Hydrogen Technical Analysis: Energy Station

Work in Progress

2003 Hydrogen and Fuel Cells Merit Review Meeting

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Hydrogen energy stations could substantially enhance competitiveness of on-site hydrogen production in the near and long-term.

- Key hurdles to the development of a hydrogen infrastructure are:
  - Long-term cost of hydrogen
  - Transition cost to implement the minimum infrastructure
  - Efficiency of hydrogen production in on-site stations
- Combining hydrogen production with power production could provide synergy that could make both parts competitive:
  - Revenue from power sales help overall economics in early years
  - Improved economy of scale from larger systems reduces specific system cost
  - Synergy in storage system allows for cost reduction and low-cost back-up and rapid start-up for power generation system
  - Integration can increase overall efficiency slightly

The purpose of this study is to evaluate the issues surrounding the establishment of a hydrogen energy station.

- Evaluate combined fuel cell power/hydrogen Energy Stations
- Assess integration with buildings and potential for cogeneration
  - Analyze economics of energy station configurations
- Identify potential fleets for vehicle operation
- Establish partnerships for hydrogen fueling and power sales
- Identify barriers to hydrogen use

DOE Technical Targets: Integrated Stationary PEMFC Power System

Characteristics	Large (50-250 kW) Systems			
Calendar Year	Units	2003 Status	2005	2010
Electrical Energy Efficiency @ rated power	%	30	32	40
CHP Energy Efficiencyc @ rated power	%	70	75	80
Cost	$/kWe	2500	1250	750
Transient Response (time from 10% to 90% power)	msec	< 3	< 3	< 3

DOE R&D Plan

DG Technical Barrier F: Heat Utilization.

The low operating temperature of PEM fuel cell system technology limits the use of heat generated by the fuel cell, which represents approximately 50% of the energy supplied by the fuel. More efficient heat recovery systems and improved system designs and/or higher temperature operation of current systems are needed to utilize the low-grade heat and achieve the most efficient (electrical and thermal) distributed generation power systems.

The purpose of this study is to evaluate the issues surrounding the establishment of a hydrogen energy station

- Evaluate combined fuel cell power/hydrogen Energy Stations
  - Analyze energy station systems with 50 kW PEMFCs that are suitable for installation in Federal buildings
  - Analyze options for system components including direct hydrogen and reformate fuel cells and various storage, power production, and hydrogen usage configurations
  - Determine costs and energy efficiency for different system configurations
- Assess integration with buildings and potential for cogeneration
  - Analyze potential for heat recovery from fuel cell/hydrogen production systems
  - Identify potential for cogeneration in Federal building applications
- Identify potential fleets for vehicle operation
- Establish partnerships for hydrogen fueling and power sales
- Identify barriers to hydrogen use
- *This study was supported by DOE contract DE-FC36-01GO11088*

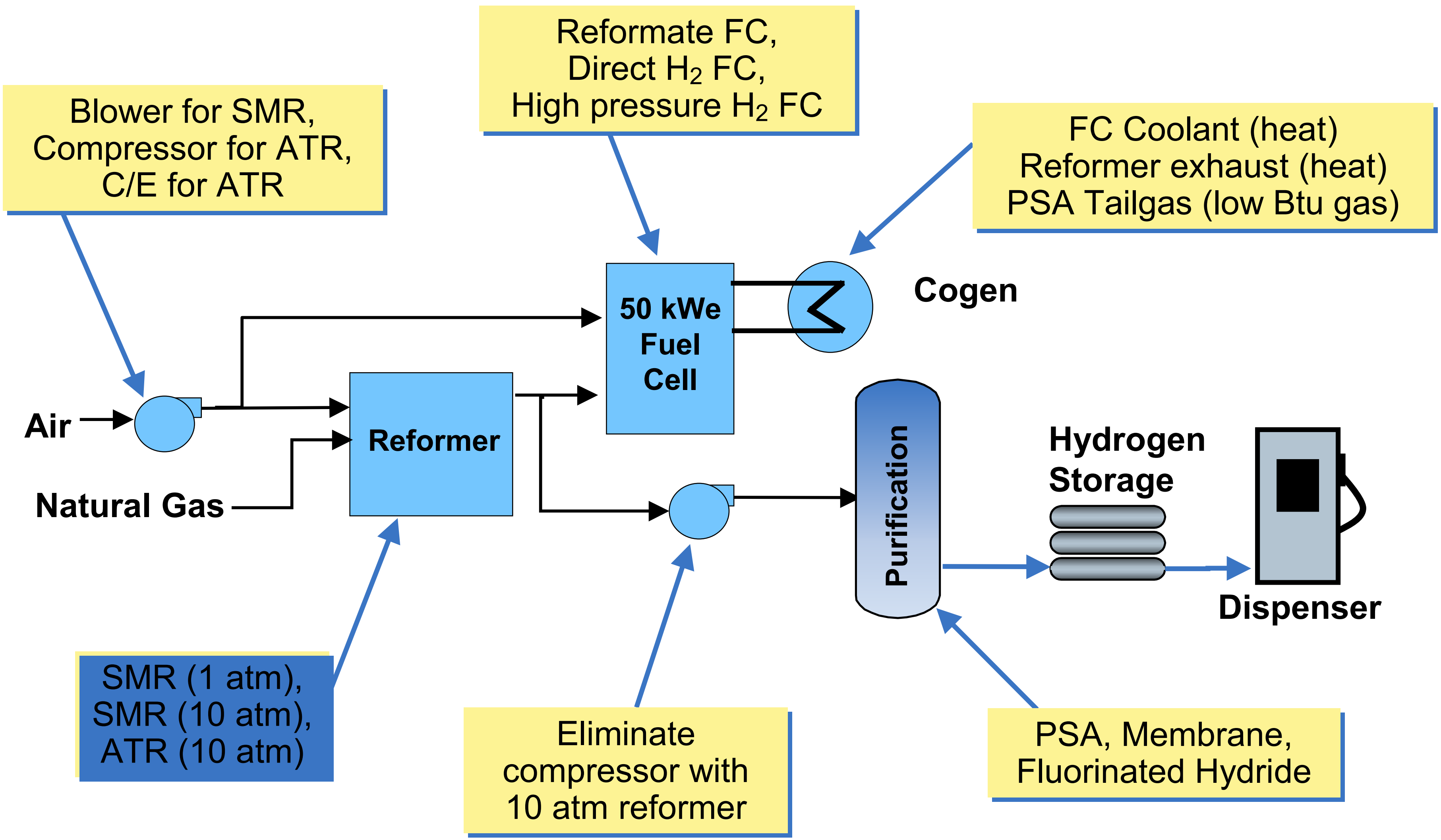
Prior to finalizing our analysis, we intend to obtain input from a range of potential stakeholders in both conventional and hydrogen fuel chains.

	Task	FY02				FY03				
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1
1	Analyze System Cost and Performance									
2	Assess Public/Private Fleets									
3	Evaluate Building Integration									
4	Analyze Integrated Power and Fueling									
5	Explore Public/Private Partnerships									
5	Identify Barriers to Hydrogen Use									
	Milestones									

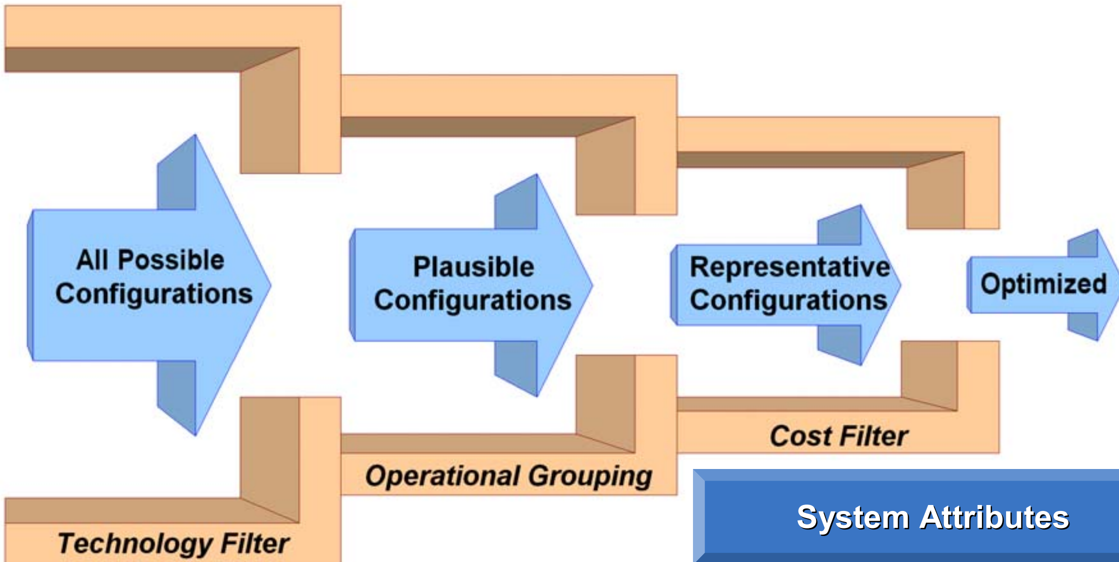
Identify Options for Analysis

Draft and Final Report

Several component choices are options for hydrogen production systems



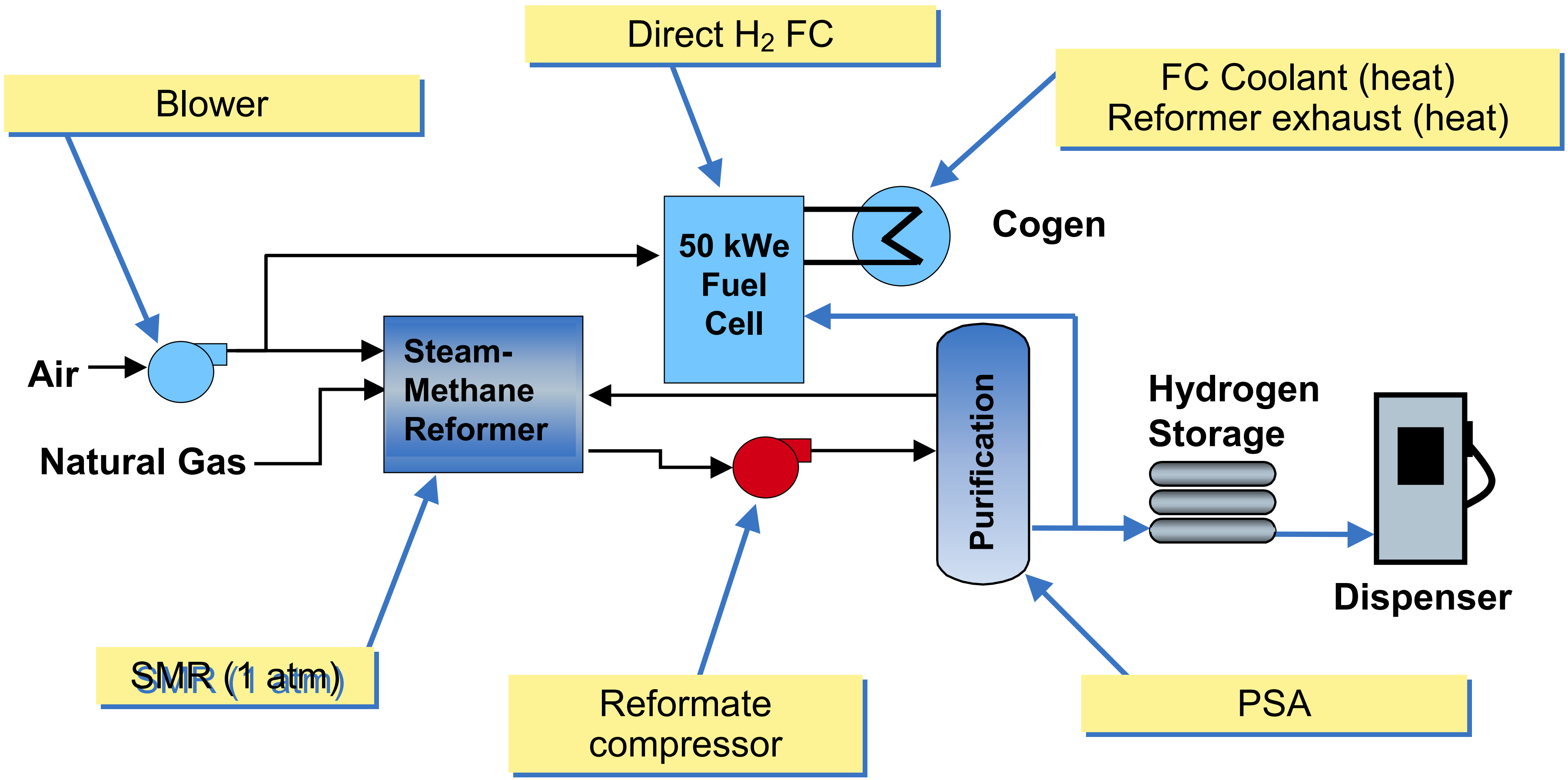
We applied filters to the matrix of possible configurations to select four promising technology combinations that meet various customer needs



System Attributes	Major Components
Conventional system	SMR, Reformate Fuel Cell, PSA
Lower cost fuel cell	SMR, PSA, Direct Hydrogen Fuel Cell
Small scale purification	SMR, Reformate Fuel Cell, Fluorinate metal hydrides
Simple cogeneration	Air Compressor, ATR, PSA, Direct Hydrogen Fuel Cell

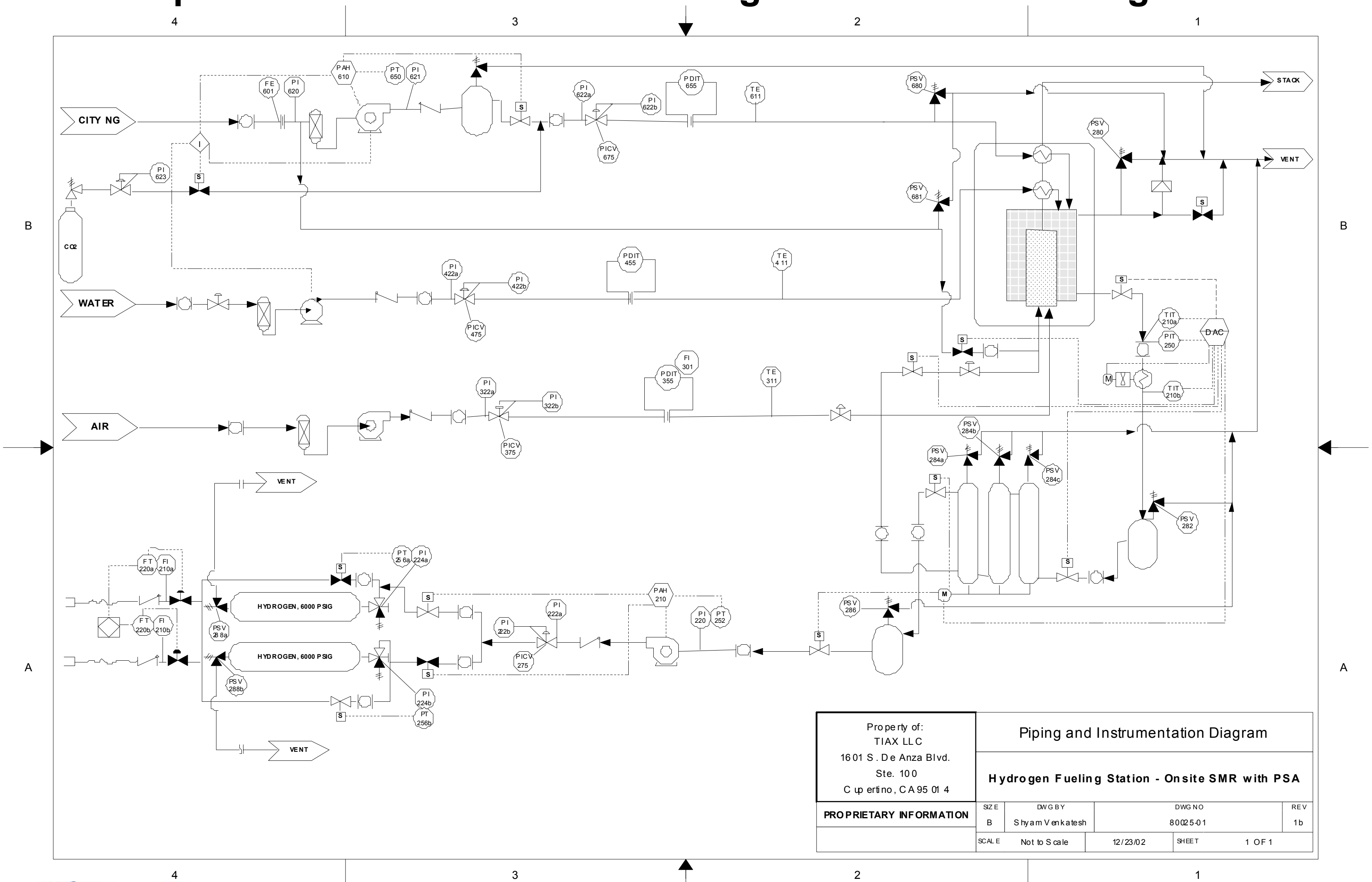
Note: Cost are for high production volumes: 1,000+ units per year.
Variations in operating profile are also being considered

A steam reformer results in higher hydrogen yield and simpler purification.



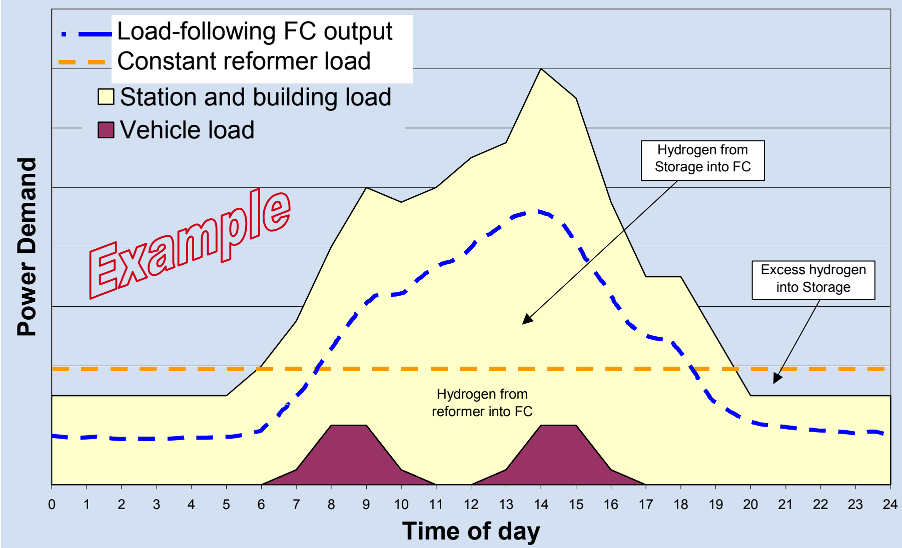
An ideal system would include a high pressure reformer and eliminate the reformate compressor.

A P&ID provides the basis for estimating costs for each configurations.



Daily operational levels for the FC and reformer will vary depending upon the target energy utilization strategy for the energy station site

Power Demand and Fuel Cell Operating Strategies



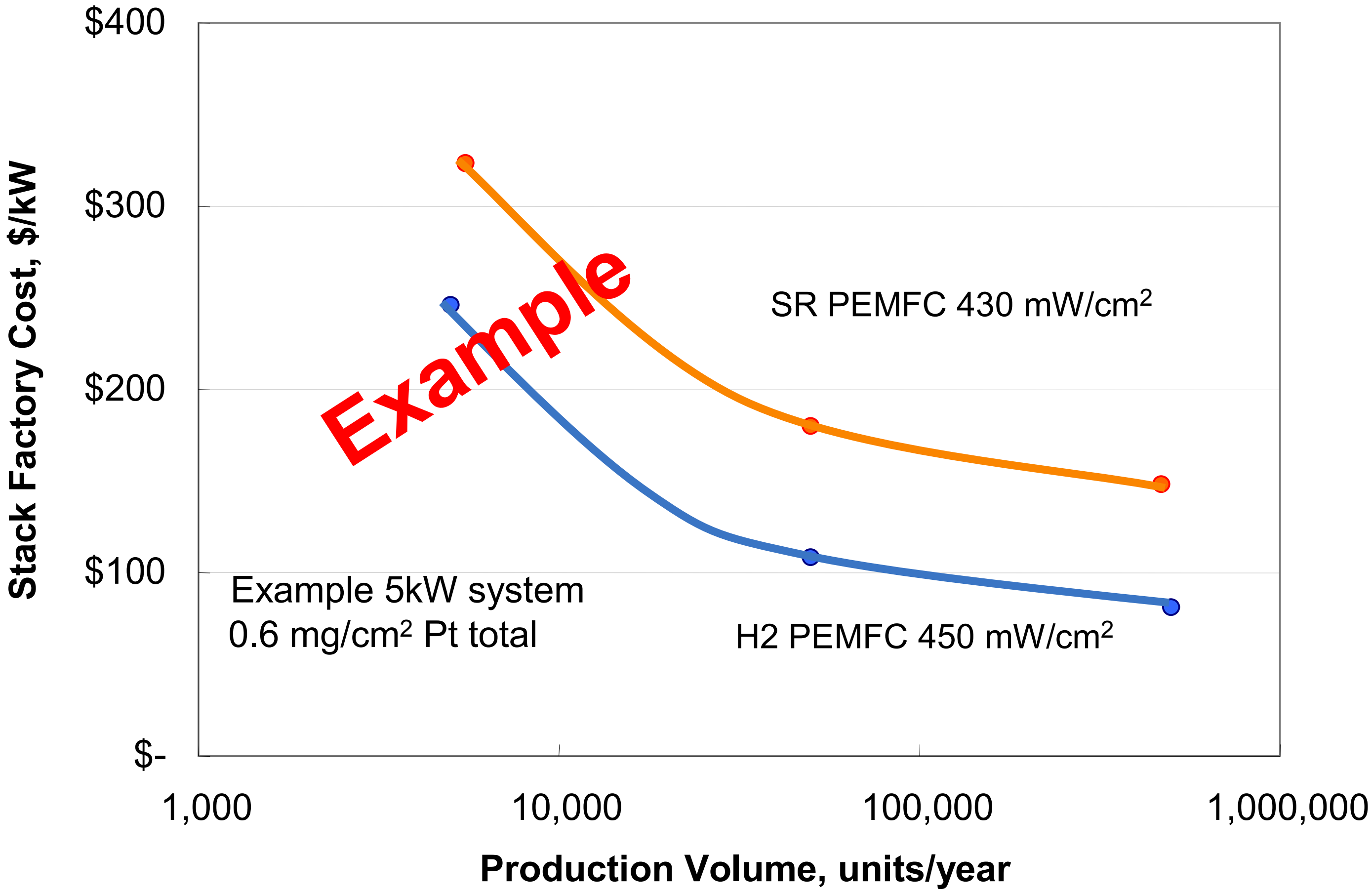
Candidate Operating Strategies

- **Base-loaded**
- **Electric load-following**
- **Heat-load following co-generation**
- **Peak shaving**
- **Back-up power**
- **Tailgas Exhaust to Boiler**

Matching Building loads:

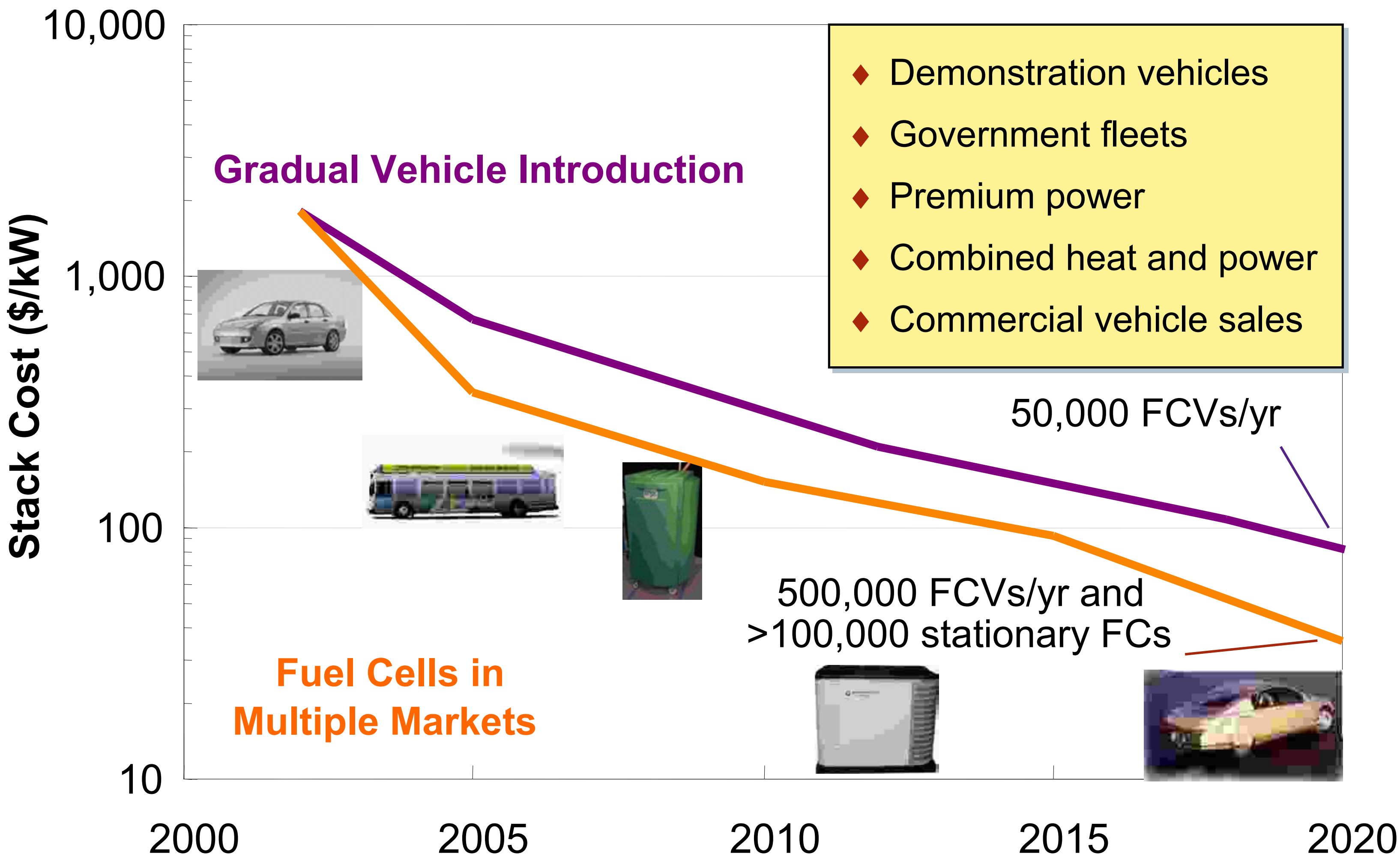
- Peak shaving: operating the fuel cell to reduce peak load on utility service
- Average load: operate the reformer and fuel cell continuously to provide power to building
- Emergency backup: operate fuel cell on stored hydrogen and/or reformer during power emergencies

In addition to technical performance parameters, the cost of components depends on production volumes.

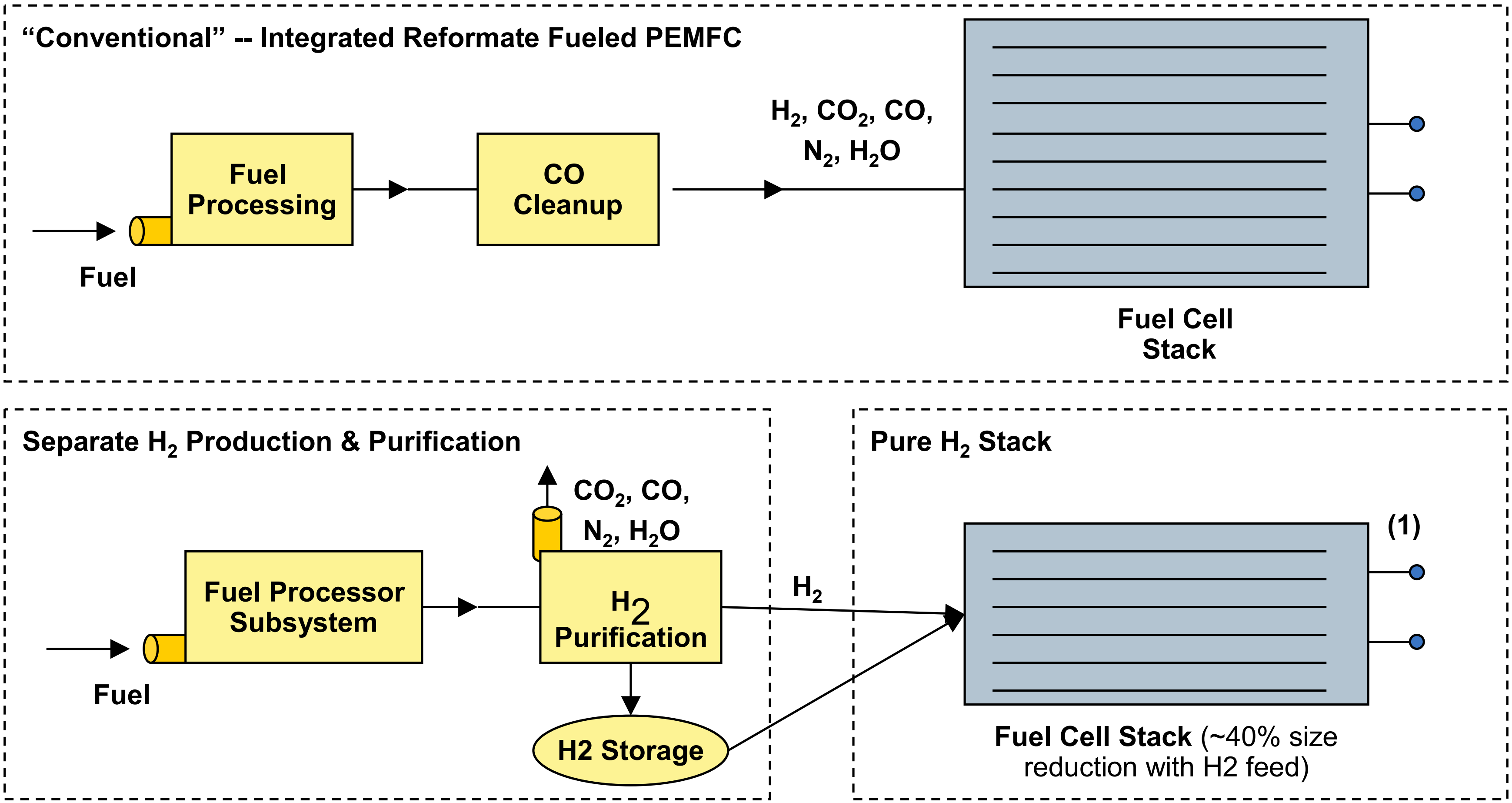


PEMFC stack components will be used in both vehicle and stationary applications while markets for steam reformers will be more limited.

The commercial success of any FCV, regardless of fuel, is tied to the cost of the fuel cell engine. Other fuel cell markets can help bring down costs.

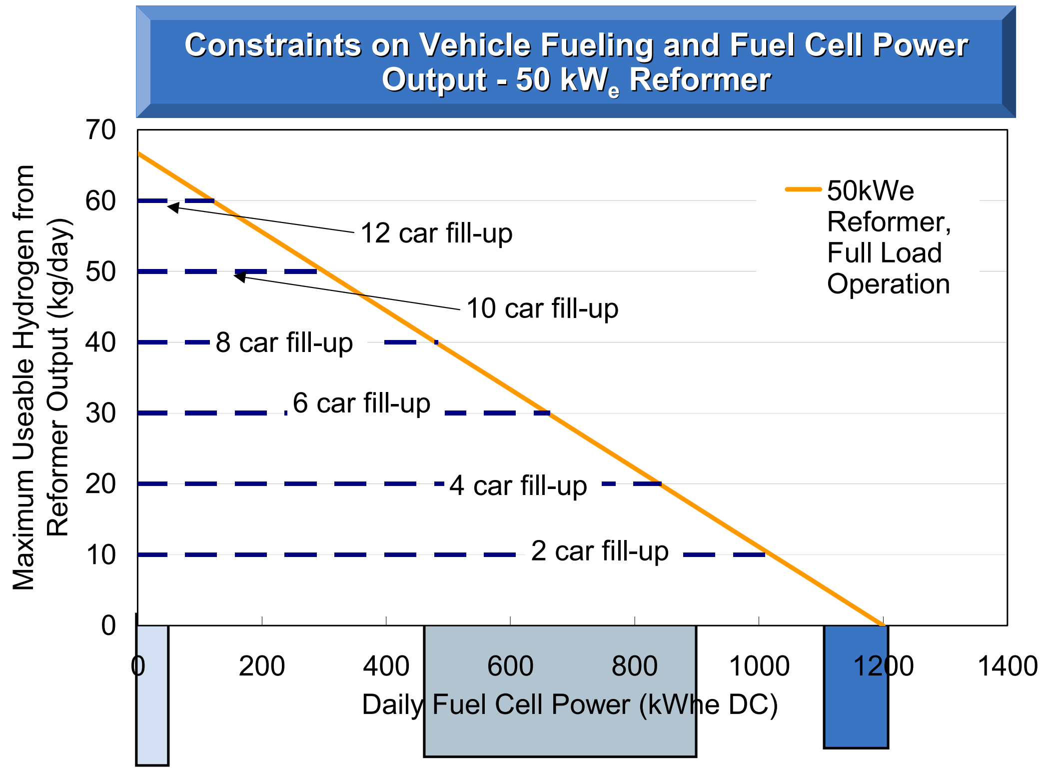


There are two basic fuel cell architectures with multiple variations thereof



This system strategy allows use of PEMFC stack technology that is likely to be available, and affordable due to early vehicle demos.

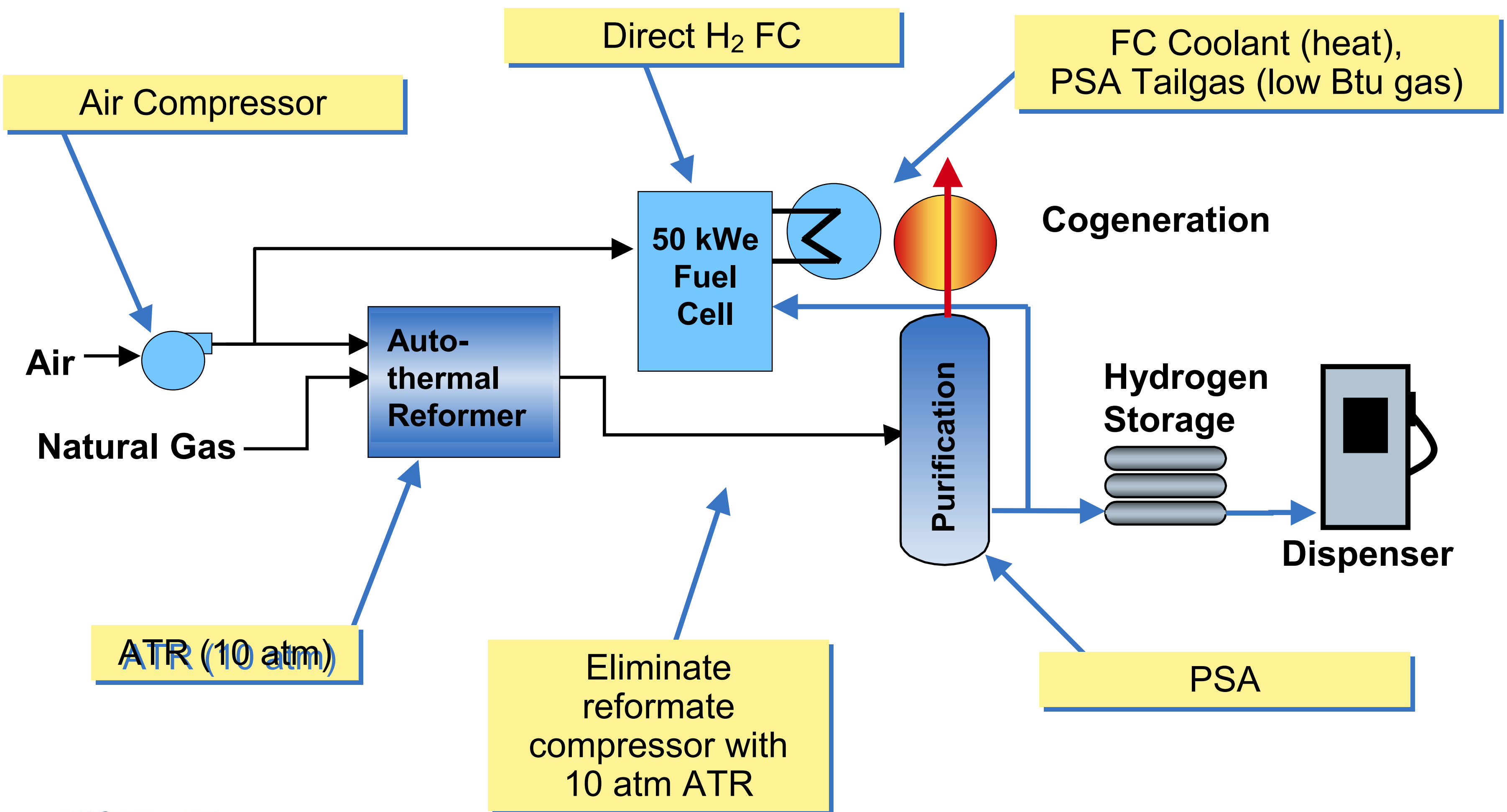
Several trade-off options available between generating FC electricity and providing sufficient hydrogen for vehicle fueling



Operating Strategies: Back up Peak Shaving Base Load

The reformer capacity, vehicle refuelings, and fuel cell can be matched for different operating strategies

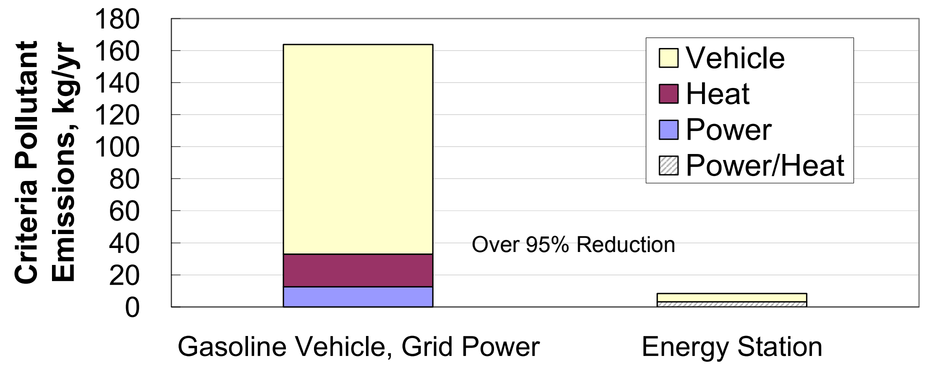
A simple cogeneration system uses the waste gas from an ATR to produce heat. Recovering the waste heat is simplified.



With an energy station, optimal use of natural resources could be combined with zero emissions and extremely high reliability.

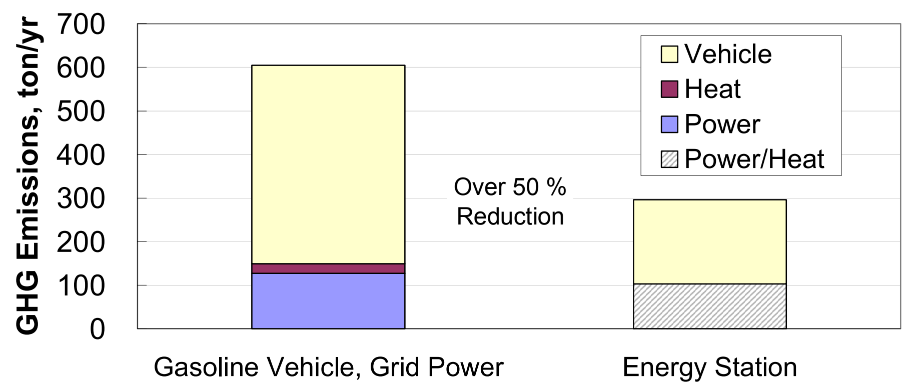
- Over 90% reduction of criteria pollutant emissions
- Enhances grid reliability through energy storage and fuel cells with few moving parts
- Reduced greenhouse gas emissions
- Managed technical risk through use of hydrogen fuel cells rather than conventional stationary fuel cell systems
- Facilitates implementation of fueling infrastructure
- Lower cost through shared components for vehicle fueling and stationary fuel cell power

Annual Criteria Pollutant Emissions



Note: criteria pollutants include NO_x, CO, and hydrocarbons

Annual Greenhouse Gas Emissions



Future energy stations need to evolve along with the vehicles.

Future Work	Challenges
Compare cost and performance to baseline technologies	• Cost depends on vehicle and stationary FC production volume
Develop a design concept for larger scale production	• Much smaller packaging would facilitate acceptance in more locations • Required stand off distances for hydrogen storage can be over 50 ft
Identify partners for commercialization	• Need to obtain better perspective of benefits to federal fleets
Evaluate barriers to hydrogen utilization	• Strained economy limits new ventures • Code requirements are evolving • Deployment of hydrogen FCVs from manufacturers presents a chicken/egg problem to potential energy station users

A number of stakeholders are being contacted to determine their requirements and interest in energy stations.

Stakeholders	Outreach Efforts	Comments
◆ Automakers ◆ Fuel cell manufacturer ◆ Electric utilities ◆ Government hospitals ◆ Military bases ◆ Government fleets ◆ EPACT fleets	◆ Attend Fuel Cell Seminar Nov '02 ◆ Made presentations on environmental impacts to CA Air Resources Board, South Coast AQMD, Blue Water Network, and others ◆ Submitted Paper to Dec '03 Fuel Cell Seminar	"This (energy station) is the only way fuel cell infrastructure will ever work" "Aren't SOFCs more efficient for stationary applications?" "We have to deal with Rule 21, for grid interconnection." "With the downturn in the economy we have to focus on our core activities." "If we could get a fuel cell car, this (energy station) would be a good idea."