
Sigma Xi

Fueling the Future

Detroit, Michigan
4 November 2006



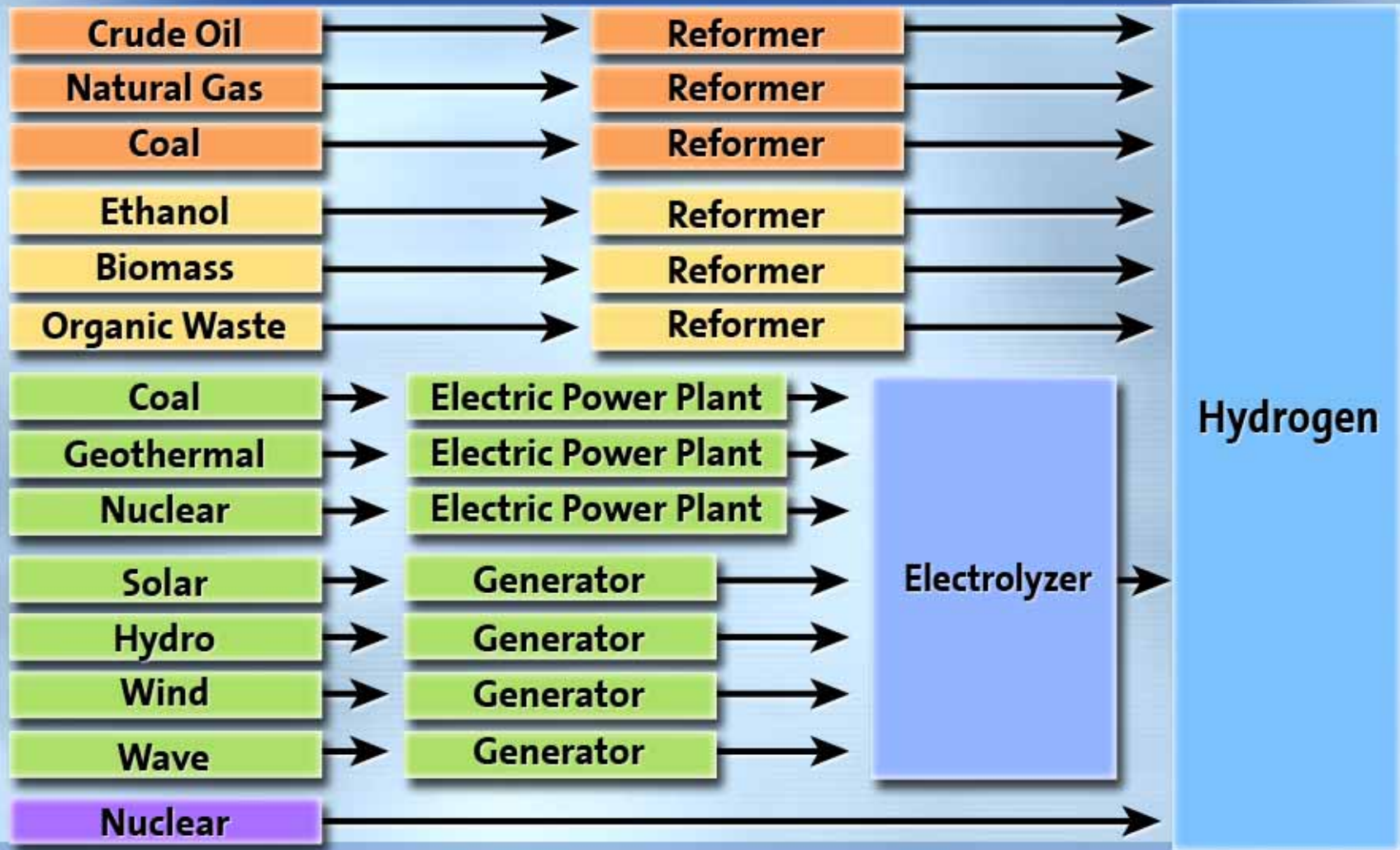
Britta Gross
GM Fuel Cell Activities
Hydrogen Infrastructure



Critical Need for More Diverse, More Secure,
and Cleaner Energy Pathways

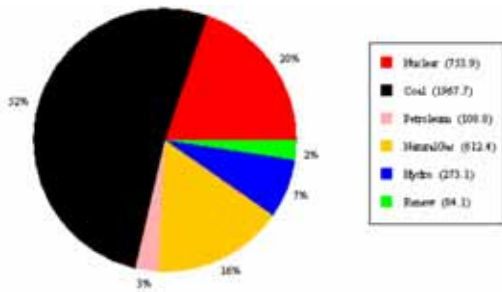


Hydrogen Pathways

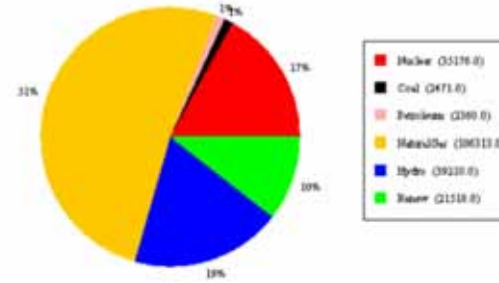


In the U.S. there is considerable diversity among the states in the sources of energy used to generate electricity...

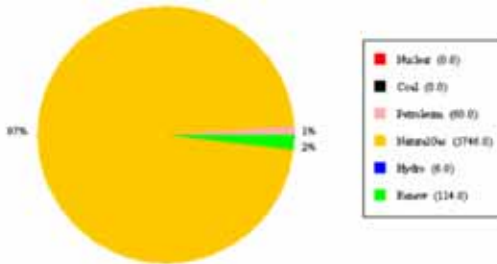
U.S. Average



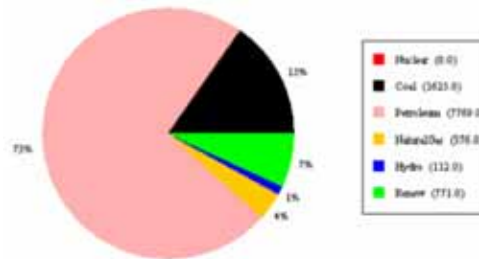
California



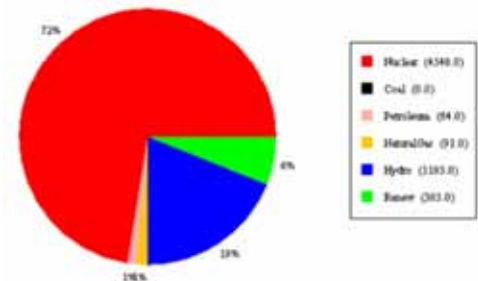
Rhode Island



Hawaii

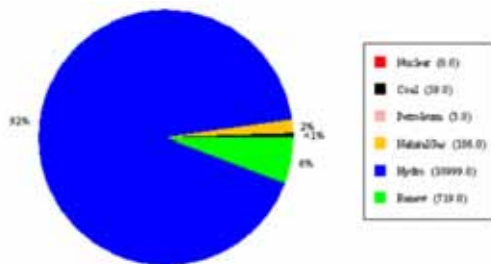


Vermont

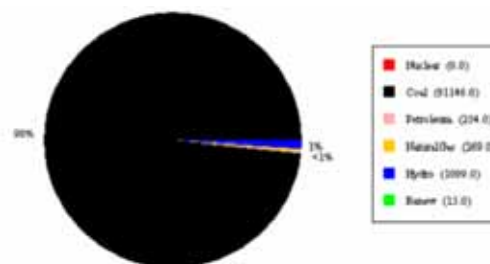


Coal
Nuclear
Natural Gas
Hydro
Petroleum
Renew

Idaho



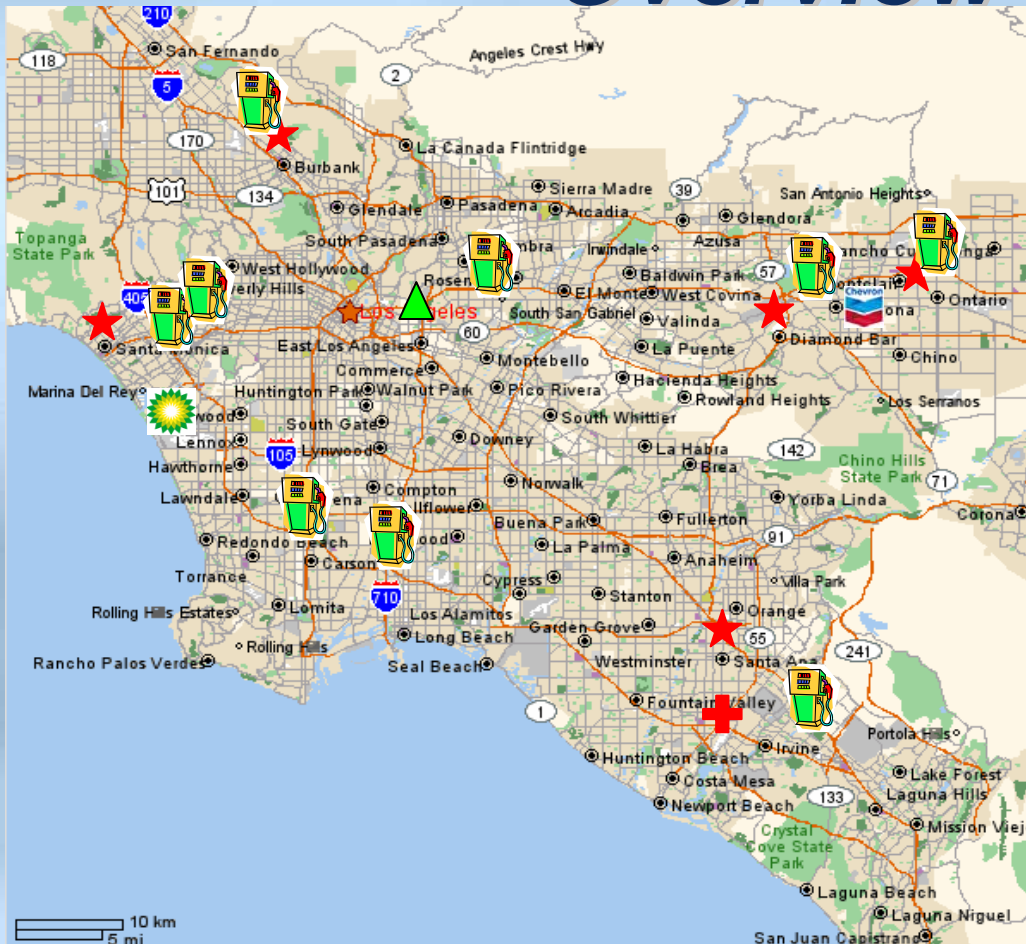
West Virginia




... some "local" sources support the production of clean

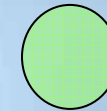
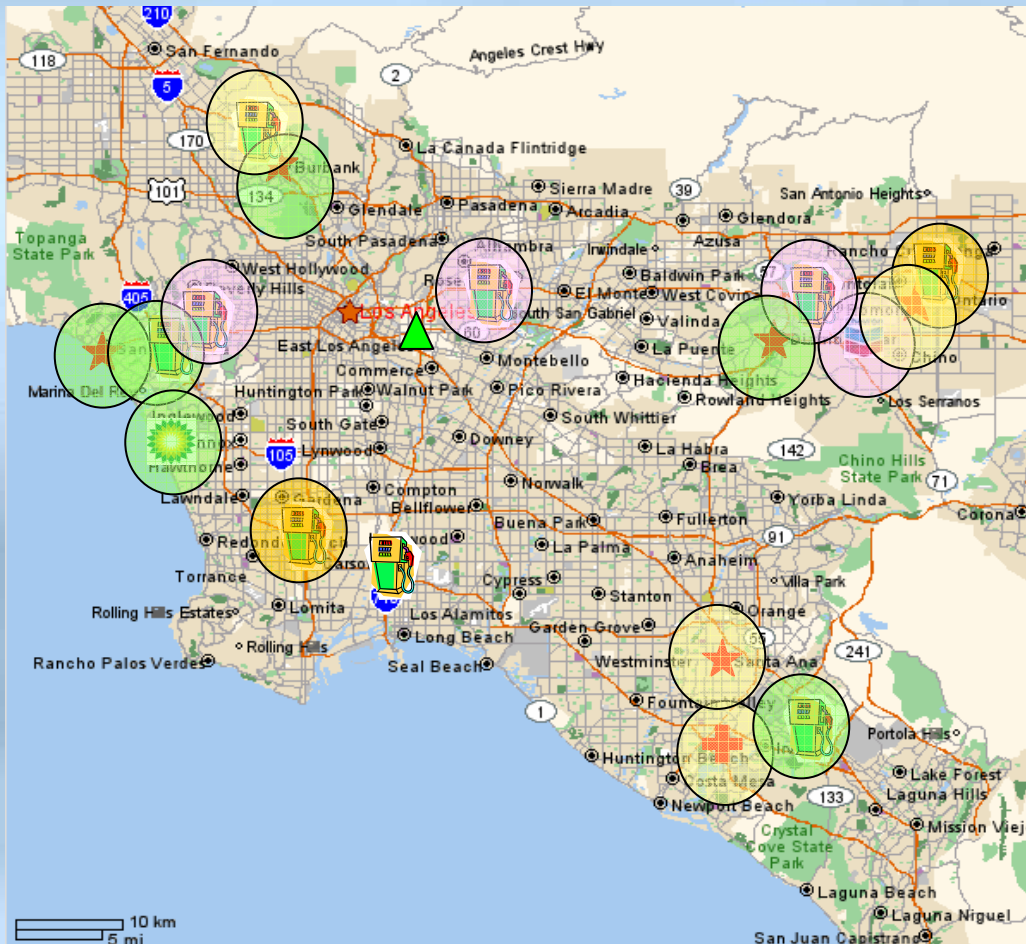
(Numbers in parentheses are million kWh-hours generated in the state by utility and non-utility generators); Source: EIA, Electric Power Annual 2000

L.A. Hydrogen Refueling Station Overview



- ★ AQMD + 5-cities
- ☀ BP
- ▲ CSU-LA (announced)
-  CVX
-  Shell
- ✚ UC Irvine
-  Other – tentatively planned for 07-08

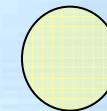
... Diverse Hydrogen Sources



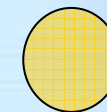
Onsite Electrolysis



Onsite SMR or non-fossil fuel based reforming

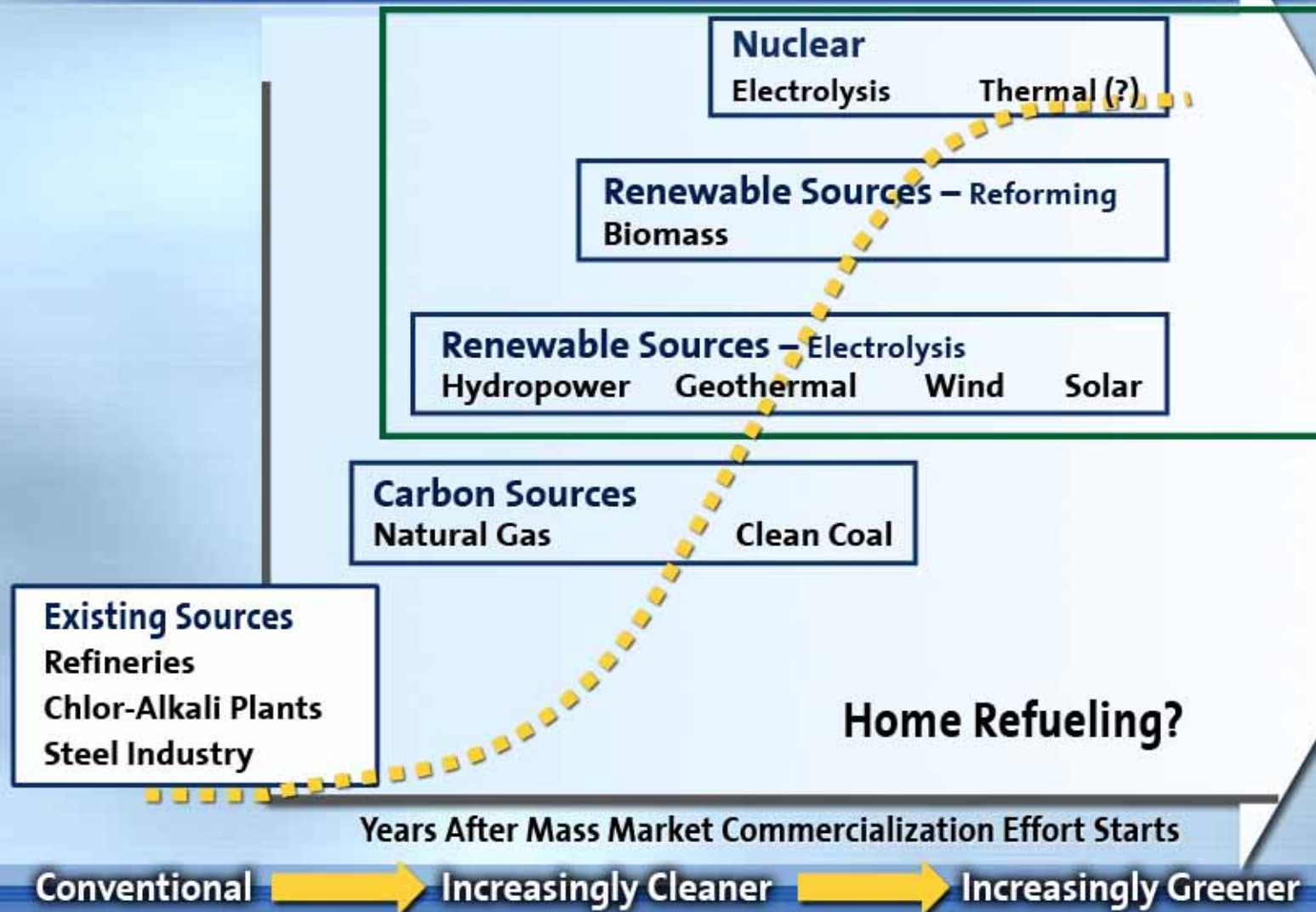


Delivered H2 - SMR



Pipeline H2 - SMR

Where Will the Hydrogen Come From?



Hydrogen Production Pathways

- Many different energy pathways to hydrogen
- No single “best” pathway
- Benefits associated with all pathways
- Like electricity, locally available resources will drive pathways pursued
- Pathways will evolve over time

Hydrogen Production Pathways

- Flexibility in the source of Hydrogen
 - Natural Gas, Organic Waste, Biomass, Water ...
 - Fuel Cells are twice as Efficient as other Engines
 - Reduced Oil Imports - Energy Independence
 - Conserve Resources
 - Emit only Water - Protect the Environment
 - Sustainability: A Future Built on Renewable Energy
- 



GM HyWire, 2002



GM Demonstration Vehicle

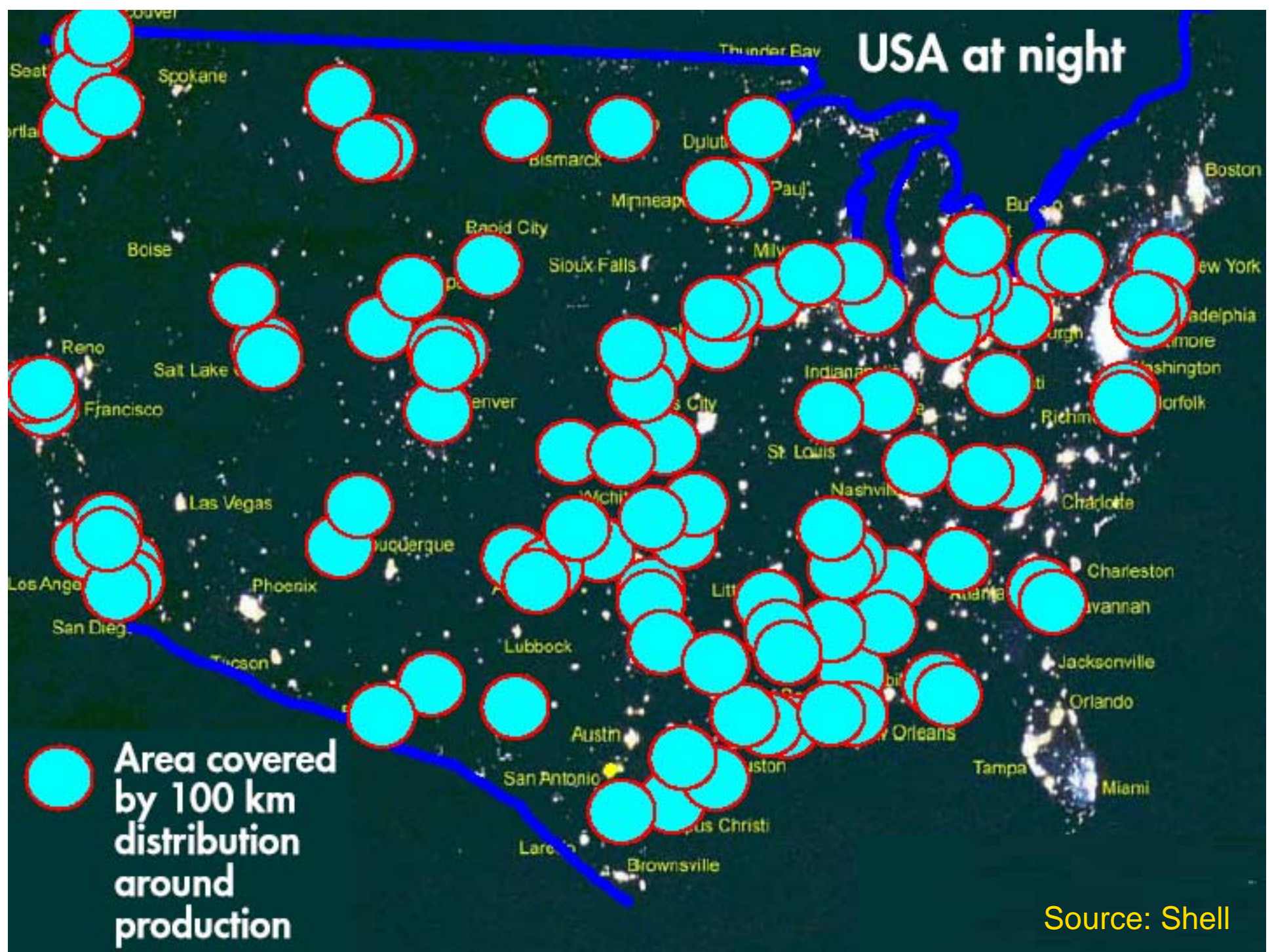


GM AUTOmomy, 2002



GM Sequel, 2005

USA at night



Source: Shell

DOE H2A Case Studies (October 2006)

Summary of Results (Delivered Hydrogen = H2 production, delivery, dispensing - \$/kg):

H2 Pathway	2005	2015	2030	Capacity	Operating Capacity Factor
Distributed – Steam Methane Reforming (SMR)	3.10	2.00		1500 kg/d	70%
Distributed – Wind/Grid **	5.70	3.10		1500 kg/d	70%
Centralized – SMR *	5.00				
Centralized – Wind (w/ Grid 2030) ***	9.50		2.70	125,000 kg/d	41% (97% 2030)
Centralized – Biomass Gasification	5.10		2.40	155,000 kg/d	90%
Centralized – Coal Gasification (w/ Seq)	5.10		2.20	308,000 kg/d	90%
Centralized – Nuclear (Sulfur-Iodine)			3.20	768,000 kg/d	90%

* Details not provided in DOE scenarios below (was “not lowest cost near-term solution and not desired as long-term solution”)

** 2005 - 30% wind / 70% grid; 2015 – 50% wind / 50% grid

*** 2005 – 100% wind / 0% grid; 2030 – 50% wind / 50% grid

**** Results shown assume 350bar dispensed; DOE verbal – 700bar adds \$0.10-0.20/kg [Fred Josek, Mark Paster]

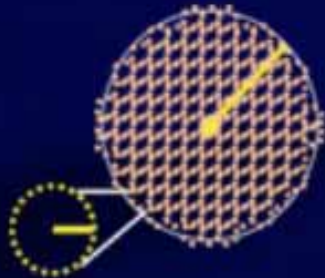
Infrastructure Deployment

Feasibility of Initial Nationwide Seeding of H2 Refueling Stations

\$10-15B would establish a network of 11,700 stations

- Top 100 urban areas (70% U.S. population)
- 130,000 miles of highway
- First million fuel cell vehicles

**Station always within
2 miles in urban areas**



**Top 100 U.S.
metro areas**

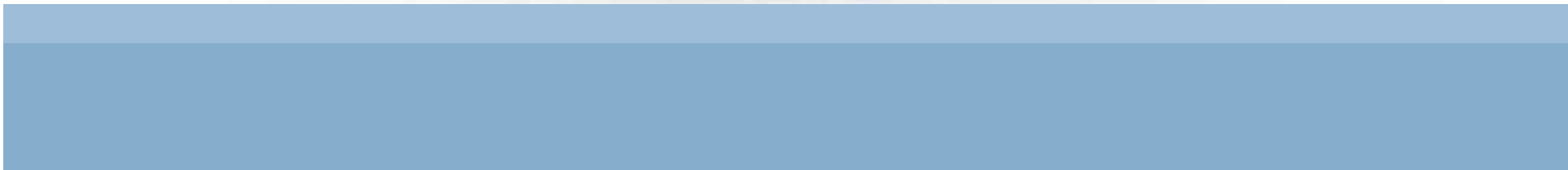


**1 highway station
every 25 miles**



Hydrogen Issues for Commercialization

- Storage (density, cost)
- Quality and purification (technology, cost)
- Metering (technology)
- Station siting
 - footprint, cost
 - liability, NIMBY, permitting
- Codes and standards
- Harmonized (coordinated) infrastructure build-up
- Public confidence on safety and benefits (education)
- Capitalization challenge during early transition phase
- Government financial support
- “Collective Will” of industry, government, and consumers



The image features a 3D-rendered GM logo. The letters 'GM' are rendered in a metallic, silver color with a slight shadow, giving them a three-dimensional appearance. They are centered within a dark blue square that also has a 3D effect, with a lighter blue highlight on its top edge. The entire logo is set against a light blue background that has a subtle gradient and a soft shadow cast to the left. At the bottom of the image, there is a solid, medium-blue horizontal bar.

GM