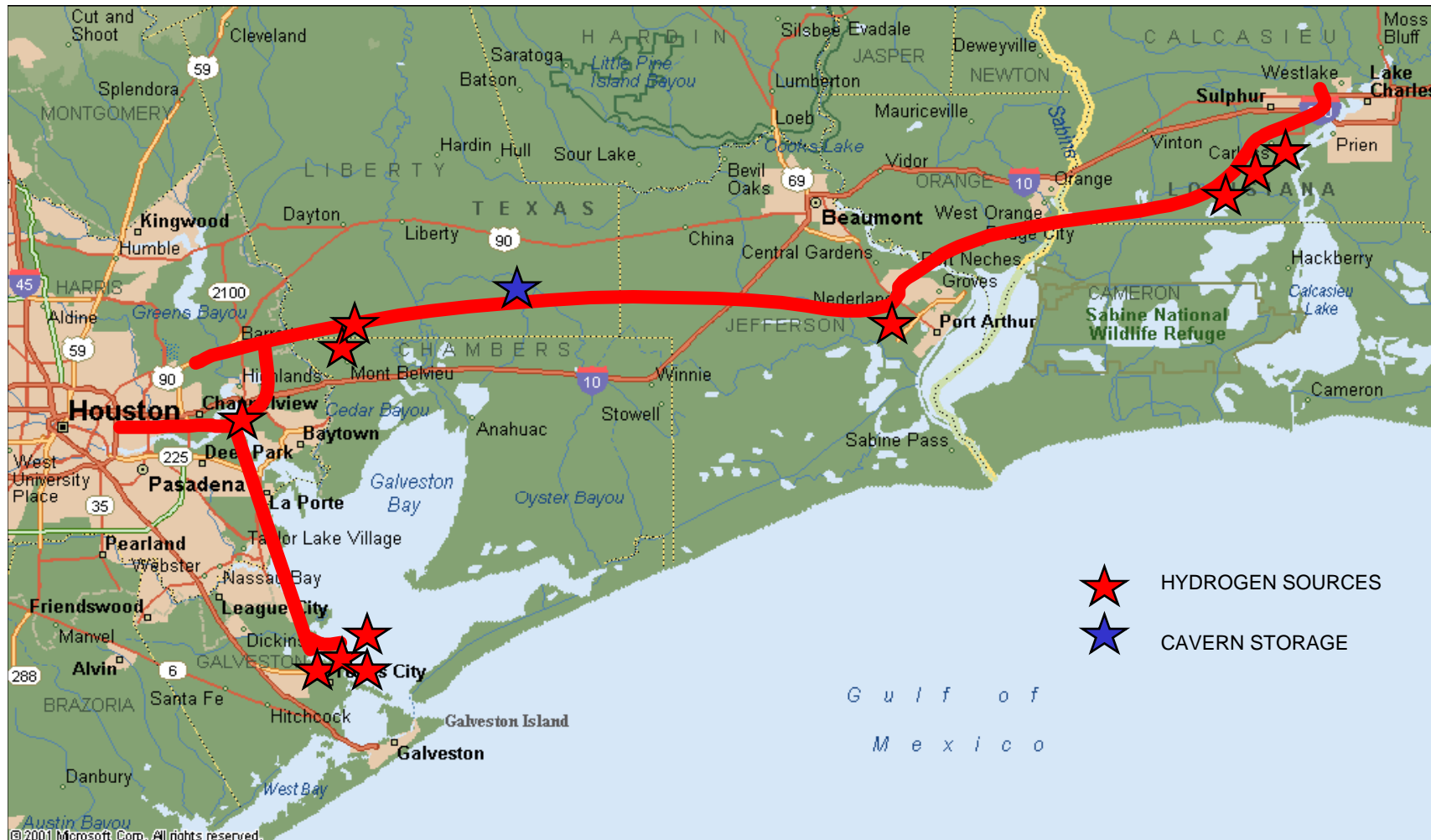
San Antonio, TX

October 18, 2010

- ◆ **Largest Industrial Gas Company in North and South America, one of the largest worldwide**
  - 27,000 employees
  - 2009 sales: \$9 Billion
  - Fortune 300 company (NYSE:PX)
  - Hold almost 3,000 patents
- ◆ **Praxair's primary products are:**
  - atmospheric gases (oxygen, nitrogen, argon and rare gases)
  - process & specialty gases (carbon dioxide, helium, hydrogen, semiconductor process gases, acetylene)

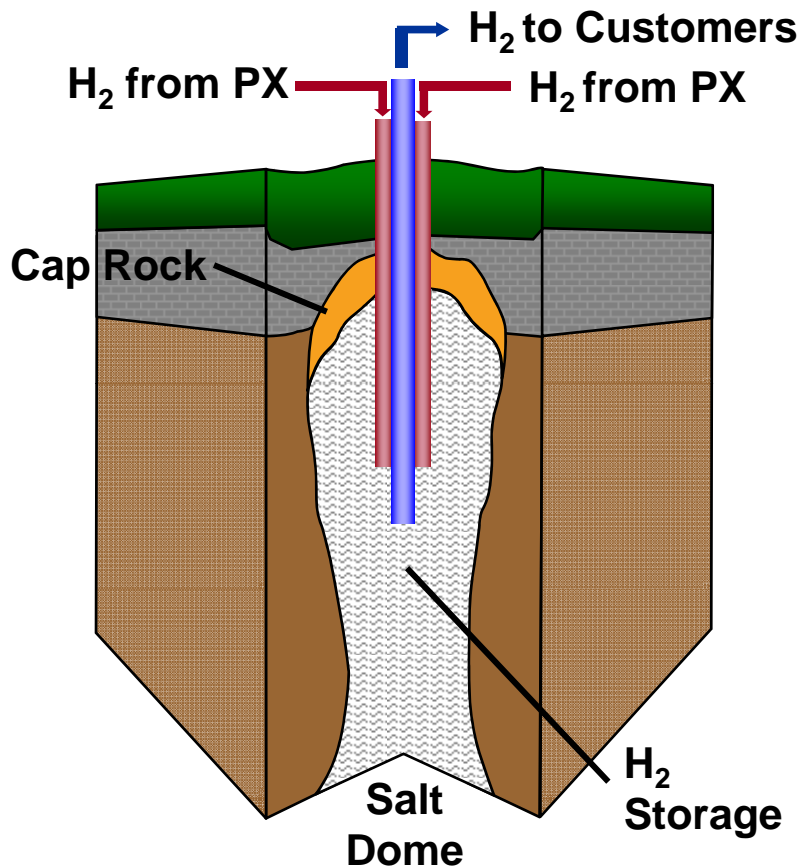


# Gulf Coast Hydrogen Infrastructure



◆ Cavern and Pipeline system connected to 11 out of 14 refineries

# Hydrogen Cavern Overview



## ◆ Praxair's Hydrogen Storage Cavern consists of

- Injection compressor with ancillary equipment,
- Hydrogen product dryer and
- Associated metering & control equipment.

# Hydrogen Cavern Design Basis

- ◆ **Storage Capacity: 2.5 Billion CF**
- ◆ **Working Capacity: 1.4 Billion CF**
- ◆ **Max Storage Pressure: 2200 psig**
- ◆ **Commissioned: Q4 2007**

# Cavern Commercialization Goals

- ◆ **Safe injection / withdrawal of hydrogen**
- ◆ **“real-time” operation**
  - add value for supply-system optimization and peak demand
- ◆ **Establish operational procedures**
  - informed, timely decision making around sales, withdrawals and injections
- ◆ **Key value creation streams:**
  - Reliability sales (sales within firm volume)
  - Operational and sourcing optimization
  - Spot sales (sales outside of firm volume – option refiners did not have in the past)

# Cavern Support Infrastructure



- ◆ More than just a hole in the ground – patented technology

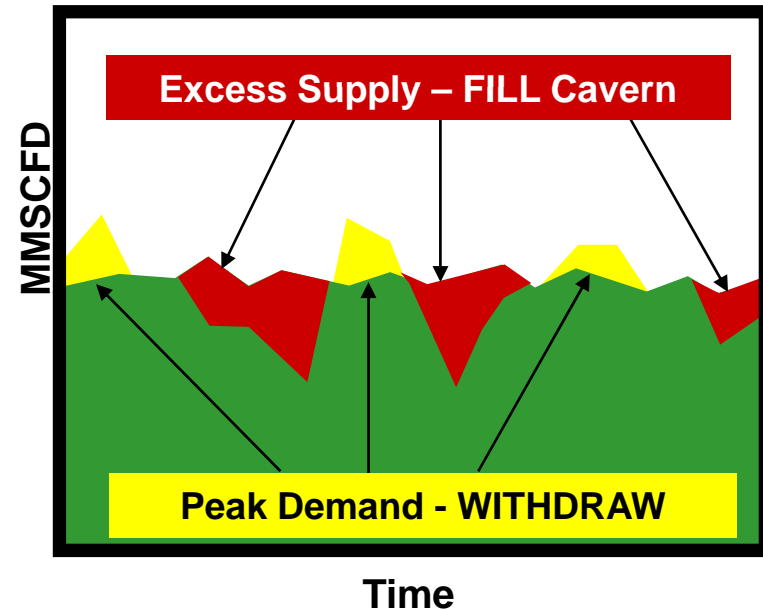
# Cavern Benefits

## ◆ Instant Sales Capability

- Planned customer turnaround
- Unplanned customer outage
- 3rd party supply interruptions

## ◆ Superior System Reliability

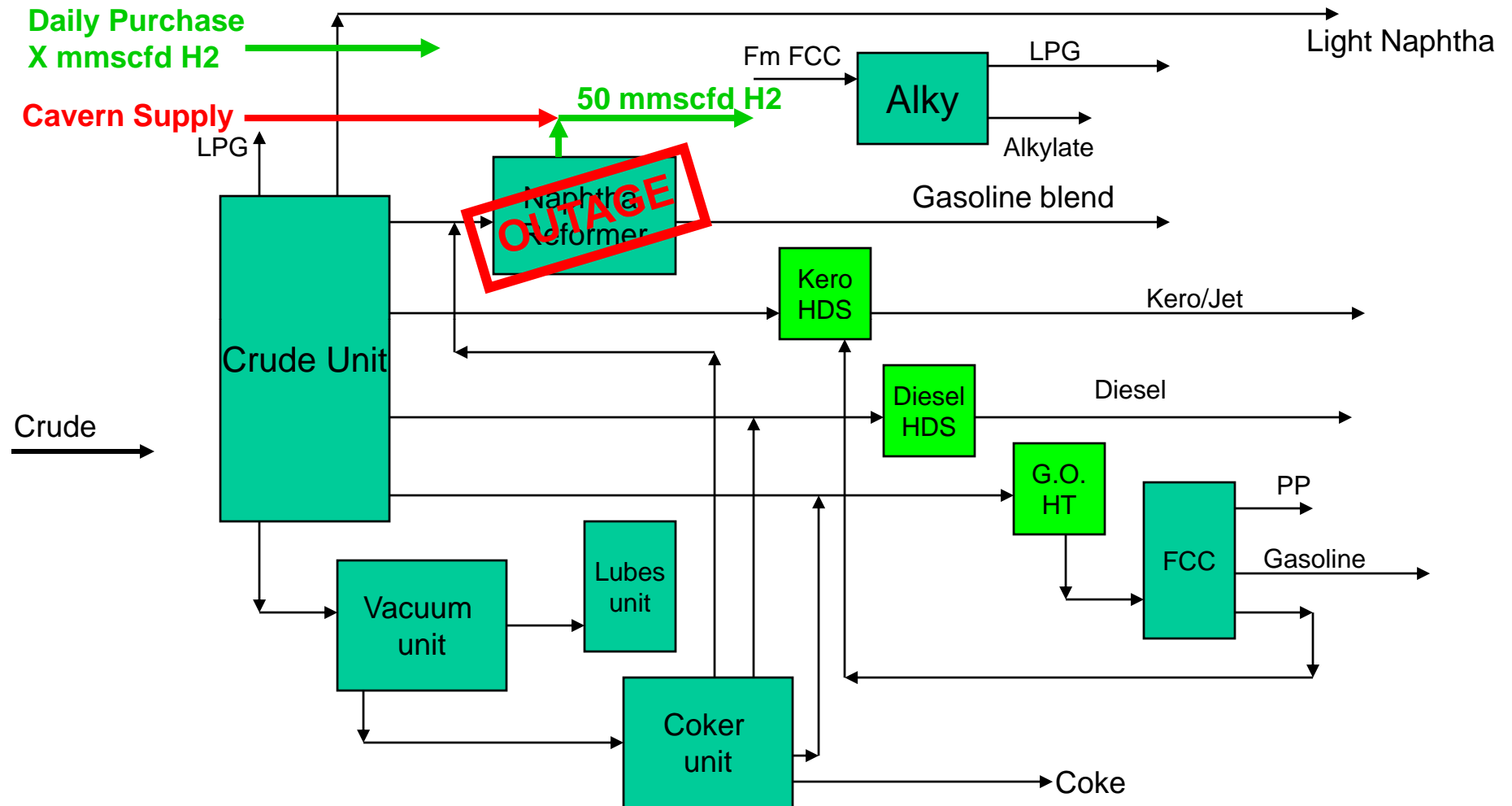
- Praxair facility turnaround
- Praxair equipment outages
- Feedstock / Utility interruptions



## ◆ Operational Considerations

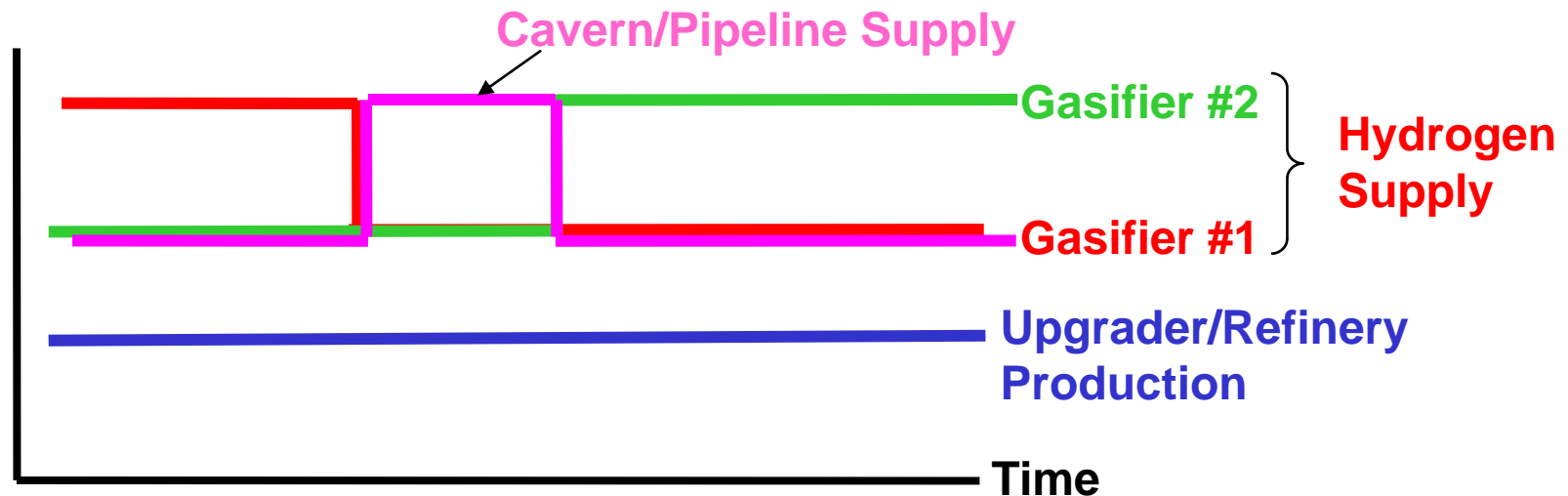
- Enable steady state operations
- Provide low demand “sink”
- Improved pipeline operability

# Instant Customer Backup



◆ Cavern Supply Can Help Avoid Cutback of Profitable Units

# Potential Use with Gasification



- ◆ Cavern/pipeline backup adds flexibility and smoothes hydrogen supply from gasifiers