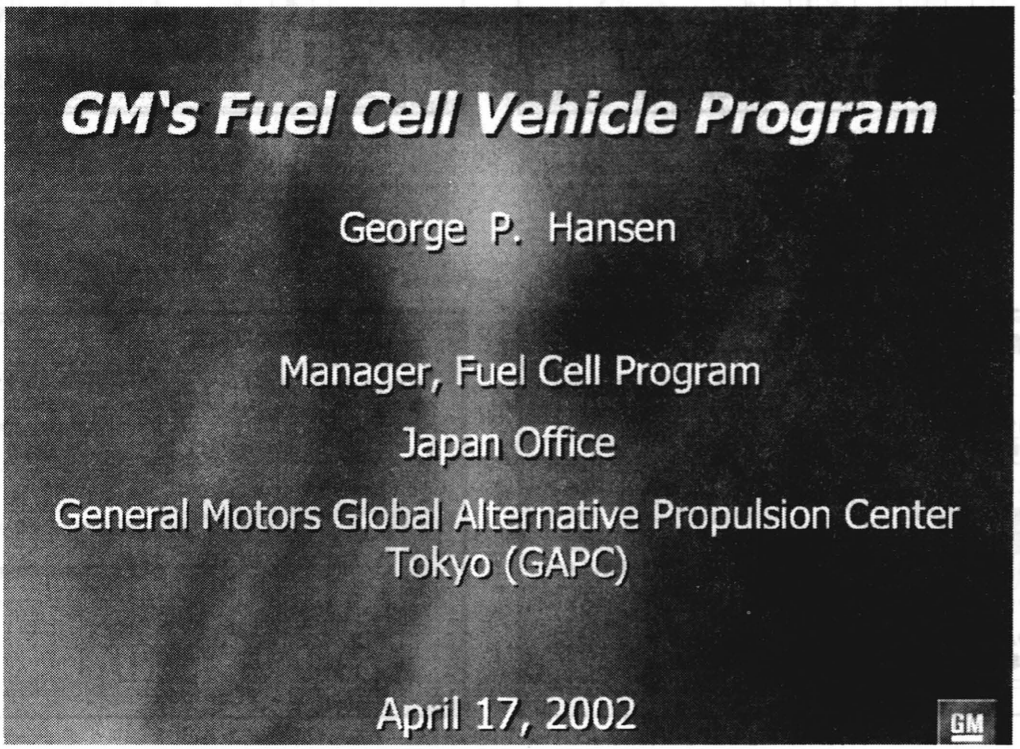

GM's Fuel Cell Vehicle Program
George P. Hansen
Manager, Fuel Cell Program
Japan Office
General Motors Global Alternative Propulsion Center Tokyo (GAPC)
April 17, 2002
GM

GM's Fuel Cell Vehicle Program

George P. Hansen

Manager, Fuel Cell Program

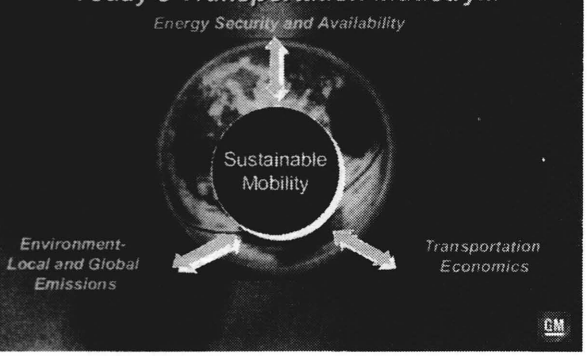
Japan Office

General Motors Global Alternative Propulsion Center Tokyo (GAPC)

April 17, 2002

GM

GM's Fuel Cell Program was Created to Meet Head-on the Global Challenges Facing Today's Transportation Industry...



GM

GM Global Alternative Propulsion Center

Warren (MI, USA)
Basic R&D

Honeoye Falls(NY, USA)
Non-automotive & FC Stack

Mainz-Kastel (Germany)
Automotive applications

Total number of employees: > 300

GM

GM Global Alternative Propulsion Center

Warren (MI, USA)
Basic R&D

Fundamental Research
Catalyst Development
Fuel Cell Membrane Research

GM

GM Global Alternative Propulsion Center

Honeoye Falls(NY, USA)
Non-automotive & FC Stack

Non-automotive Applications
Fuel Cell Stack Development
Fuel Cell Stack Prototyping
Gasoline/CNG Fuel Processor Development

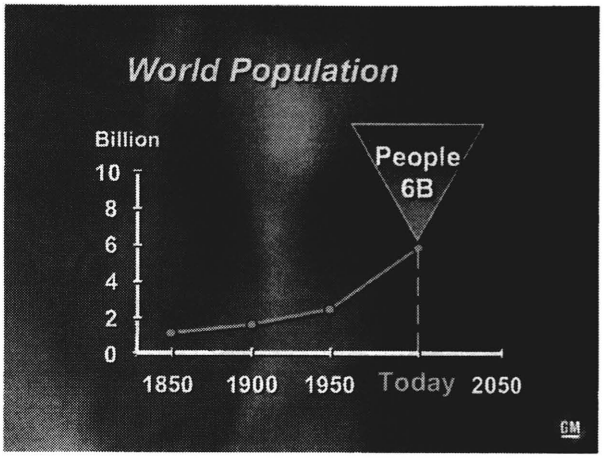
GM

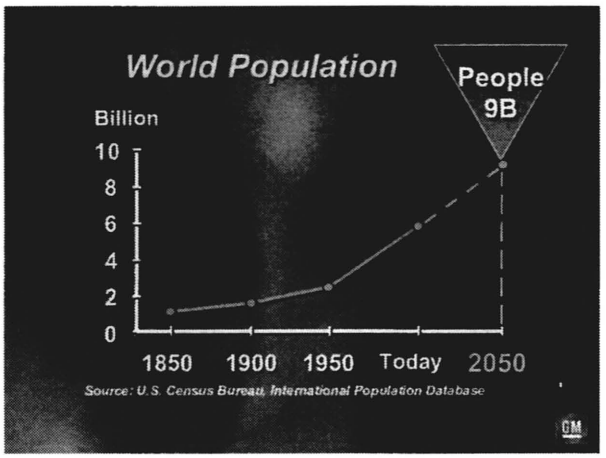
GM Global Alternative Propulsion Center

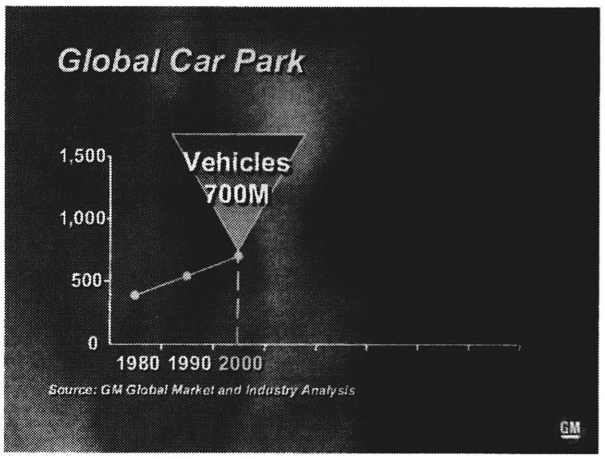
Mainz-Kastel (Germany)
Automotive applications

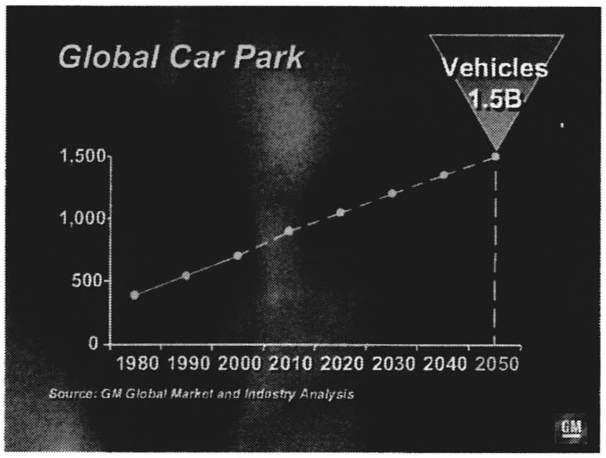
Hydrogen FC Power Systems Development
Vehicle Integration
Vehicle Packaging & Thermal System Optimization
Hydrogen Storage Systems Development
Electric Traction System Development

GM

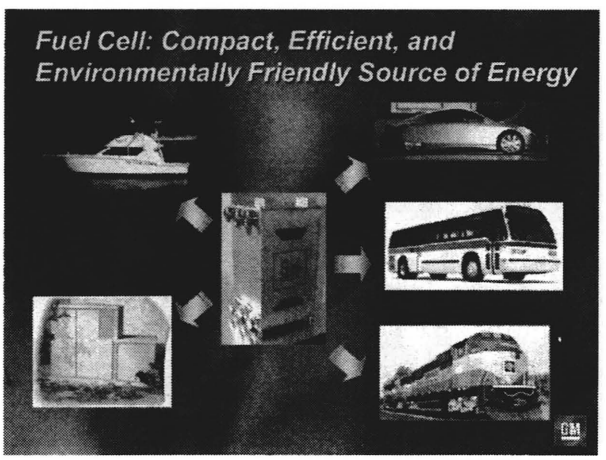

World Population
Billion
10
8
6
4
2
0
People
6B
1850
1900
1950
Today
2050
GM


World Population
People
9B
Billion
10
8
6
4
2
0
1850
1900
1950
Today
2050
Source: U.S. Census Bureau, International Population Database
GM

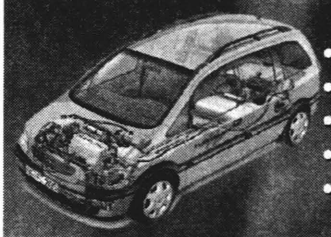

Global Car Park
Vehicles
700M
1,500
1,000
500
0
1980 1990 2000
Source: GM Global Market and Industry Analysis
GM


Global Car Park
Vehicles
1.5B
1,500
1,000
500
0
1980 1990 2000 2010 2020 2030 2040 2050
Source: GM Global Market and Industry Analysis
GM


VISION:
Hydrogen Economy
GM


Fuel Cell: Compact, Efficient, and
Environmentally Friendly Source of Energy
GM

Technical Specifications of "HydroGen1"



- Fuel cell stack (200 cells):
  Power: 80 kW
  Start-up: 30 s at -20 ° C
- Electric motor: 60 kW
- Acc. (0-100 km/h): 16 s
- Top speed: 140 km/h
- Fuel: 5 kg LH_2
- Range: 400 km (EDC)

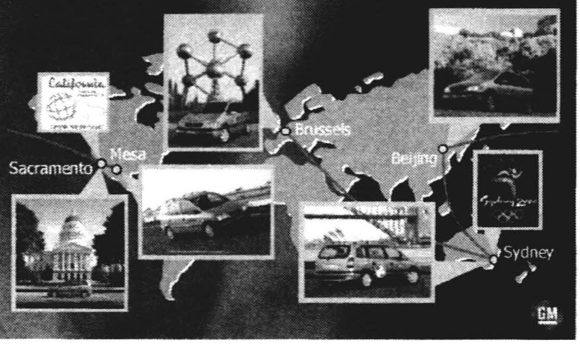
GM

World Tour of "HydroGen1"

June 2000 - May 2001: More than 600 journalists, scientists and politicians got behind the wheel of "HydroGen1"

GM

World Tour of "HydroGen1"



GM

Endurance Tests in Arizona

GM

Endurance Tests in Arizona

- 1 km (standing start) in 37.7 s
- 100 km in 59.99 min ›› 101.4 km/h
- 1000 km in 11:23.38 h ›› 87.8 km/h
- 1386,9 km in 24 h ›› 57.8 km/h

→ 15 international records

GM

IAA 2001: Launch of "HydroGen3"

Improved performance and day-to-day practicality

GM

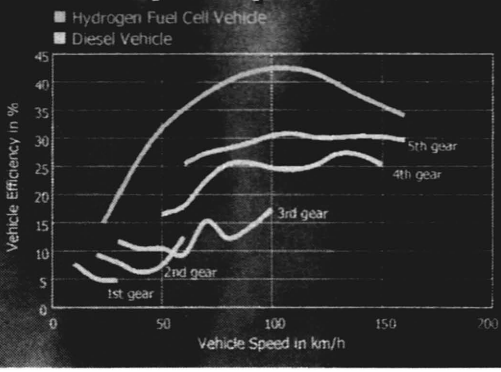
IAA 2001: Launch of "HydroGen3"

Improved performance and day-to-day practicality

- No high-performance buffer battery
- Increased power density of fuel cell unit, no external humidification devices
- Compact propulsion module
- Air conditioner, diagnosis system
- Full loading space of production model

GM

Efficiency Comparison



GM

Fuel Cell Vehicle with/without Battery

	Strategy A ☐ Regen ☐ Stack shut off				Strategy B ☑ Regen ☐ Stack shut off				Strategy C ☑ Regen ☑ Stack shut off			
Drive Cycle	Efficiency Tank to Wheel	Efficiency Benefit	Range	Range Benefit	Efficiency Tank to Wheel	Efficiency Benefit	Range	Range Benefit	Efficiency Tank to Wheel	Efficiency Benefit	Range	Range Benefit
	%	%	km/kg	%	%	%	km/kg	%	%	%	km/kg	%
EDC	36,7	X	79,89	X	37,5	0,8	81,72	2,2	38,0	2,3	84,92	5,9
Japan 1015	36,8	X	84,56	X	38,5	1,8	88,63	4,6	41,8	5,0	96,21	12,1
FTP 75	37,7	X	86,76	X	38,9	1,2	83,34	3,1	40,6	2,3	85,78	5,9
Highway	39,9	X	90,56	X	40,1	0,2	91,06	0,5	40,2	0,2	91,09	0,6

➔ Benefit of using battery is affected by driving cycle, weight/volume and cost

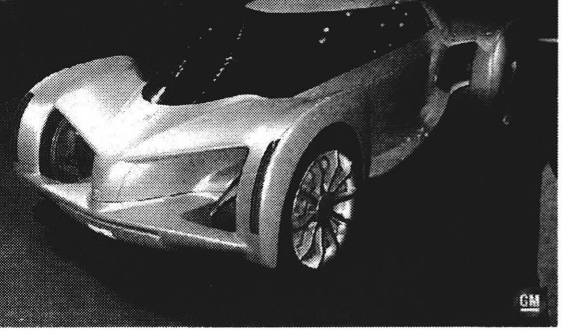
GM

August 2001: Chevrolet S10 with Gasoline Fuel Processor

World's first gasoline fuel processor for fuel cell propulsion

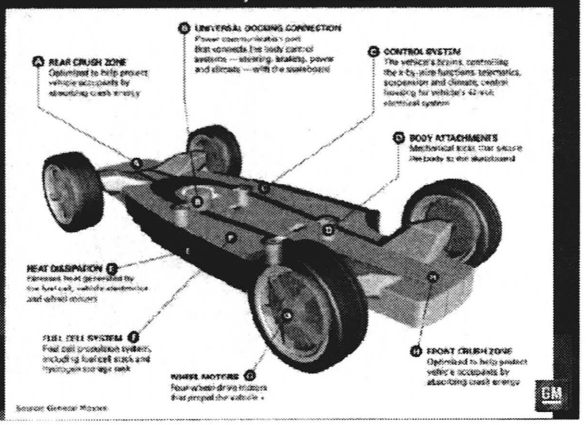
GM

Reinventing the Automobile...



GM

Autonomy's "Skateboard"



GM

Conclusions

- GM pursues two parallel approaches:
  - Hydrogen fuel cell vehicle
  - Gasoline fuel processor fuel cell vehicle
- Long-term goal is hydrogen fuel cell vehicle due to advantages of simpler vehicle architecture and zero CO_2-emissions
- HydroGen3 shows major step towards series production

GM

Hydrogen Infrastructure - Introduction Scenario -

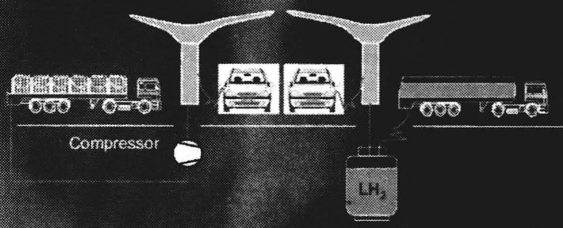
GM

Hydrogen Infrastructure

Introduction Scenario

Step 1 Initiation

Truck Delivery of Compressed and Liquefied Hydrogen

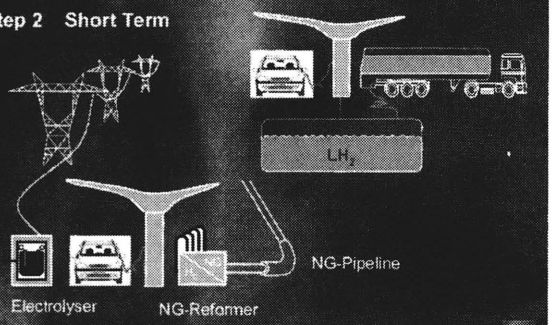


GM

Hydrogen Infrastructure

Introduction Scenario

Step 2 Short Term

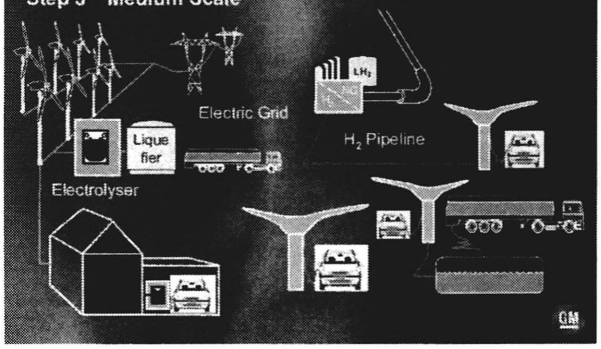


GM

Hydrogen Infrastructure

Introduction Scenario

Step 3 Medium Scale

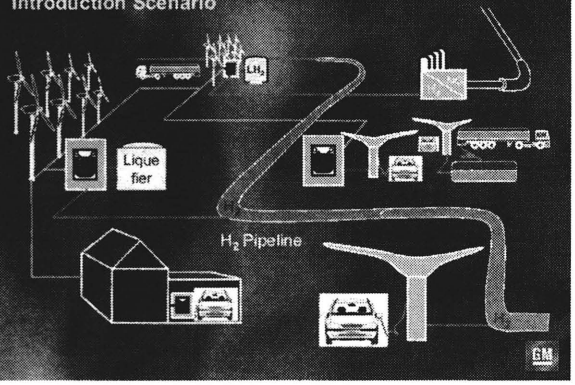


GM

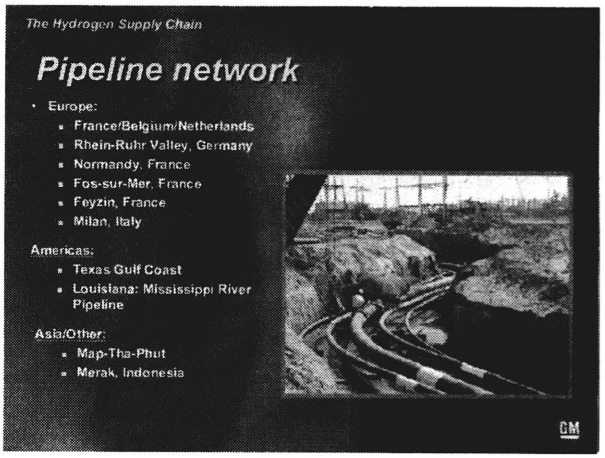
Hydrogen Infrastructure

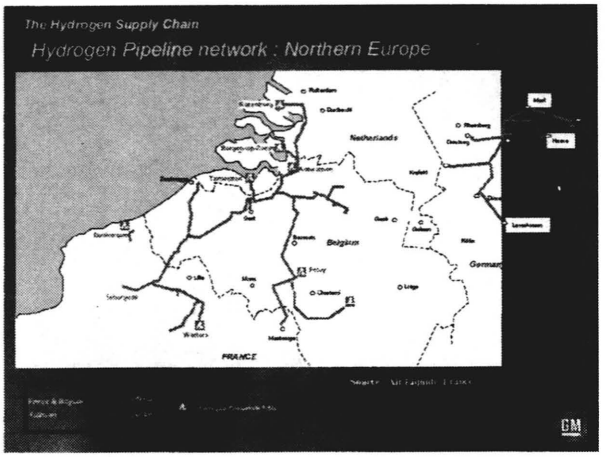
Introduction Scenario

Step 4 Large Scale



GM


The Hydrogen Supply Chain
Pipeline network
Europe:
France/Belgium/Netherlands
Rhein-Ruhr Valley, Germany
Normandy, France
Fos-sur-Mer, France
Feyzin, France
Milan, Italy
Americas:
Texas Gulf Coast
Louisiana: Mississippi River Pipeline
Asia/Other:
Map-Tha-Phut
Merak, Indonesia
GM


The Hydrogen Supply Chain
Hydrogen Pipeline network : Northern Europe
Netherlands
Belgium
FRANCE
GM