Creating a Hydrogen Economy: Challenges & Opportunities

bp cleaner energies / Hydrogen

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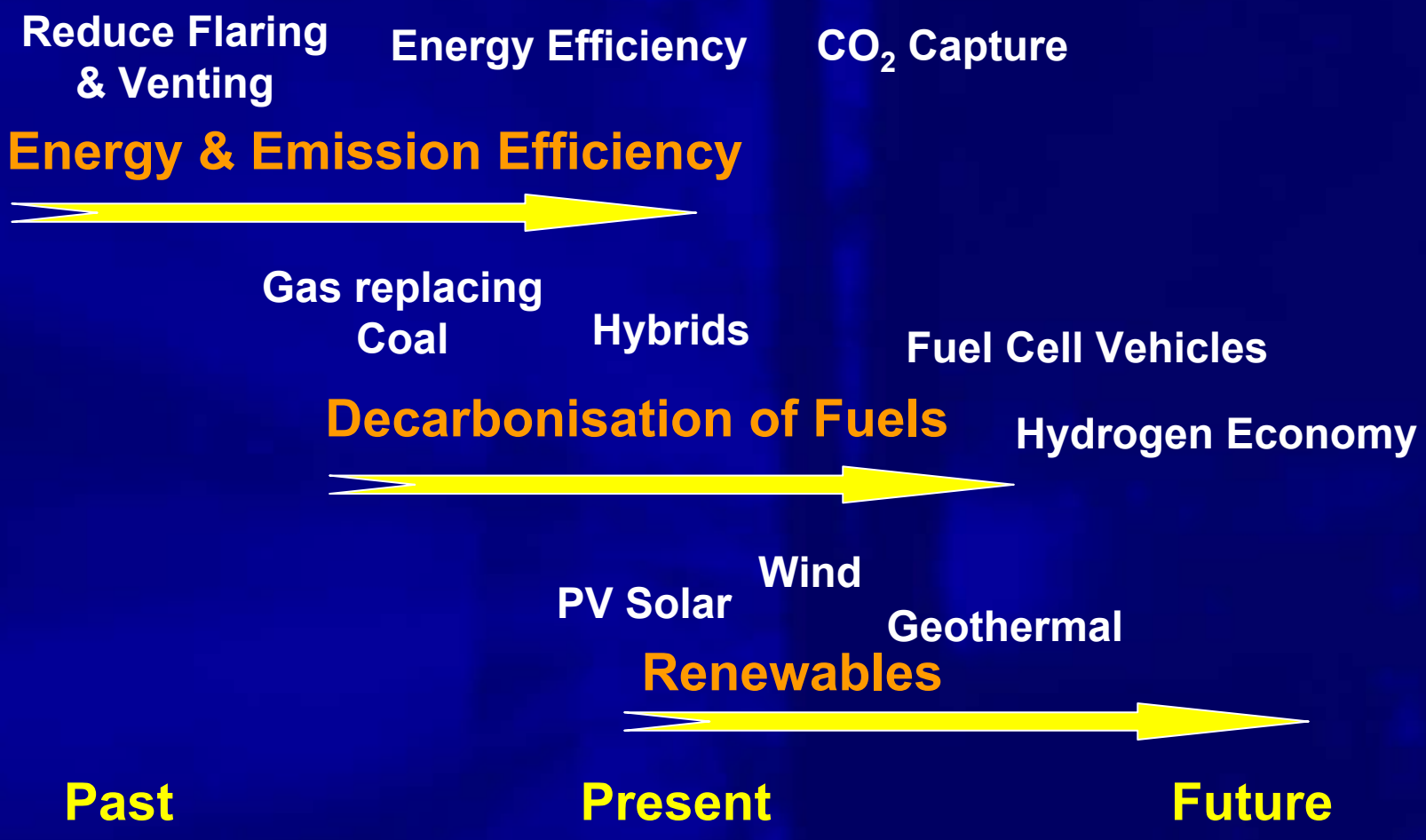
Overview

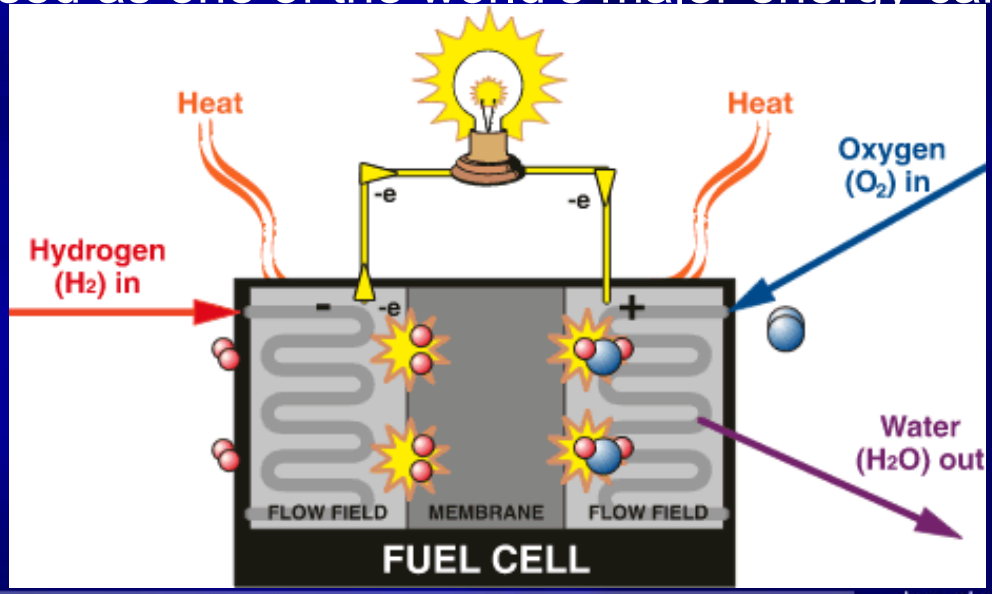
- Context
- The Hydrogen Economy
- BP Hydrogen Experience
- H2 Challenges
- Role of BP
- Role of Government
- Summary

Lower carbon growth



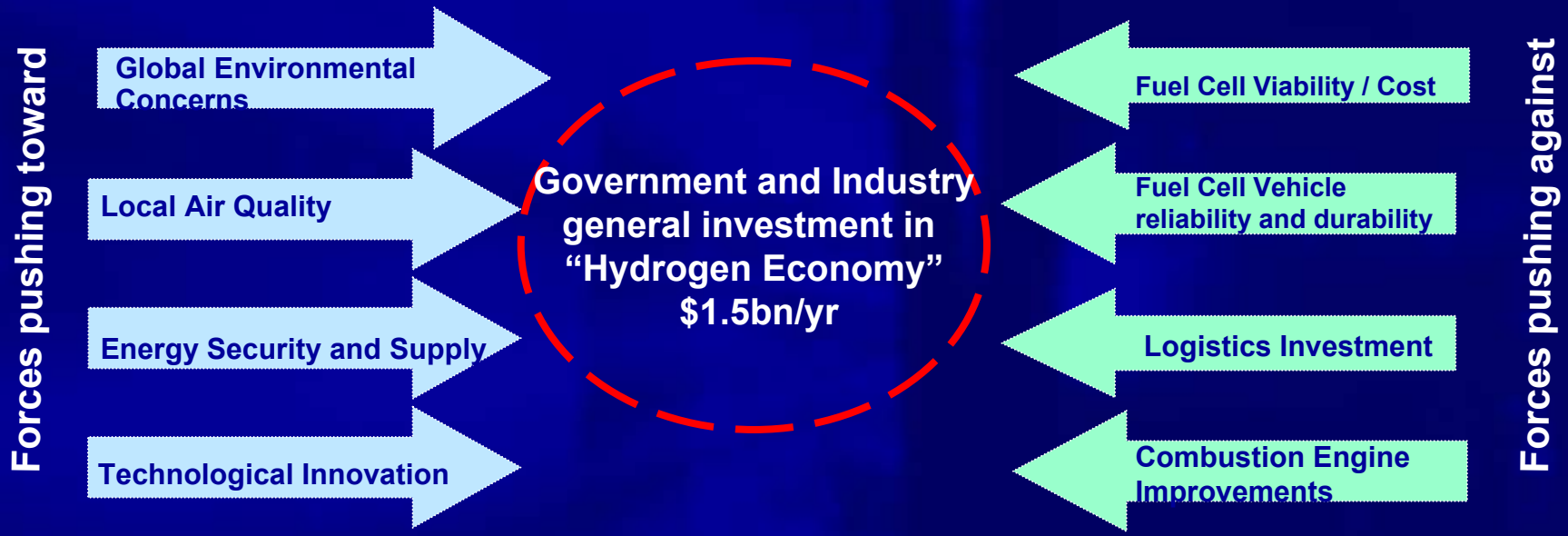
What is the hydrogen economy?

- Internal combustion engines are only about 15-20% efficient
- Fuel cells offer an efficient means of energy conversion (50-70% efficiency)
- Fuel cells require hydrogen (and oxygen)
- Hydrogen is an energy carrier
- The 'hydrogen economy' can be defined as a scenario in which hydrogen is used as one of the world's major energy carriers



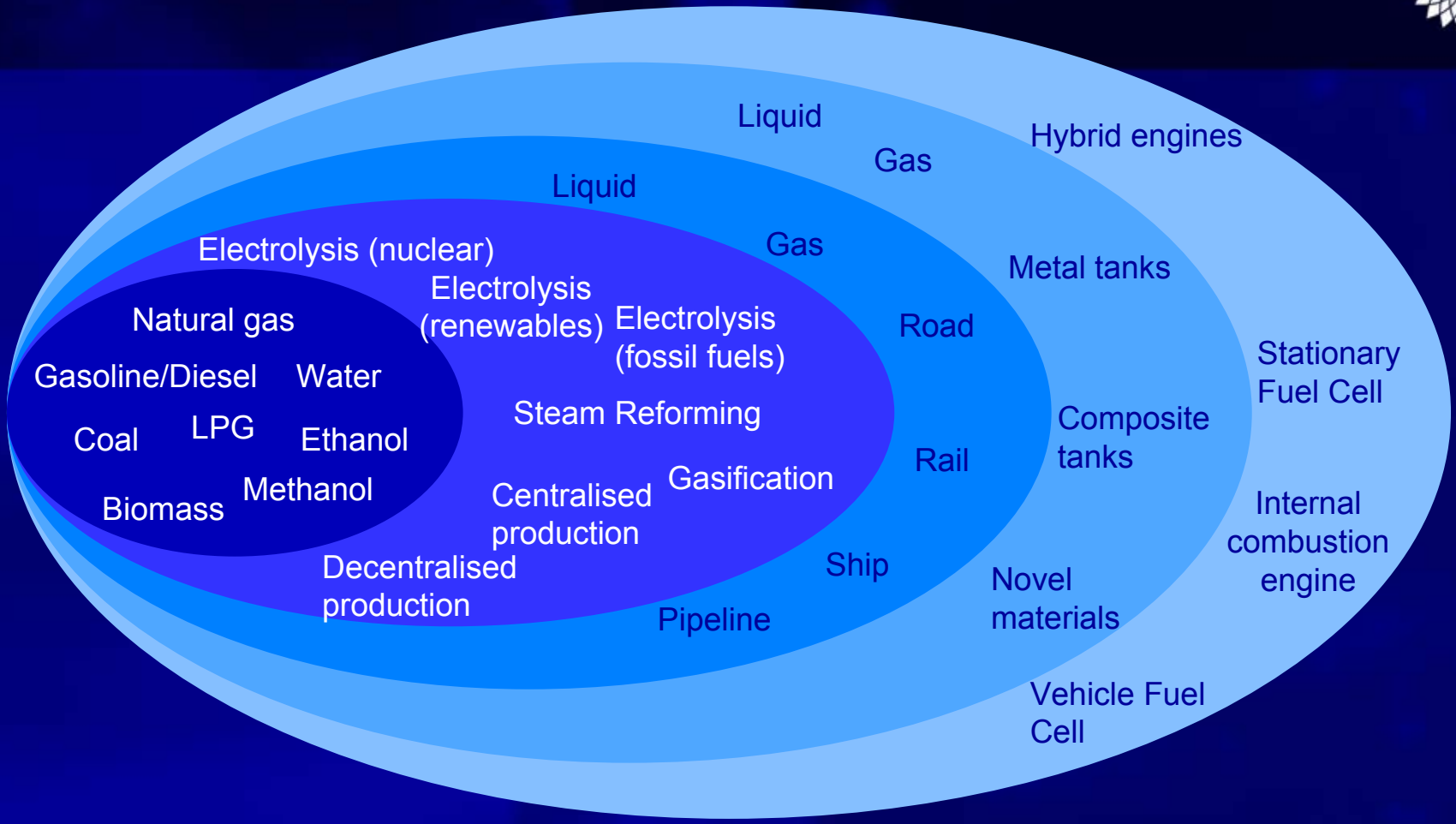
Will there be a hydrogen economy?

- Hydrogen powered fuel cells promise to provide clean and efficient energy for future vehicles and stationary power generation.
- The “Hydrogen Economy” is an end state based on hydrogen produced from renewable energy such as solar or wind. It is not yet economic to produce hydrogen in this way.
- A long transition based on hydrogen from hydrocarbons is likely
- Cost/technical hurdles to overcome to allow mass adoption of fuel cell technology



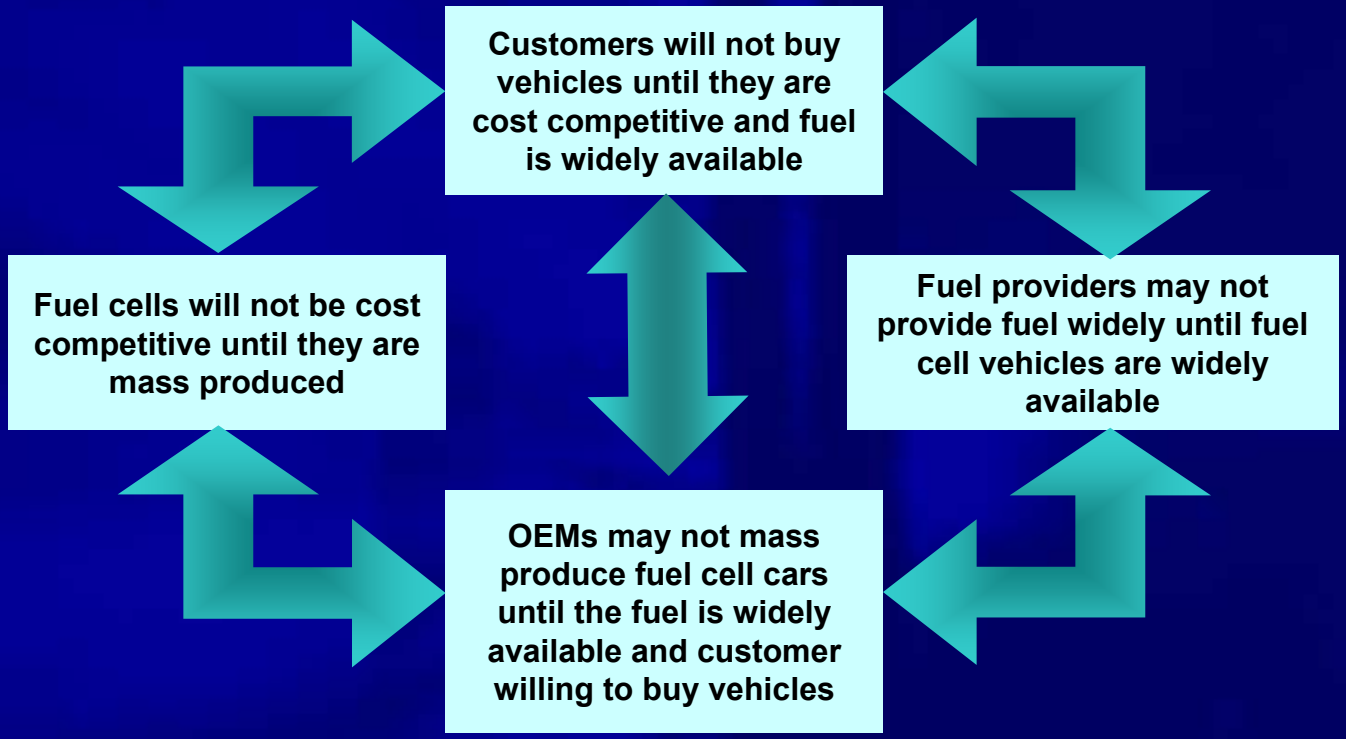
Despite increased momentum the timing to a Hydrogen Economy is uncertain…

Paths to a Hydrogen Economy

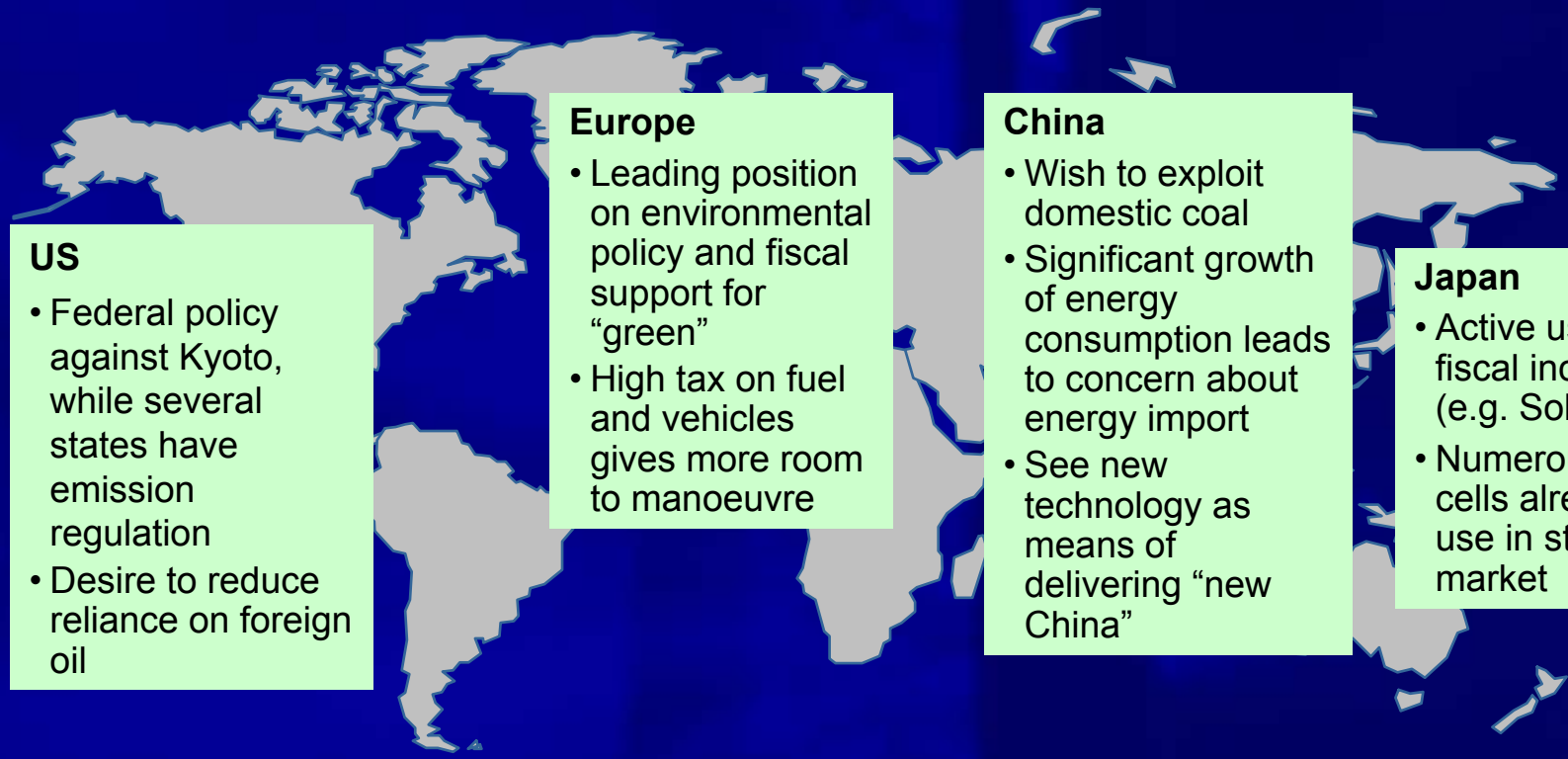


A complex transition?

- Competing new technologies– Radical change and market disruption.
- Long wavelength and uncertain end-state hamper investment.
- Government and Industry alliances will be critical to delivery.



Regional variations impact pathways



US

- Federal policy against Kyoto, while several states have emission regulation
- Desire to reduce reliance on foreign oil

Europe

- Leading position on environmental policy and fiscal support for "green"
- High tax on fuel and vehicles gives more room to manoeuvre

China

- Wish to exploit domestic coal
- Significant growth of energy consumption leads to concern about energy import
- See new technology as means of delivering "new China"

Japan

- Active use of fiscal incentives (e.g. Solar)
- Numerous fuel cells already in use in stationary market

BP produces and uses over 5000 tonnes per day of hydrogen worldwide

BP's Hydrogen Activities

BP's hydrogen activities

- Participants in:
  - **California Fuel Cell Partnership**
  - **UC Davis H2 Risk Mitigation Modeling**
  - **DOE Freedom Car and Fuel Program**
  - **IHIG (International Hydrogen Infrastructure Group)**
  - **National Hydrogen Association**
- Stationary Fuel Cell Demonstration (Alaska)
- Fuel cell testing at HARK (Houston)
- 700 bar refuelling (Vancouver)
- Perth fuel cell bus project (Australia)
- Singapore (2 sites)
- Munich Airport (Aral)
- Clean Energy Partnership Berlin (Aral)
- Los Angeles Airport

Progress is being made

State of the art Oct 2000

3 years later

By 2005

Making It Work: Hydrogen Demonstrations

Customer Focus is key

•Planning and permitting

•H2 safety is paramount – both real and perceived

•Codes and Standards

•Outreach is essential

Production & Infrastructure challenges

- Timing – matching investment with demand
- Retail components – capital, operation and maintenance costs, footprint, energy efficiency, reliability, GHG emissions
- Distribution – cost and technology
- Customer acceptance
- Permitting

The costs of hydrogen

Hydrogen is not inherently expensive…

Production cost of fuels	US$/GJ
Hydrogen (from Natural Gas)	8-10
Petrol (equiv to US$ 1.1/gallon)	8

but current means of delivery is expensive….

Truck delivery cost of hydrogen US$/GJ	100 miles	500 miles
•Gaseous H2	15-20	60-70
•Lliquid H2	1-2	6-7

Other Technical Challenges

- Fuel cells
  - Costs
  - Materials
  - Cold weather durability
  - Input sensitivity
- Hydrogen storage
  - Novel materials needed to reduce station and vehicle H2 storage space

Role of BP

To address these challenges, BP is working on a number of projects

- Refuelling demonstration projects - cars & buses
- Stationary fuel cell testing
- Education and outreach on hydrogen
- Industry workgroups on codes & standards

Through these efforts we are:

•Building technical competence

•Identifying and promoting enabling technologies

•Determining retail compatibility of different supply options.

•Investigating technology and cost potential.

•Identifying and addressing issues with codes and permits.

•Gaining operational experience.

role of government

- Educate the public on the use and benefits of hydrogen.
- Establish codes and standards based on test results, to allow hydrogen to be dispensed alongside conventional fuels.
- Ensure local regulatory approval bodies adopt and support developing codes and standards.
- Support fundamental research into distributed hydrogen production and *storage*.
- Share the potential financial risks of testing and building hydrogen infrastructure through promoting demonstration projects, the key to building real life experience.
- Promote public policy such as:
  - **When commercially available, serve as early adopter of stationary fuel cell power stations and FCVs.**
  - **Provide capital allowances towards infrastructure costs.**
  - **Implement zero tax on fuels and vehicles for customers who purchase FCVs**
  - **Government action to overcome high infrastructure barriers (i.e. RD&D efforts, standards and codes, and education outreach).**

IN SUMMARY

As shown the scale and complexity involved in a transition to a hydrogen economy naturally creates interdependencies across industries. We believe that partnerships with government, auto manufacturers, NGOs and academia will be key to enabling this transformation.

Hydrogen Bus Program

- DaimlerChrysler “Citaro” buses
- Buses delivered over 2003.
  - First buses launched in Madrid, May
  - Buses operate for 2 year period
- Total project is ca 90M Euro
  - EC contribution 19M Euro.
- BP will be largest hydrogen fuel provider.
- BP supplying refuelling infrastructure in London, Barcelona, Oporto, and Perth, Western Australia.
- Partners in Hamburg and Stuttgart with utility companies