

Introduction to the Safe Design of LNG, CNG and Hydrogen Refueling Stations

**Presentation to
SFPE
Northern California and Nevada Chapter**

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Background

- Existing LNG Import Terminals
 - ◆ 5 in North America, 17 new plants approved, 25 proposed and submitted for approval, 17 more in planning
- Existing LNG/CNG Refueling Facilities
 - ◆ Garden Grove, Anaheim, Irvine, Santa Monica
- Proposed
 - ◆ LNG offloading in Long Beach
 - ◆ 5 Hydrogen plants in SoCal



Alternative Fuels

- Demand driven by environmental goals
- Methanol
- Electrical (Batteries)
- Natural Gas
 - ◆ CNG
 - ◆ LNG
- Hydrogen



CRYOGENIC CHARACTERISTICS

Cryogenic temperatures are defined as between -150°F and -460°F (absolute zero).
At atmospheric pressure LNG boils at -259°F .
Hydrogen boils at -430°F



FIRE HAZARD PROFILE - LNG

Lower Explosion limit (% by vol.):	5.0
Upper explosion limit (% by vol.):	15.4
Auto ignition temperature:	537°C
Flammability classification	Flammable
Sensitivity to static discharge	Ignitable by static electricity. Escaping gas may self ignite



FIRE HAZARD PROFILE- HYDROGEN

Lower Explosion limit (% by vol.): 4.0

Upper explosion limit (% by vol.): 75.00

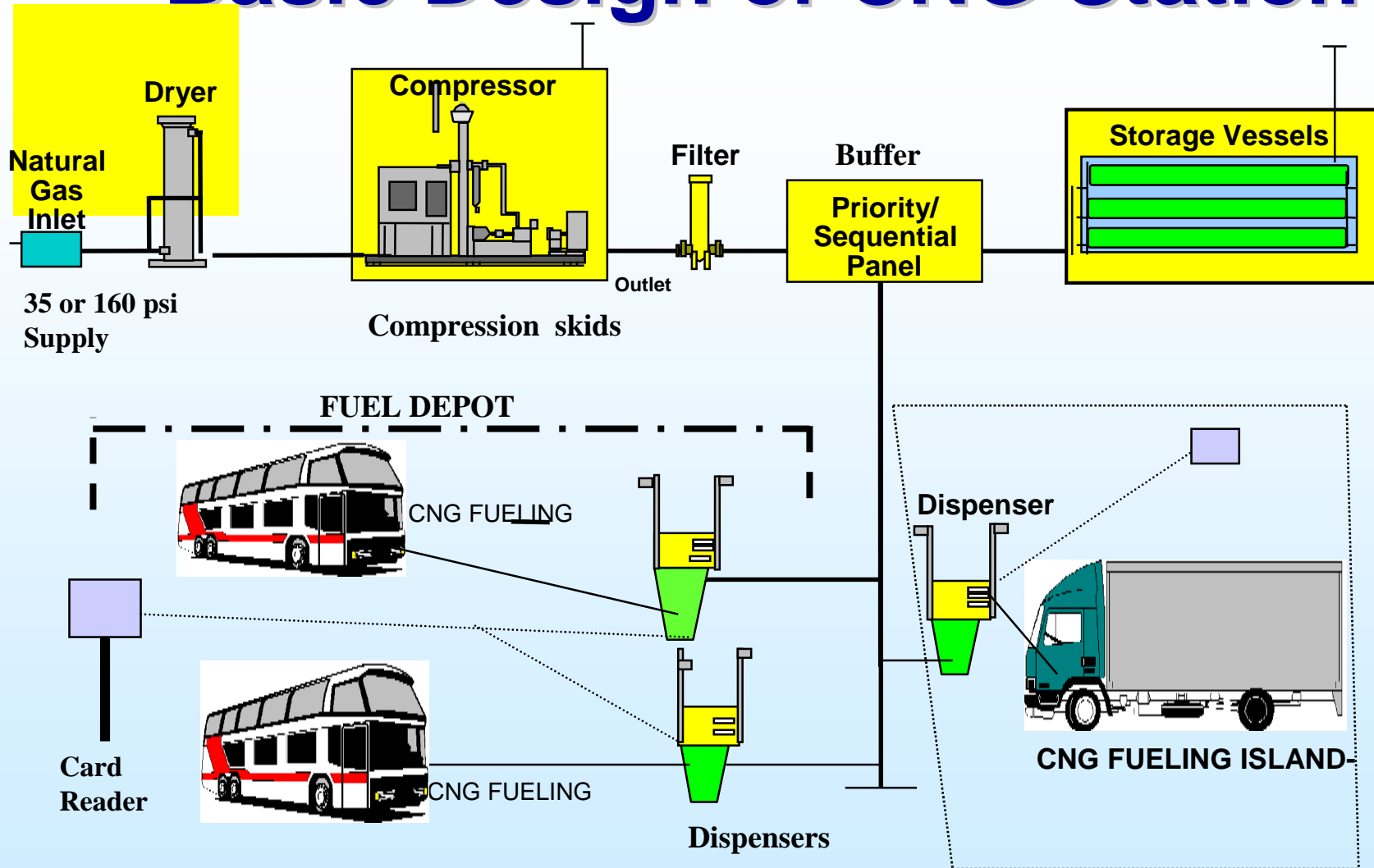
Auto ignition temperature: 575°C

Flammability classification Flammable

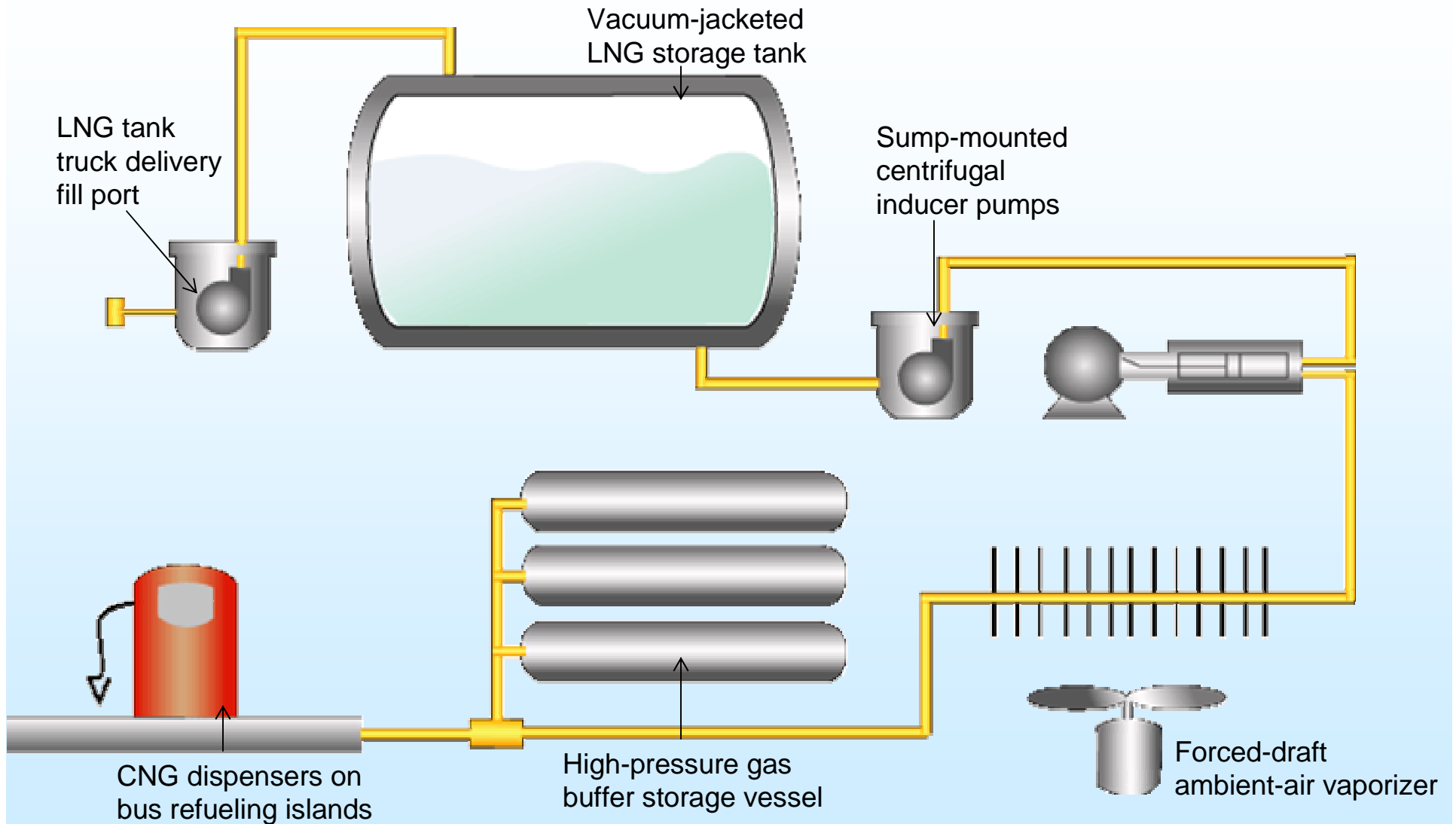
Sensitivity to static discharge Ignitable by static electricity. Escaping gas may self ignite because of friction.



Basic Design of CNG Station



Basic Design of L/CNG Station



LNG/CNG

LNG Release Behavior (Cont'd)

- As LNG vaporizes, water in air
 - ◆ Condenses
 - ◆ Forms visible cloud
- Initial release heavy, as it warms becomes light like CNG at -30°F



LNG/CNG

Methane Gas Supplies

■ CNG

- ◆ Pipeline to compressor to CNG storage
- ◆ Truck as CNG to CNG storage

■ LNG

- ◆ Made on site
- ◆ Shipped in trucks to LNG storage



LNG/CNG

Methane Gas Supplies (Cont'd)

■ L/CNG

- ◆ LNG/pump/vaporizer/
CNG storage
- ◆ LNG/vaporizer/
compressor/storage



LNG/CNG

Hazards of Natural Gas

- Fuel accumulation
 - ◆ Near ceiling
 - ◆ In presence of potential ignition sources
- Fast releases
 - ◆ Possible
 - ◆ Considered improbable



Applicable Standards

- NFPA 52, 2006 edition
- NFPA 55 2005 edition
- NFPA 57 (Combined into NFPA 52)
- NFPA 59A, 2006 edition
- NFPA 88
- Building Code
- Fire Code
- Pressure-vessel Code



Applicable Standards

California Title 8: Pressure Vessel Code (Cont'd)

- Incorporates NFPA 52/57/59A
- Approved in March, 2000 Methane Detection
- Addressed engineering approval of LNG Refueling



Site Considerations

- Spacing
 - ◆ Site
 - ◆ Equipment
- Drainage
 - ◆ Away from buildings/equipment
 - ◆ LNG vaporization rate
 - ◆ LNG spill rate
 - ◆ Environmental contamination
- Pressure Relief Discharge



Facilities

Above-ground Tank, L/CNG Station



Tank, pumps, vaporizer,
containment, buffer



Fueling island
dispensers



Facilities

Above-ground Vault, L/CNG Station



Space constrained in residential area



Facilities

- LNG tanks & pumps in low-profile 87' x 38' vault
- High-expansion Foam System fills vault in ~2 minutes
- HAZOP - Process Safety Analysis
- Vault
 - ◆ ½ above grade
 - ◆ ½ below grade
 - ◆ Walls Concrete Masonry Unit
 - ◆ Ventilation System
 - ◆ Blast-proof Doors
 - ◆ Deflagration-relief Roof Panels



Facilities

LNG Vessels Inside Vault



Facilities

LNG TO CNG

Pumps Inside Vault



Facilities

Above-ground Vault Foam System Test



Facilities

Below-ground Tanks



Facilities



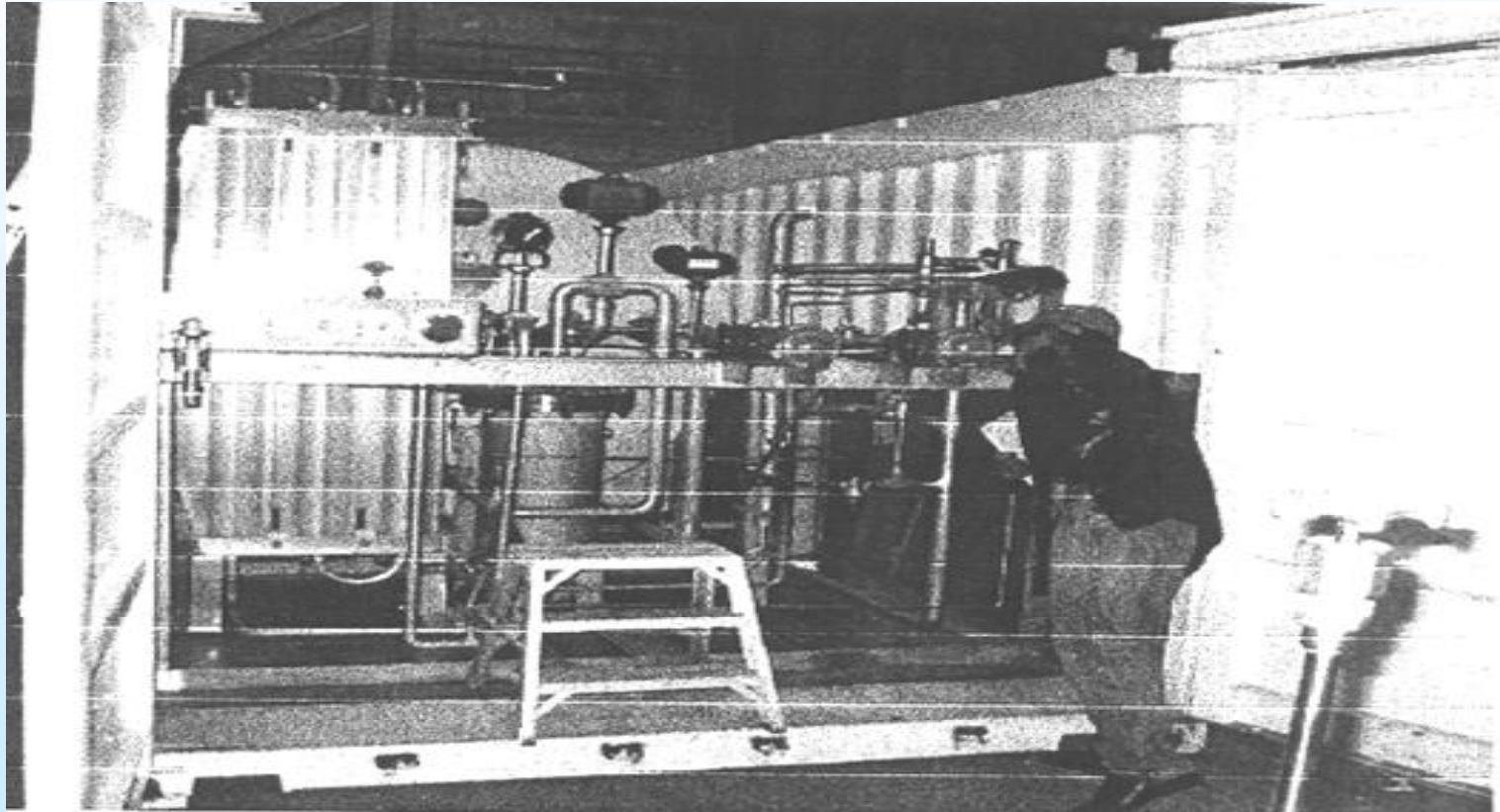
Temporary



Facilities – Refueling Station



Facilities- Temporary



Pressure Letdown During Delivery



Sodium Bicarbonate Application



Sodium Bicarbonate Application



What is Hydrogen?

- Odorless
- Tasteless
- Nonirritating
- Nontoxic
- Colorless
- Flammable
- Rises and dissipates quickly
- No environmental impact

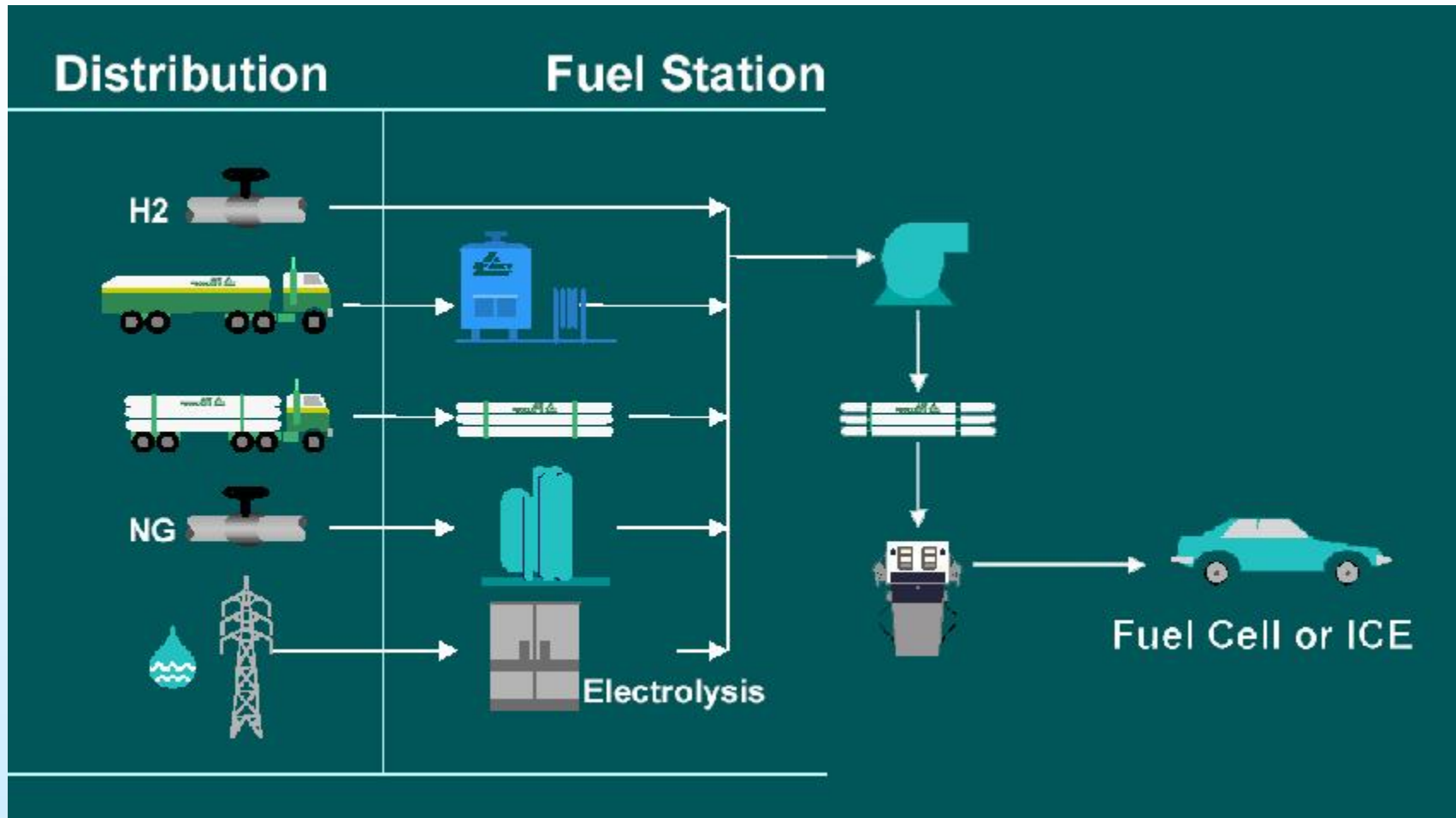


For Automotive Applications Where Does H₂ Come From?

- Hydrogen is DERIVED from
 - ◆ Hydrocarbon based fuels, steam methane (SMR) reforming - 80% today
 - ◆ By-product of chemical processes, purification (20% today)
 - ◆ Water, electrolysis (niche applications today)



Hydrogen Supply Modes



Hydrogen Supply Modes

Liquid Hydrogen Delivery

- Delivered in Tankers
- Stored onsite as Cryogenic Liquid
- Vehicle Fueling Applications:
 - ◆ Gas Onboard
 - ◆ Liquid Onboard



Hydrogen Supply Modes

Gaseous “Tube Trailer” Delivery

- ◆ Delivered in High Pressure Tubes



Basis for H₂ Fuel Stations

- Hydrogen Supply Mode
 - ◆ Onsite Production or hauled in
 - ◆ Utilities
- Compression
 - ◆ Required pressure, flow rates
 - ◆ Maintenance program
 - ◆ Gaseous Compression vs. Liquid Pump
- High Pressure Storage
 - ◆ ASME Compliant Vessels for Stationary
 - ◆ DOT Compliant for Mobile Storage



H₂ Fuel Stations

- Dispensing
 - ◆ Automatic vs. Manual
 - ◆ Trained Operators
- Siting Issues/Permits/
Codes and Standards -
NFPA, DOSH.
- Miscellaneous
 - ◆ Personal Protective Equipment (PPE)
 - ◆ Safety Reviews - FEMA, Hazop
 - ◆ Develop site document



APCI Hydrogen Fuelers

- H2 Delivery for small fleets or spot jobs
- Various sizes and pressures



Hydrogen Supply Modes

- On-site Reforming
 - ◆ Fossil Fuel Feed Stock
 - ◆ Demonstration Project



Hydrogen Supply Modes

- On-site Electrolysis
 - ◆ Water and Electricity Feed Stock
 - ◆ Up to 100 kg/day
 - ◆ Demonstration Projects
 - ◆ Pathway to renewable fuel



Hydrogen Supply Modes

- Packaged Gases - Cylinder Supply
 - ◆ Small volumes, spot requirements
 - ◆ Portable Fueling Center/Cart



Hydrogen Fuel Stations

University of California Davis



Hydrogen Fuel Stations



University of California - Irvine, CA



Ford Motor Co. - Dearborn, MI

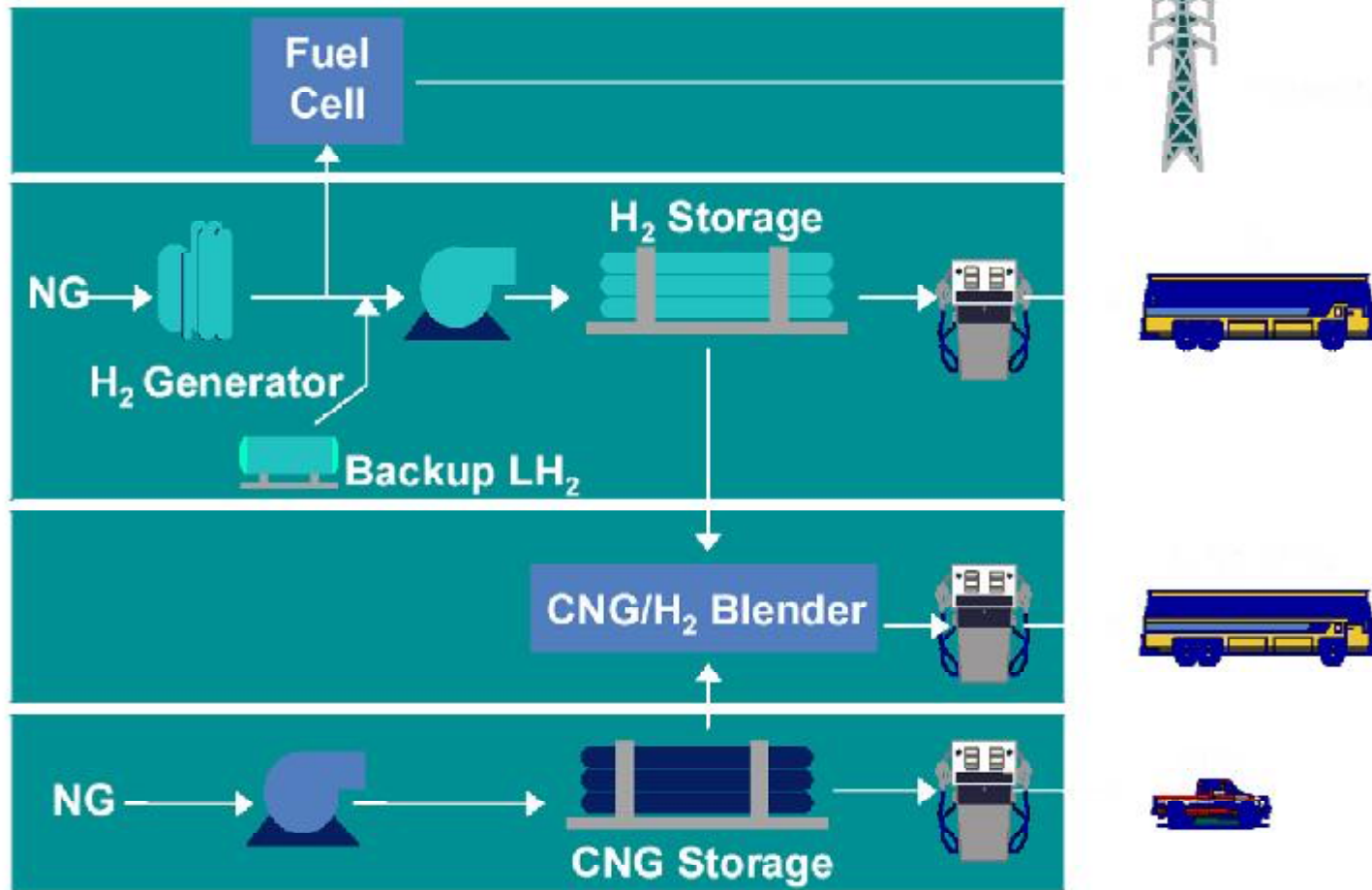


Hydrogen Fuel Stations

City of Las Vegas, NV



City of Las Vegas H₂ Projects



Hydrogen Fuel Stations

Chicago Transit Authority (CTA) Chicago, IL



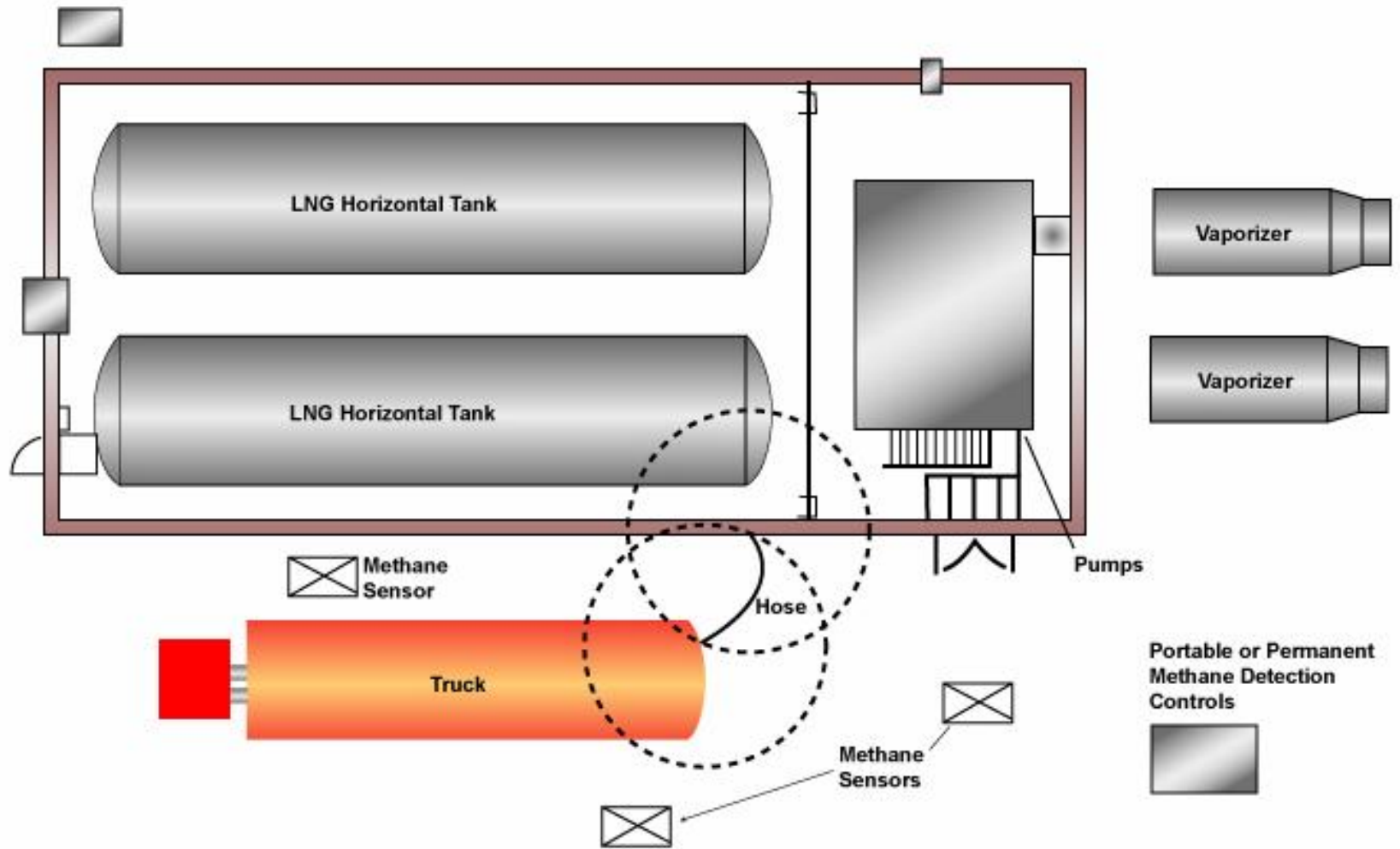
Hydrogen Fuel Stations



Cal. Fuel Cell Partnership
West Sacramento







Finished Station



Ann Arbor, MI



Compressor



Compressed H₂ Storage





Fuel Dispensers



Mobile Fueler



Tips for Successful Projects

- Process Safety Analysis
- Piping & Instrumentation Diagram
- Emergency Shut Down
- Site Plan/Spacing/Drainage



Tips for Successful Projects

- Deficiency Resolution
 - ◆ Responsibility
 - ◆ Equivalency Approvals
- Documentation
- Training



Tips for Successful Projects

- Process Safety Management

- ◆ API RP 750
- ◆ AI ChemE/CCPS
- ◆ OSHA

Don't forget Fire Protection
Considerations
for Maintenance Garage!



Tips for Successful Projects

In CA, all dispensing facilities

- Certified for
 - ◆ Engineering integrity
 - ◆ Safety and compliance

- By California Registered Engineer(s) competent in design, fabrication, construction of Cryogenic



Tips for Successful Projects

- ◆ **Fire detection**
- ◆ **Fire protection equipment**
- ◆ **Methane or hydrogen gas detection**
- ◆ **Other components of the facility**



General Requirements

- ESD Matrix
- Fixed and Portable Gas Detection
- Gas Alarms Transmit to FD
- Location of Safety Equipment



Initial Inspection

- Verify ESD Matrix
 - ◆ Alarm Triggered by Gas Detection (10%LFL)
 - ◆ Power and Fuel off (all required circuits) (50% LFL)
- Restart after Shutdown
- Electrical Area Classification



Follow-up Inspections

- Maintenance and Training Records
 - ◆ Approved Drawings, PSA, etc.
 - ◆ PRV's
 - ◆ Gas Detection System
 - ◆ Corrosion Protection
- Location of Safety Equipment
 - ◆ Shields, Gloves, Aprons, etc.
 - ◆ Portable Gas Detectors
- Retest ESD Matrix
 - ◆ All Required Power Off
 - ◆ Restart
- Non-suitable Electrical Equipment/Wiring



Burning Questions?

