H_2 Reformer, Fuel Cell Power Plant, & Vehicle Refueling System

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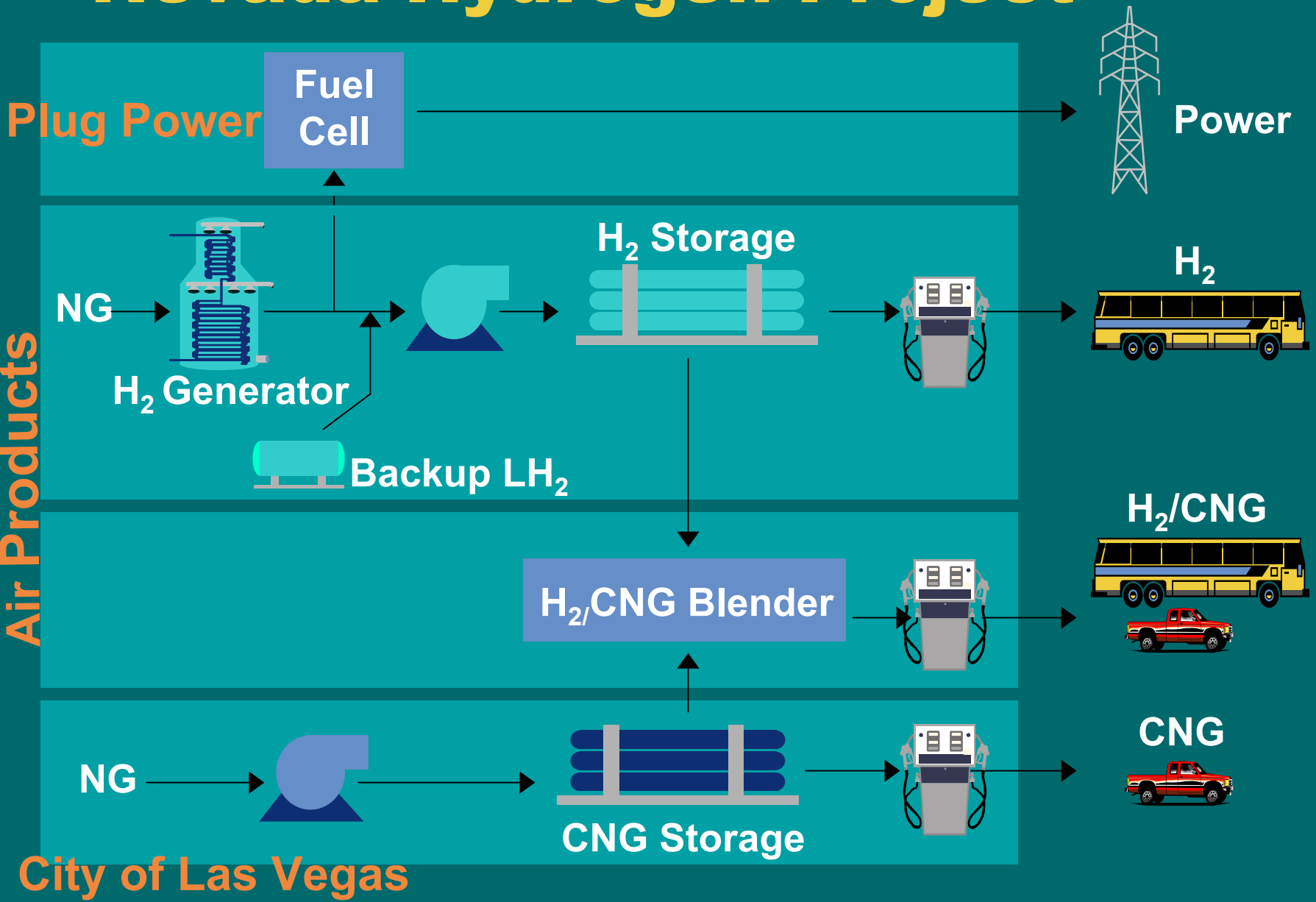
Nevada Hydrogen Project



Goals and Objectives

- Develop & demonstrate small, on-site H_2 production for fuel cells and H_2 fuel stations
- Design & install multipurpose vehicle refueling station to dispense H_2/CNG blends, and pure H_2
- Develop & install H_2-fueled stationary 50kW fuel cell
- Evaluate operability/reliability/economic feasibility, of integrated power generation and vehicle refueling designs
- Expand the current facility to serve as the first commercial facility when sufficient hydrogen demand develops.

Relevant DOE Program Objectives

- Reduce dependence on foreign oil
- Promote use of diverse, domestic energy resources
  - Natural gas reformation
- Develop and demonstrate distributed hydrogen generation technology …

Milestones

LH_2-based Fuel System On stream	July 2002
Scale-up H_2 Generator On stream	Aug 2002
Initial Startup of Fuel Cell	Aug 2002
Dedication Ceremony	15 Nov 2002

(FY 2003 Major DOE program accomplishment)

H_2 Generator & Fuel Cell

Fueling Station

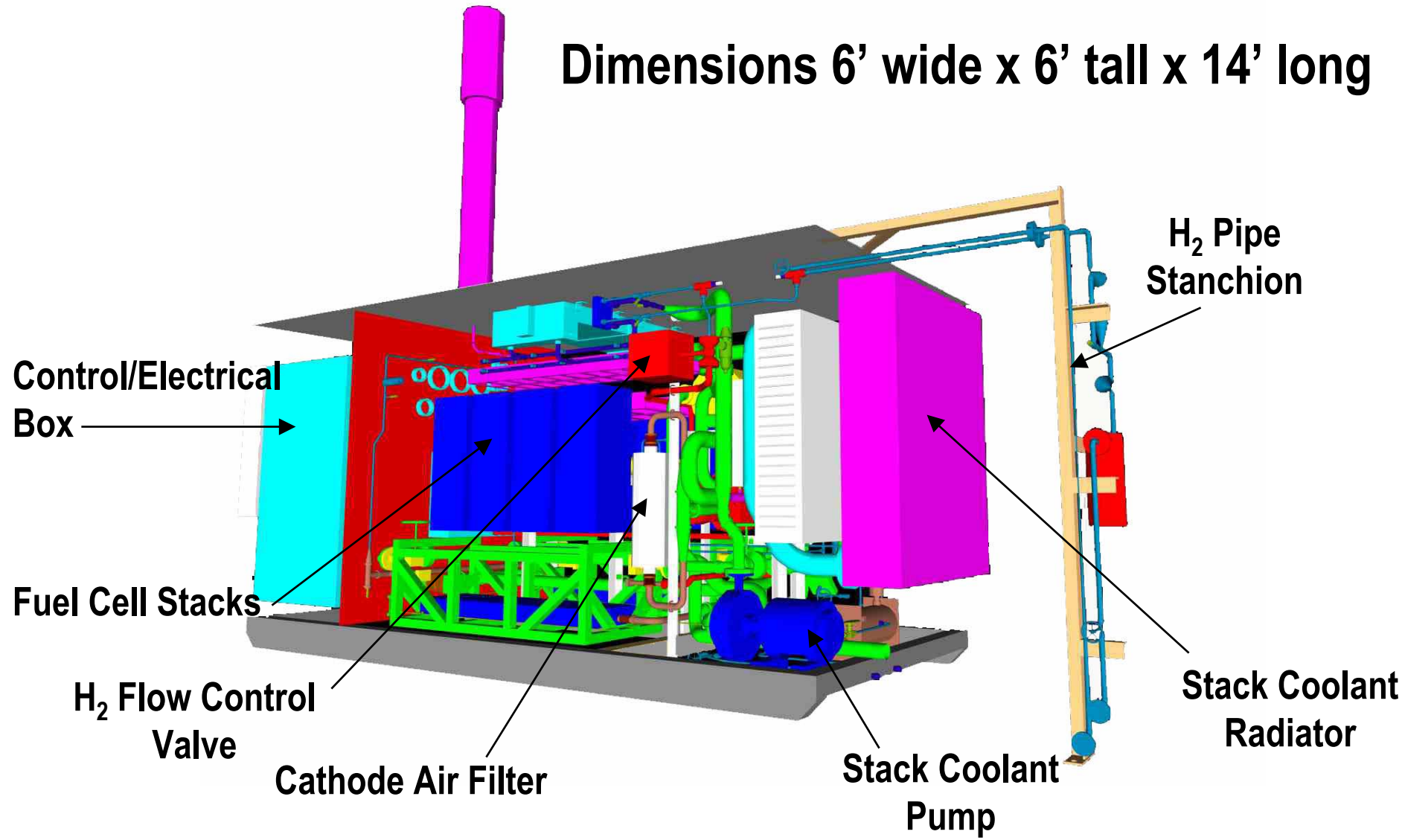
Status of Progress - H_2 Generator

- Excellent process operation and product purity of 99.95+% demonstrated
- Turn-up and turn-down of hydrogen production to accommodate varying demand by fuel cell and fuel station achieved
- Remote operation (using Enterprise remote asset monitoring) from any location
  - Currently from AP sites in Sacramento and Allentown, PA
- Performance evaluation in-progress
- Approximately 2200 total hours run time

Status of Progress - Fuel Station

- Fueling demand integrated with site wide operational controls allows for automated operation.
- CNG/H2 and H2 Fuel Dispensing successfully performed on test fill tank, CNG/H2 ICE vehicles and H2 Fuel Cell vehicles.
- Fuel dispensing integrated with City of Las Vegas fuel accounting system.
- Limited fueling demand at this time.
- CLV vehicle fleet establishment in progress; more demand for fueling expected in future.

Plug Power 50 kW Fuel Cell



Status of Progress - Fuel Cell

- Initial Startup - Aug 2002
  - Initial operational issues identified and addressed.
  - Identified two hardware design issues; scanner cards and drain valves.
- Dedication Ceremony Operation- November 2002.
- Hardware changes operational - April 2003.
  - Scanner cards redesigned and installed.
  - Water drain valve approach modified.
- Operational issues with cell voltage falloff prevented continuous operation.

Status of Progress - Fuel Cell

- Engineering team on site 4/30 to continue to evaluate root cause and develop options to place unit in operation.
- Design approach of multiple stacks with no ability to independently manage gas flows, temperature, humidity and power challenging
- Excellent list of lessons learned compiled. Additional lessons learned from PlugPower single stack 5 KW systems combined in future designs.
- Unit successfully ran 3 days with trip by reformer. Restarted successfully and ran another 3 days with trip due to low voltage stack
- Stack will be replaced week of 5/27 and restarted
- Current performance indicates near term target of 2 - 3 months operation will be met with minor tweaks.

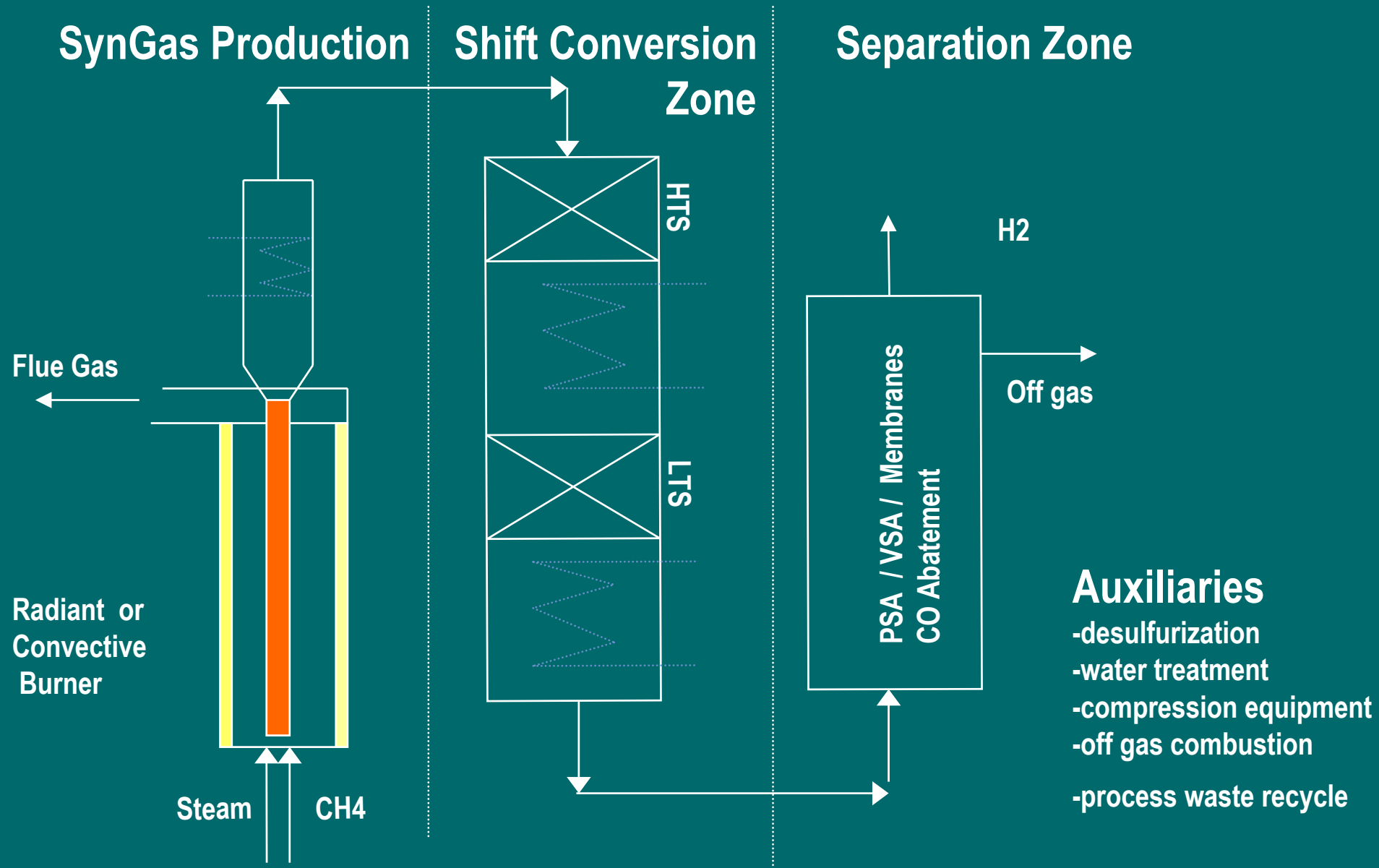
Future Work

- Begin extended unattended operation of Fuel Cell Power Generator - June 2003
- Achieve extended integrated run of H2 Generator and fuel station - June 2003
- Ongoing collection of site performance data to assess overall operation of the system - May - Nov 2003
- Vehicle fleet buildup will add 6 CLV H_2/CNG buses, and various light duty vehicles (dependent on external effort) - May 03 - May 04

Status of Business Plan & Safety Review

- Business plans to follow installation and routine operation of the integrated systems
  - Partners are interested in total integrated system as well as individual components
- Safety is top priority in design, construction and operation
  - Process & Design HAZOPs conducted on components
  - All safety and industry codes are addressed in designs
  - Air Products' 40 years of experience in commercial H_2

Traditional SMR

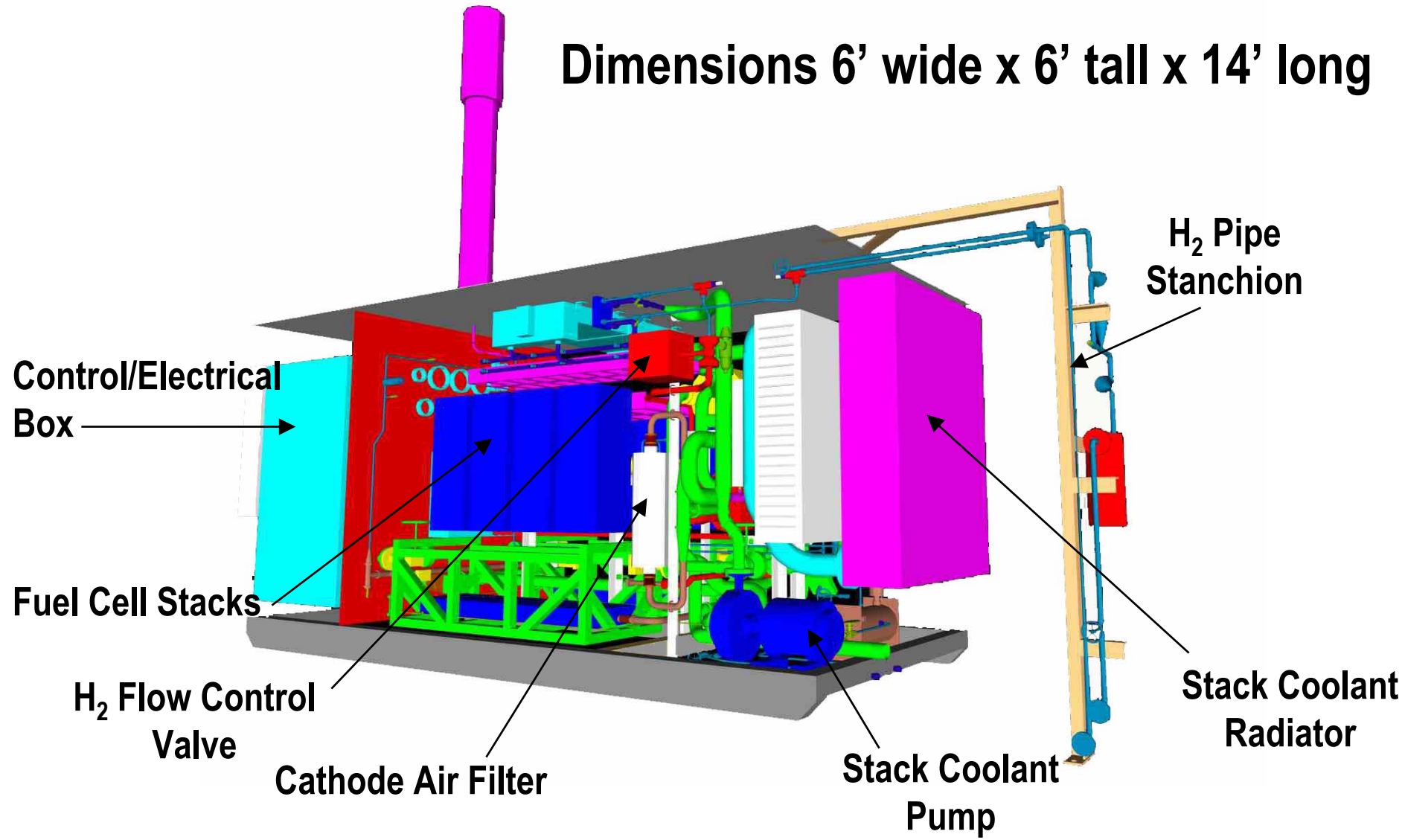


Auxiliaries

-desulfurization
-water treatment
-compression equipment
-off gas combustion
-process waste recycle

Harvest SMR – Container Internals

Plug Power 50 kW Fuel Cell



Projected H_2 Demand

Project Phase & Date	Hydrogen Applications	H_2 Demand SCFD	Proposed Hydrogen Supply Approach
Phase 1 May 2002 - Jun 2002 Initial Fuel Station Startup	1 - 3 H_2/CNG Light Duty Vehicles (LDVs) 1 H_2 Hybrid Elec. bus 1 H_2/CNG Bus by CLV for testing beginning Jan 2001.	1,000 - 3,000	LH_2 to supply vehicle fueling initially.
Phase 2 Jun 2002 - Dec 2002 Vehicle Fleet Buildup	6 - 11 H_2/CNG LDVs 1 H_2 Hybrid Elec.bus 2 - 6 H_2/CNG Buses 50kW Fuel Cell @ 25 - 50% rate	3,000 to 15,000 3,000 to 15,000	H_2 Generator Prototype (17,000 SCFD) will supply H2; Liquid H_2 is used as backup/peak shave. Fuel Cell balances H2 Gen. Production
Phase 3 Jan 2003- Sept 2004 Full Station Operation	6 H_2/CNG Buses 11 - 20 H_2/CNG LDVs 1 H_2 Hybrid Elec Bus 50kW Fuel Cell @ full rate	54,000	Commercial H_2 Generator (65,000 SCFD) will supply H2 as bus fleet buildup achieves targets.

NV Hydrogen Program Projects Initiated in FY99

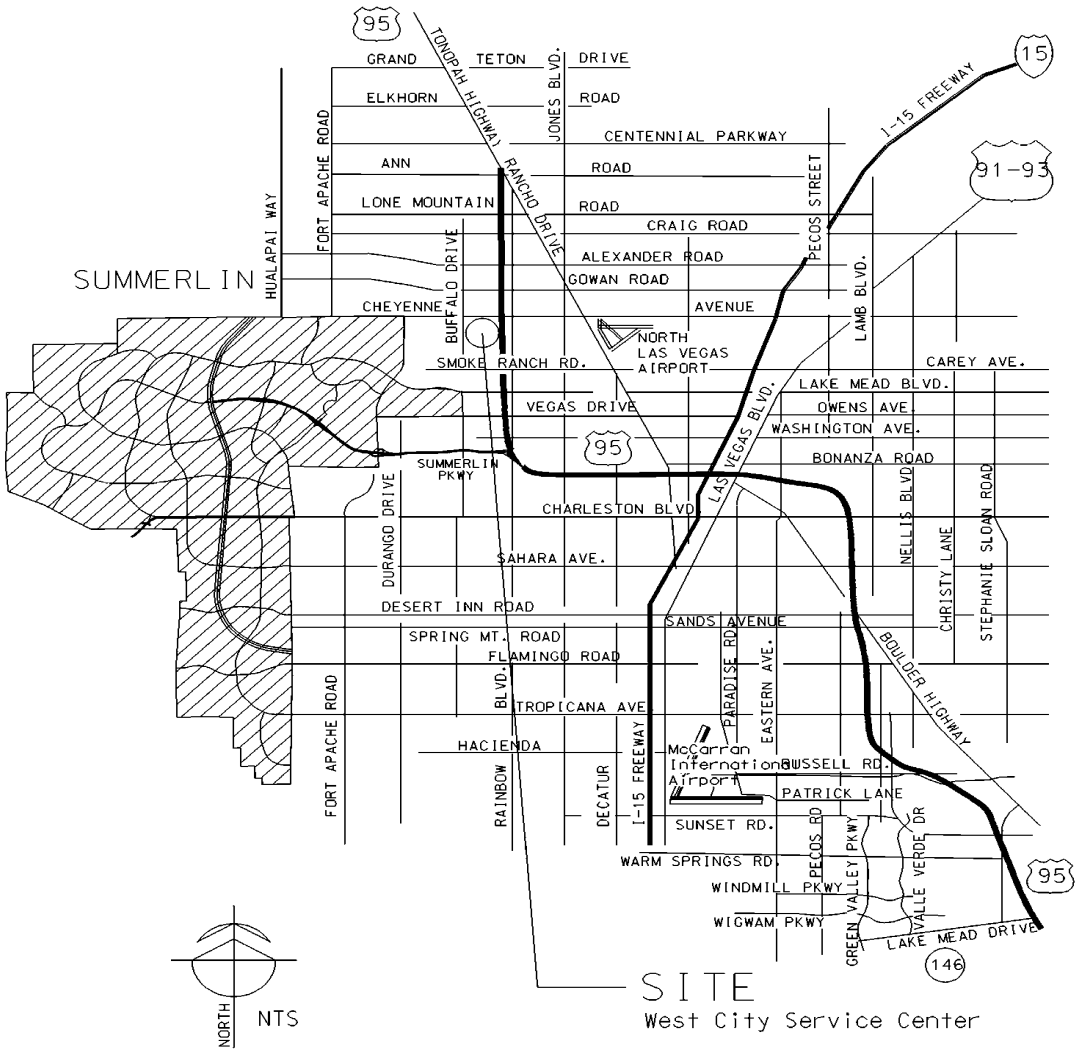
- Hydrogen Reformer, Fuel Cell Power Generator, and Vehicle Fueling System Project: Develop & demonstrate cost effective hydrogen/electricity co-production system.

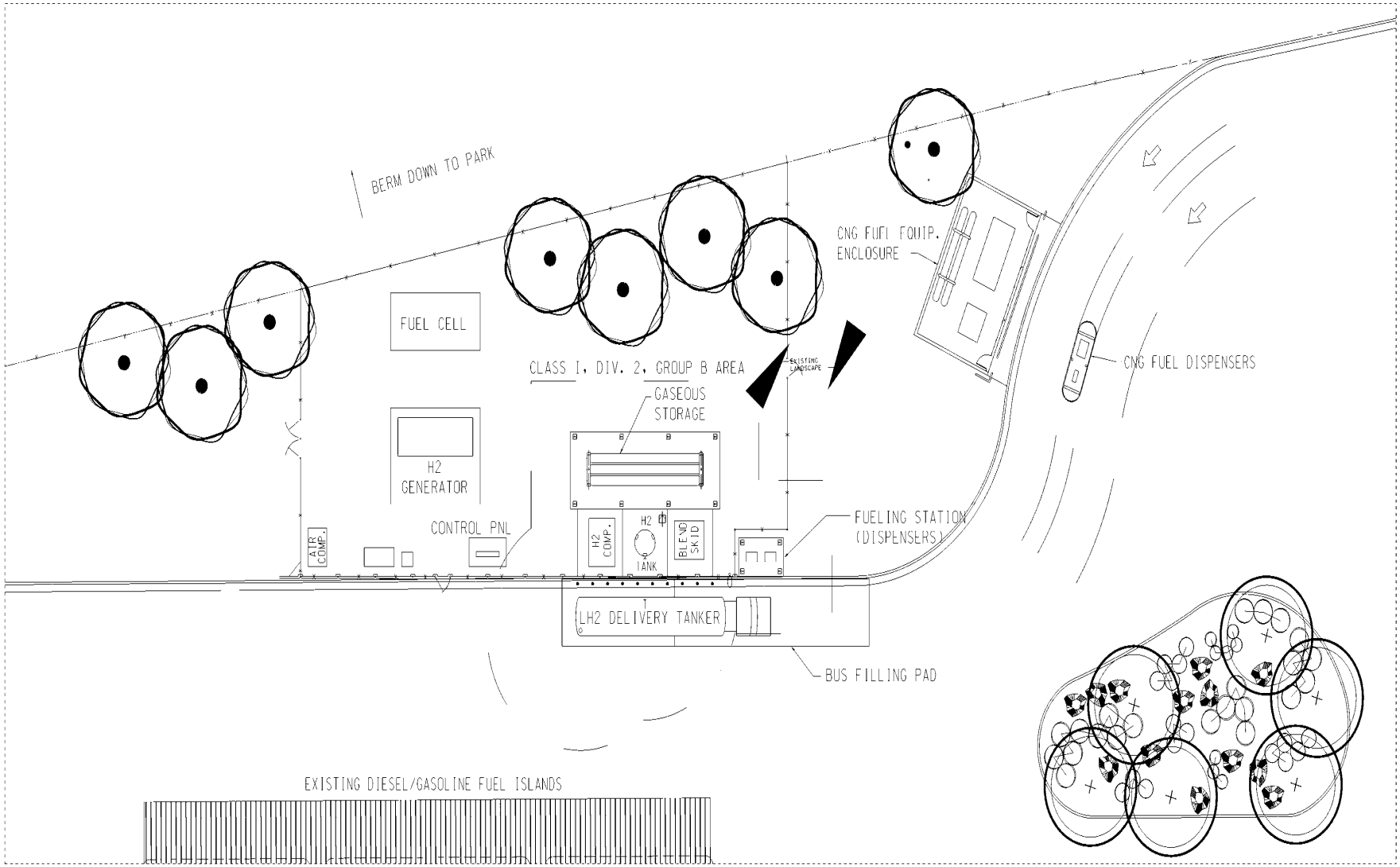
- Hydrogen-Enriched Light-Duty Vehicle Fleet Project: Achieve Equivalent Zero Emission Vehicle (EZEV) levels for combined NOx and CO.

- Hydrogen-Enriched Natural Gas City Bus Fleet Project: Demonstrate a 75% emissions reduction in heavy duty engine, mass transit application.

- UNLV H2Fuel Bus Evaluation and Upgrade Project: Develop a hydrogen transportation system demonstration platform.

VICINITY MAP – LAS VEGAS





ENLARGED PLAN - HYDROGENATED FUEL SITE & CNG FUEL SITE

Scale: 1" = 20' 0"

Hydrogen – Natural Gas Vehicles

- Heavy Duty Engine Development and Vehicle Demonstration Project

  - Retrofit up to six, 33 passenger, dedicated natural gas buses for CLV service
  - Range = 200 + miles
  - 75% reduction below EPA 1998 Heavy Duty Emission Standards

Hydrogen – Natural Gas Vehicles

- Light Duty Engine Development and Vehicle Demonstration Project
  - Convert up to 18 F-150 trucks to operate on Hydrogen enriched natural gas
  - Place in service with CLV
  - Emissions meet or exceed 2003 CARB Super Ultra Low Emission Vehicle Standards