Fuel Cells and the Hydrogen Economy

A Challenging & Compelling Vision

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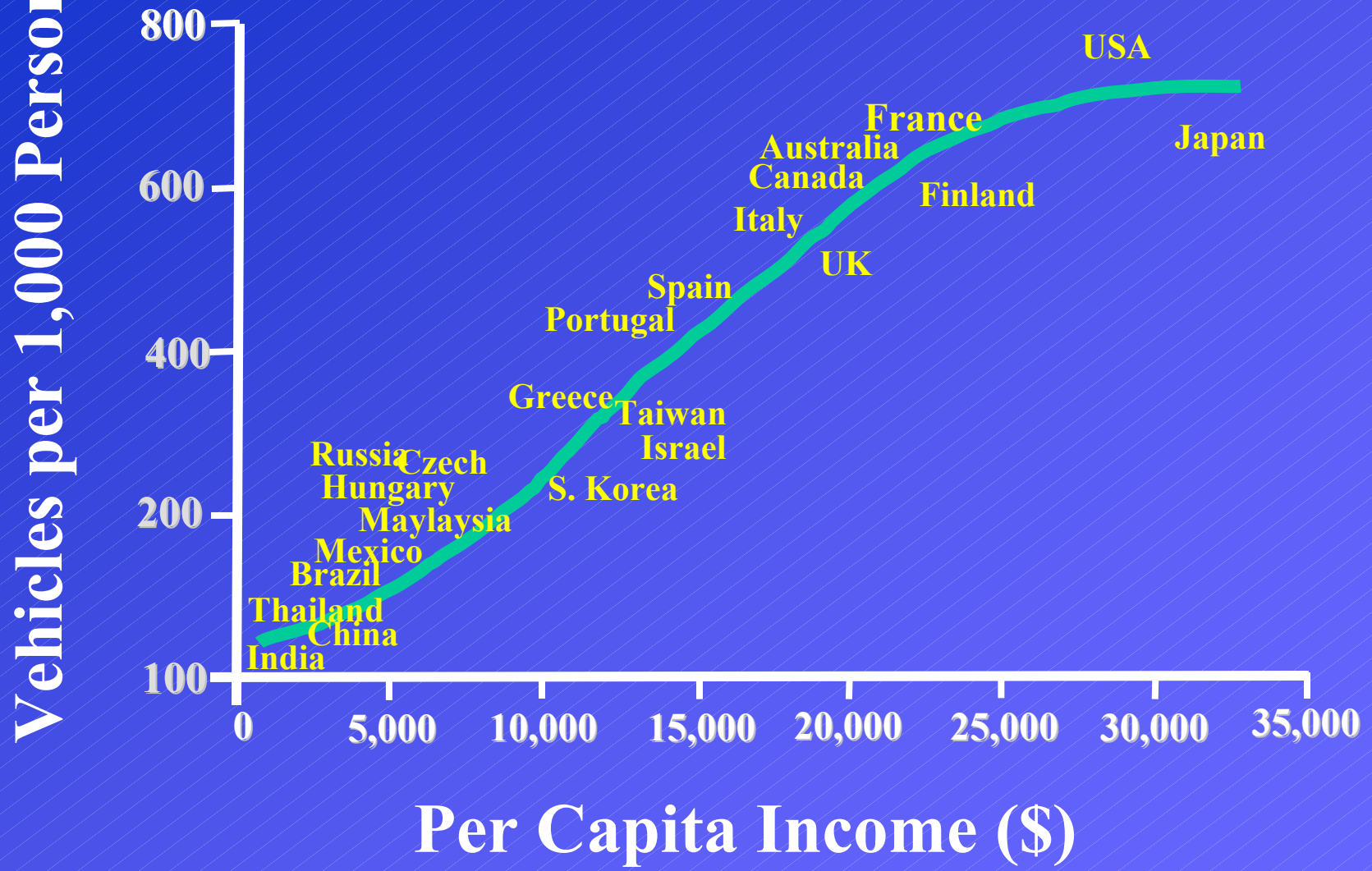
The Compelling Vision

- Cuts greenhouse gas emissions
- No vehicle emissions in urban zones with high population densities
- Relieves dependence of light duty transportation on petroleum

Relationship of Vehicles Sales to Per Capita Income



Hydrogen: An Energy Carrier That Offers Tremendous Feedstock Diversity

Non-renewables

Renewables

Oil

Natural Gas

Coal

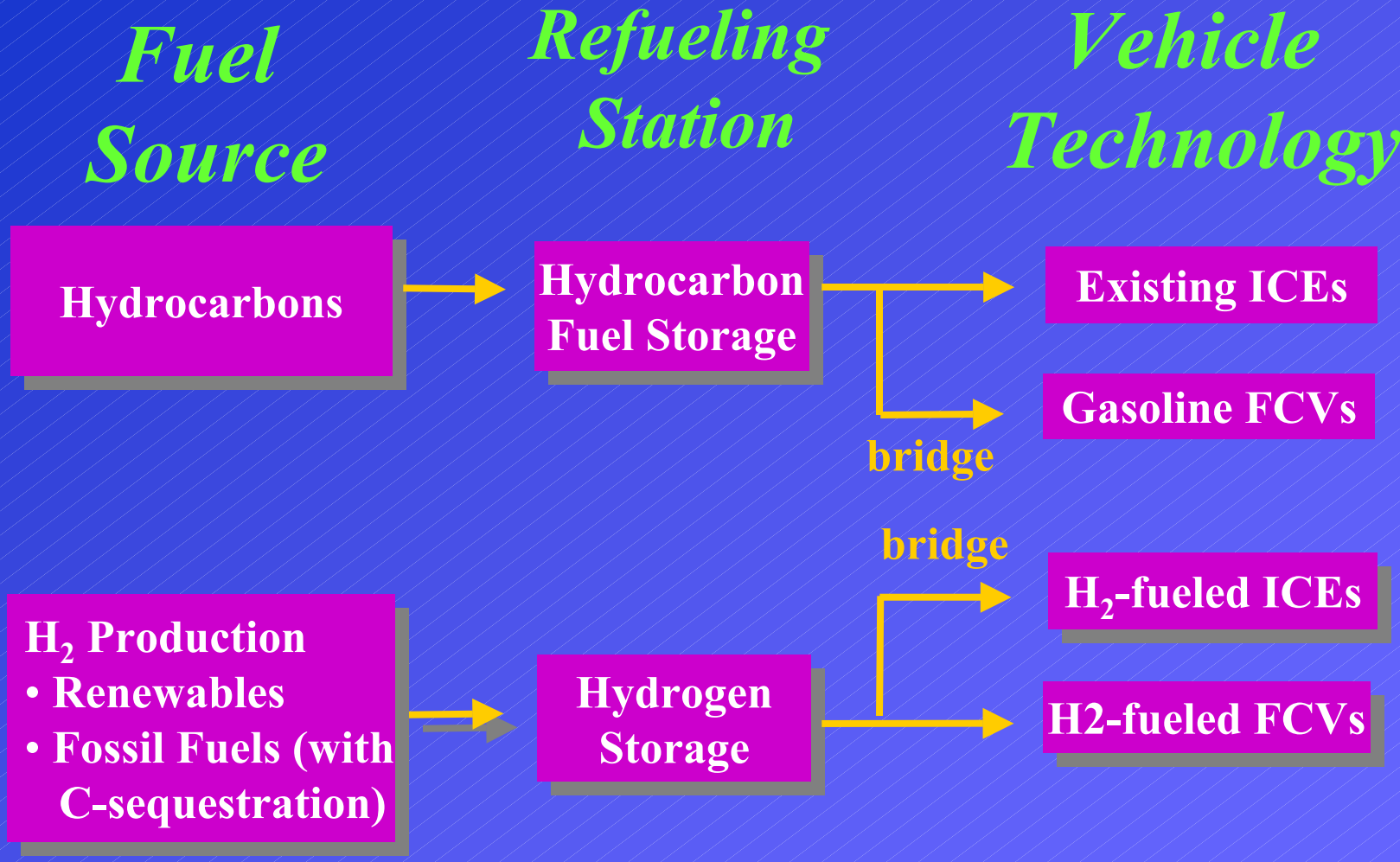
Nuclear

Biomass

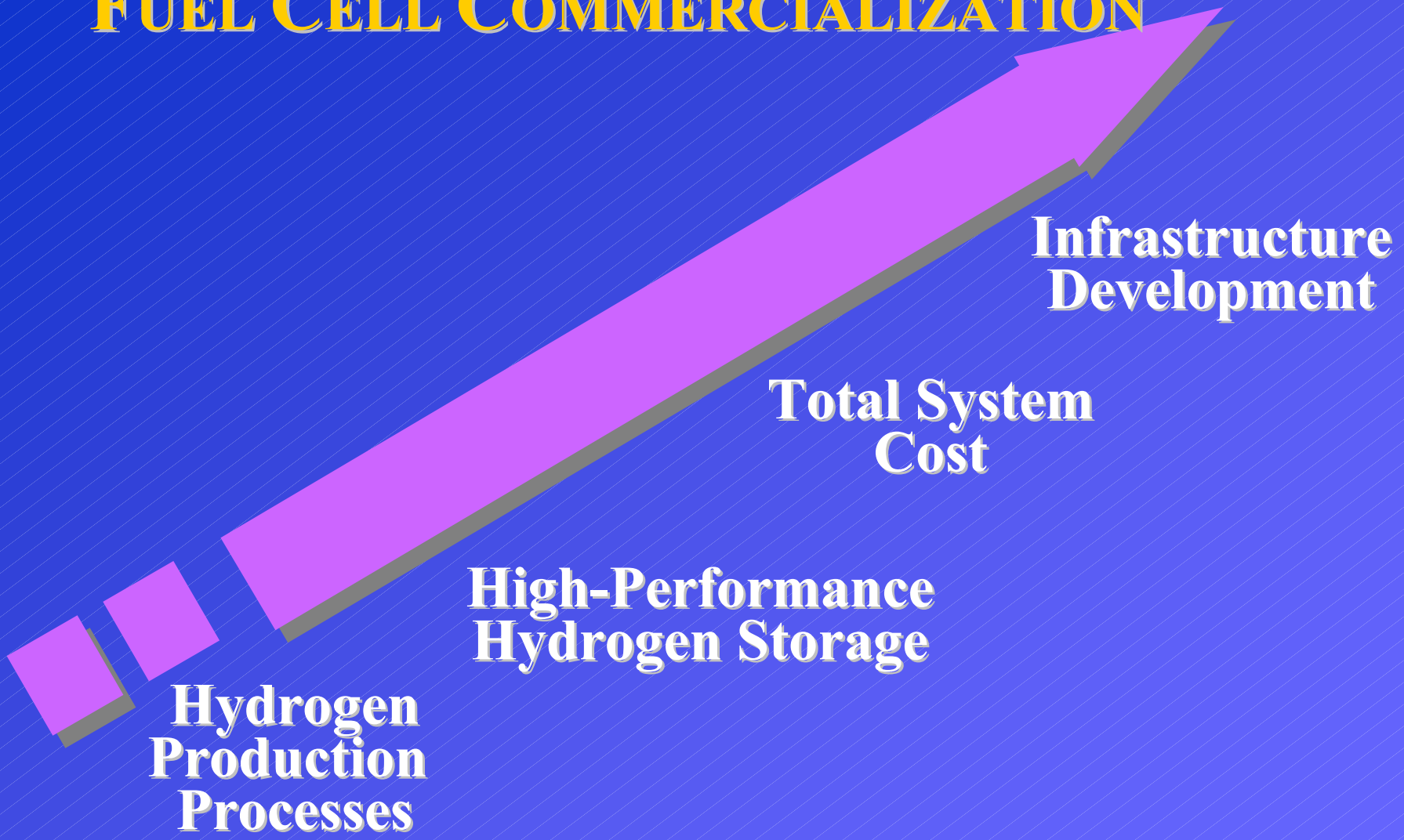
Hydro
Wind
Solar

Hydrogen

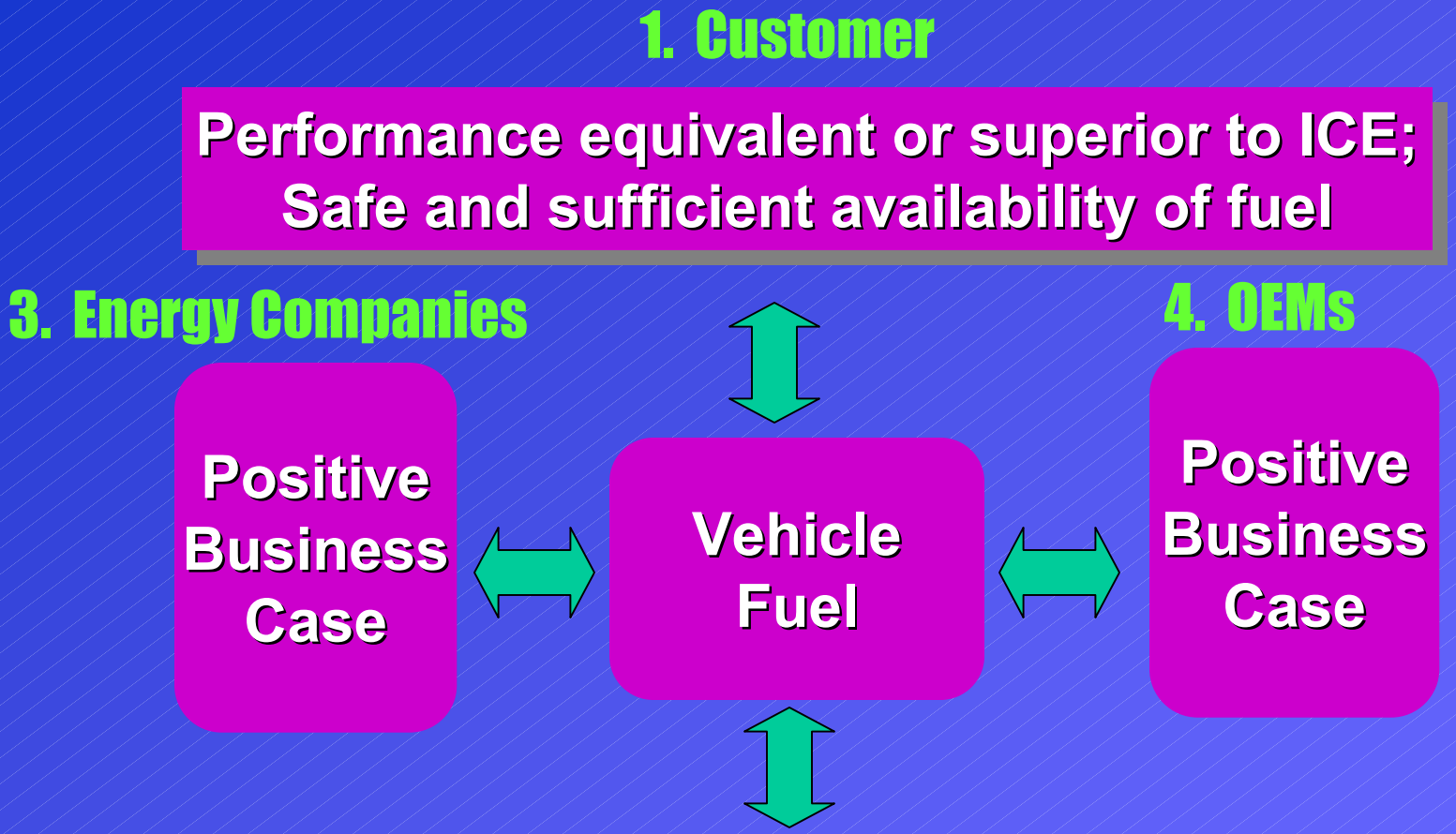
POSSIBLE FUTURE PATHWAYS TO HYDROGEN



Key Challenges for Fuel Cell Commercialization



FOUR "WINS" ARE NECESSARY FOR COMMERCIAL SUCCESS „



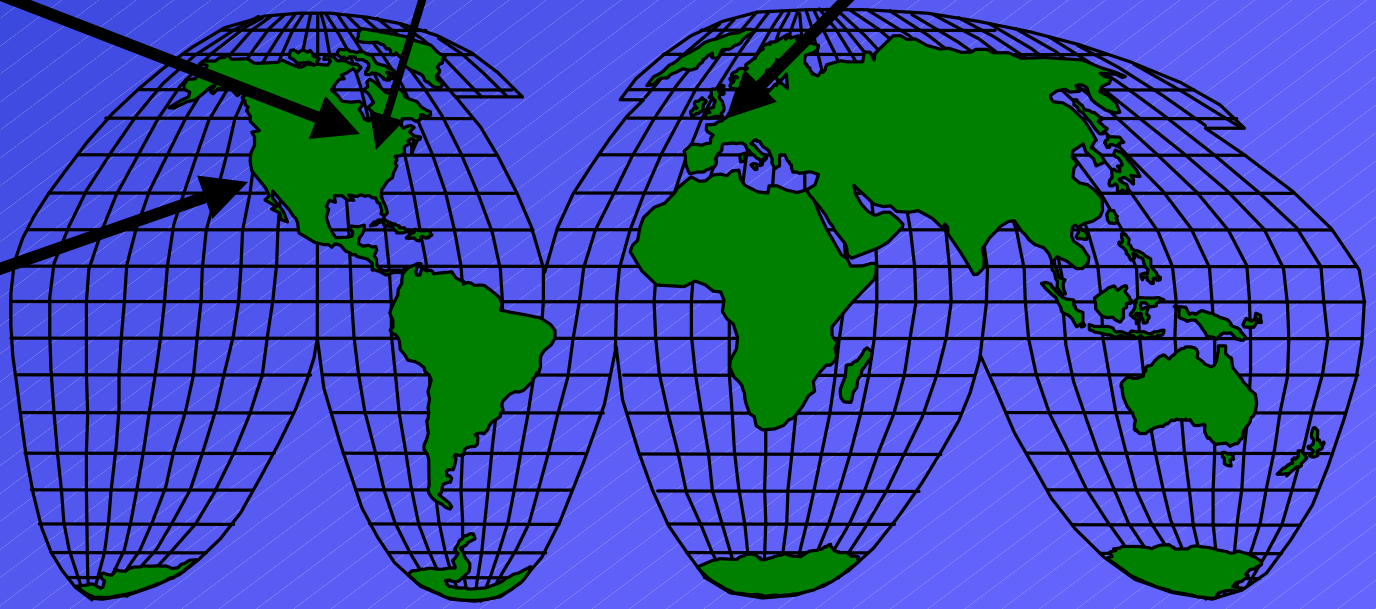
GM Fuel Cell Activities
Formed in 1997

Warren (MI, USA)
Basic Research
Hydrogen Storage

Rochester (NY, USA)
Fuel Cell Stack and Fuel Processor Applied Research, Development and Integration

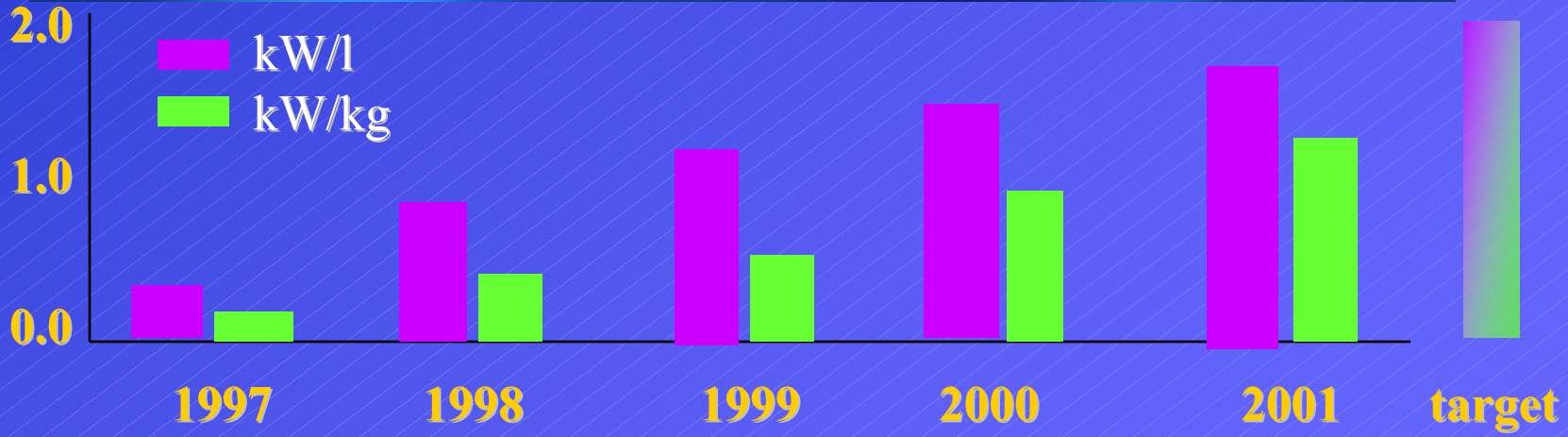
Mainz-Kastel (Germany)
Vehicle System Development, Traction System, Hydrogen Storage

Torrance (CA, USA):
Power Electronics
Electric Traction



History of General Motors Fuel Cell Stack Development

1997	1998	1999	2000	2001
GM/ LANL	GM Gen 4	GM Hydrogen1 Vehicle	GM Stack2000	GM "Pure Cell"
				
37 kW	**23 kW**	**80 kW**	**94 kW**	**102 kW**
0.26 kW/l	0.77 kW/l	1.1 kW/l	1.60 kW/l	1.75 kW/l
0.16 kW/kg	0.31 kW/kg	0.47 kW/kg	0.94 kW/kg	1.25 kW/kg
220 Cells	106 Cells	200 Cells	200 Cells	640 Cells
Peak Power: 41 kW	Peak Power: 40 kW	Peak Power: 120 kW	Peak Power: 129 kW 0 Humidification	Peak Power: 129 kW 0 Humidification



Strategic Alliances/Equity Partners

HYDROGENICS

Joint product development, engineering, prototyping, testing, branding in select applications.

General Hydrogen

Accelerate spread of hydrogen infrastructure and develop interface.

GINER, INC.

PEM fuel cell expertise and exclusive rights to electrolyzer technology application.

QUANTUM TECHOLOGIES

Hydrogen handling and storage for automotive and non-automotive applications.

GM Fuel Cell Vehicle History

1968

1968 "GM Electrovan"
LH2 and LO2 -Fuel Cell

1998

Sintra Van

1999

Zafira Mini-Van

2000

GM Precept FC

2000

Direct Hydrogen
FC Opel Zafira

2001

HydroGen1

World Record Holder
Speed, Distance

HydroGen3

No battery
improved fueling
& technology

2002

World's First
Gasoline Powered
Fuel Cell Vehicle

Autonomy

X-by-wire
Skateboard chassis
Clip on body

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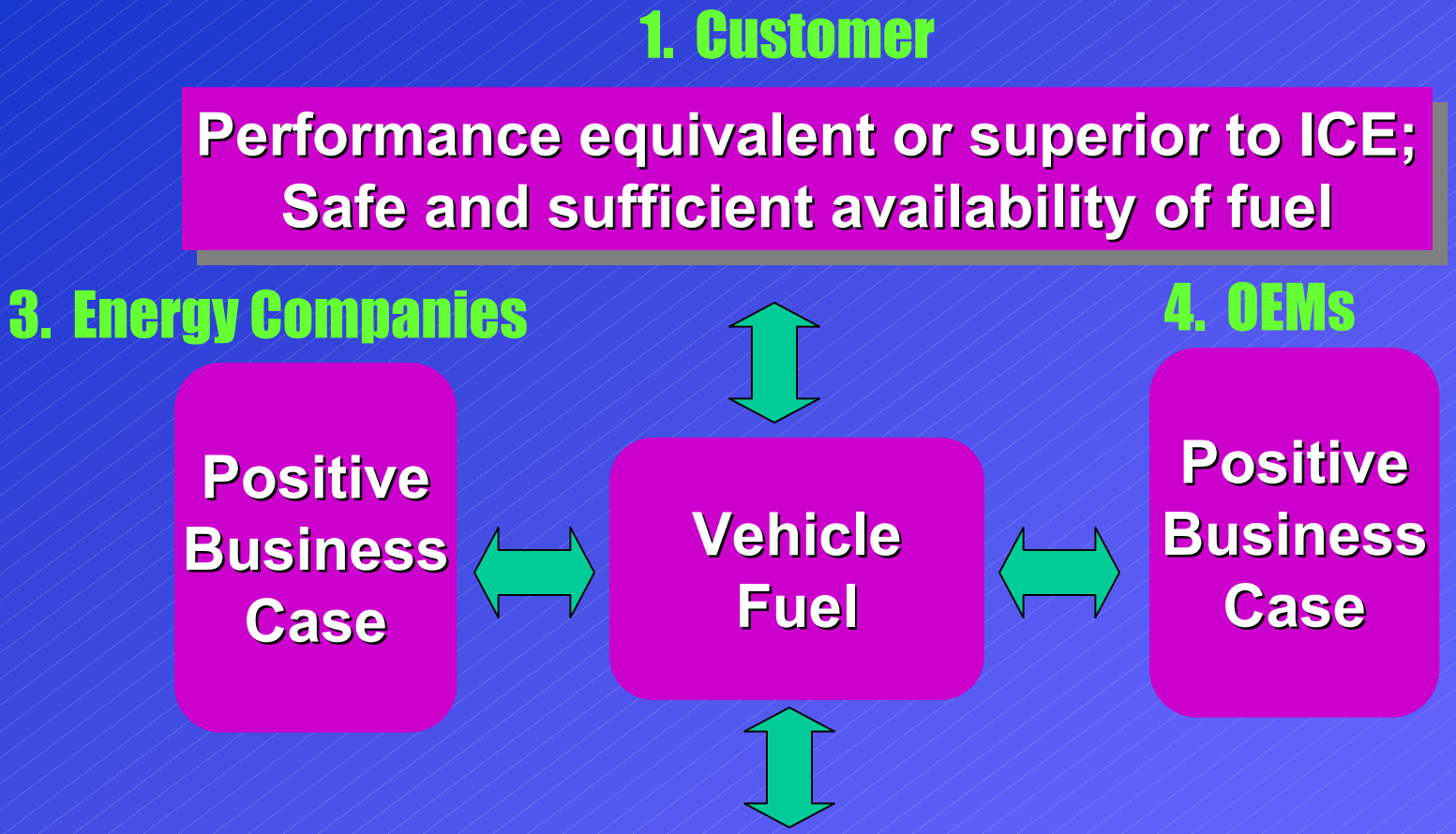

Four Elements for Commercialization