PATHways: Assessing Progress in the Global Hydrogen Industry

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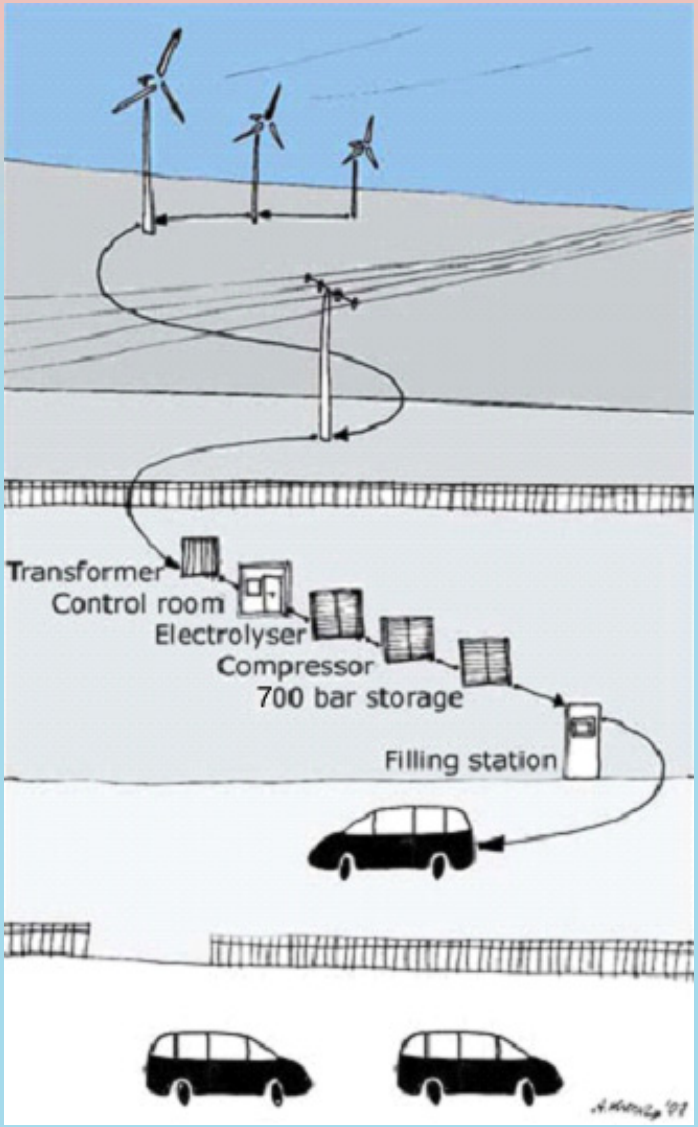

Outline

- PATH Introduction
- Global Trends
- Country Profiles – A Sample
- Conclusions – A World View

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PATH – Partnership for Advancing the Transition to Hydrogen

- **International Coalition of Hydrogen Associations**
- 16 countries and the European Hydrogen Association
- Mission: to spread a consensus vision of the hydrogen economy globally and facilitate its implementation.
- Current Activities:
  - Assisting partners in public outreach, government policy, advocacy, and codes & standards development
  - Building the international network of hydrogen advocates by holding Executive Meetings around the world
  - Sharing information among partners through newsletters, webpages, and the Initiatives Database
  - Helping other countries form associations
  - Report on the state of the global hydrogen economy

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PATH Associations

- **Asociación Argentina del Hidrógeno** (Argentina)
- **Asociación Española del Hidrógeno** (Spain)
- **Association Française de l'Hydrogène** (France)
- **Australia Institute of Energy - Hydrogen Division**
- **Canadian Hydrogen Association**
- **China Association for Hydrogen Energy**
- **DCT Energia** (Brazil)
- **European Hydrogen Association**
- **Hydrogen Energy Systems Society** (Japan)
- **Italian Hydrogen Forum**
- **Hydrogen Energy Systems Society of Japan**
- **Massey University Centre for Energy Research** (New Zealand)
- **National Hydrogen Association** (U.S.)
- **Polish Hydrogen and Fuel Cell Association**
- **Sociedad Mexicana del Hidrógeno** (Mexico)
- **United Kingdom Hydrogen Association**

PATH associations represent 39% of the world's population and 76% of the global GDP

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PATH Board of Directors

- Terry Kimmel, Canadian Hydrogen Association (Chairman)
- Ken-Ichiro Ota, Hydrogen Energy Systems Society (Vice Chairman)
- Jay Laskin, National Hydrogen Association (Treasurer)
- Juan Carlos Bolcich, Asociación Argentina del Hidrógeno
- Claude Derive, Association Francaise de l'Hydrogene
- Andrew Dicks, Australia Institute of Energy - Hydrogen Division
- Lars Sjunnesson, European Hydrogen Association

Managed by Technology Transition Corporation

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International H2 Organizations

- **IAHE**: International Association for Hydrogen Energy
  - Scientists, engineers, and environmentalists
- **PATH**: Partnership for Advancing the Transition to Hydrogen
  - Industry and academic-led national hydrogen associations
- **IPHE**: International Partnership for the Hydrogen Economy
  - 17 national governments

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Why Hydrogen is Important

- CO_2 reduction
  - Prevent global warming
- Reduce urban pollution
- Energy security
  - Use domestic resources
  - Reduce oil imports
- Wealth generation
  - Foster new industry
- Energy equity
  - Development

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Global State of Hydrogen Energy

PATH Project Under Development

National, State/Province, Local

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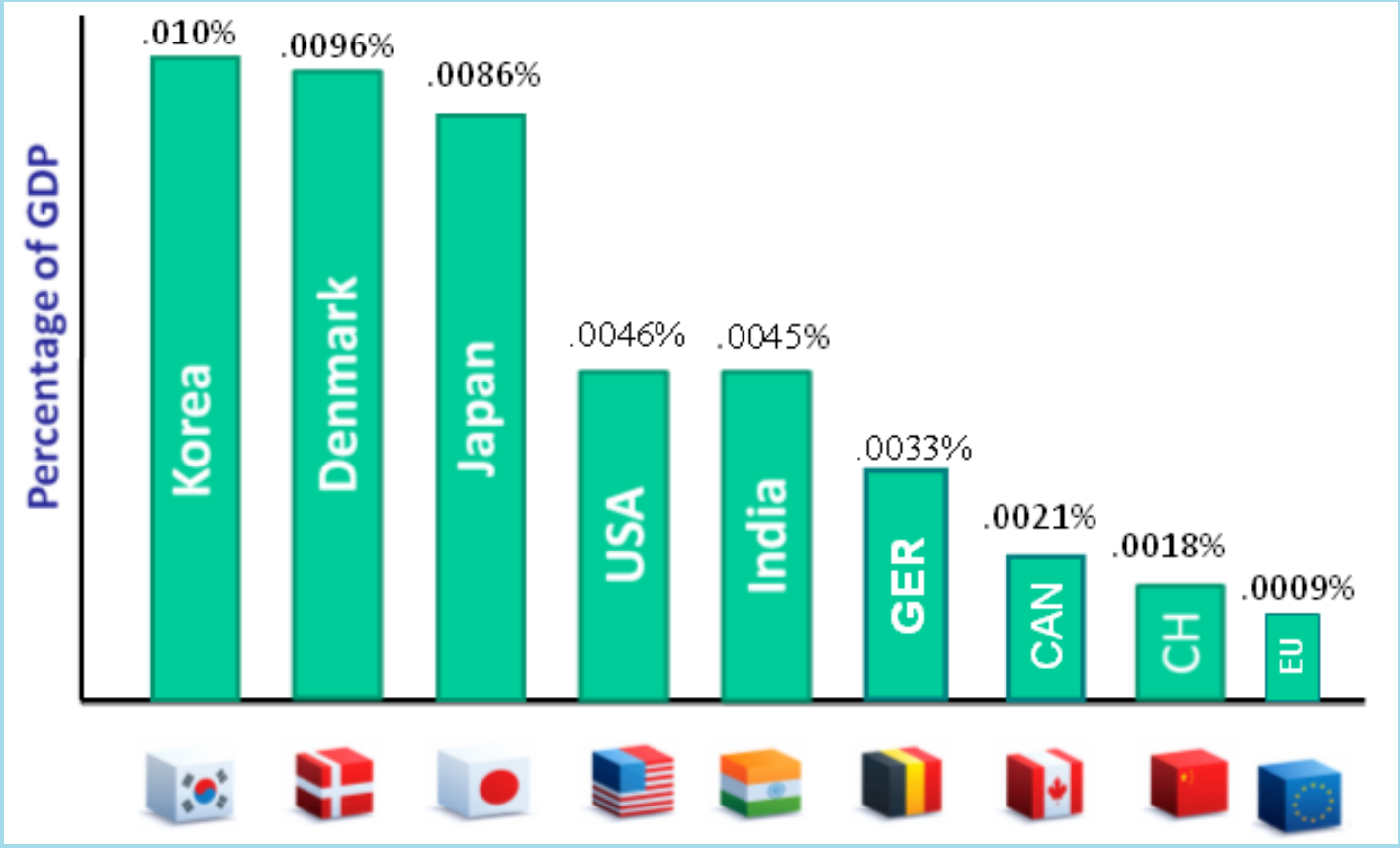
Hydrogen and Fuel Cell government investment against GDP 2009



Source: Terry Kimmel, Canadian Hydrogen and Fuel Cell Association, Vice President

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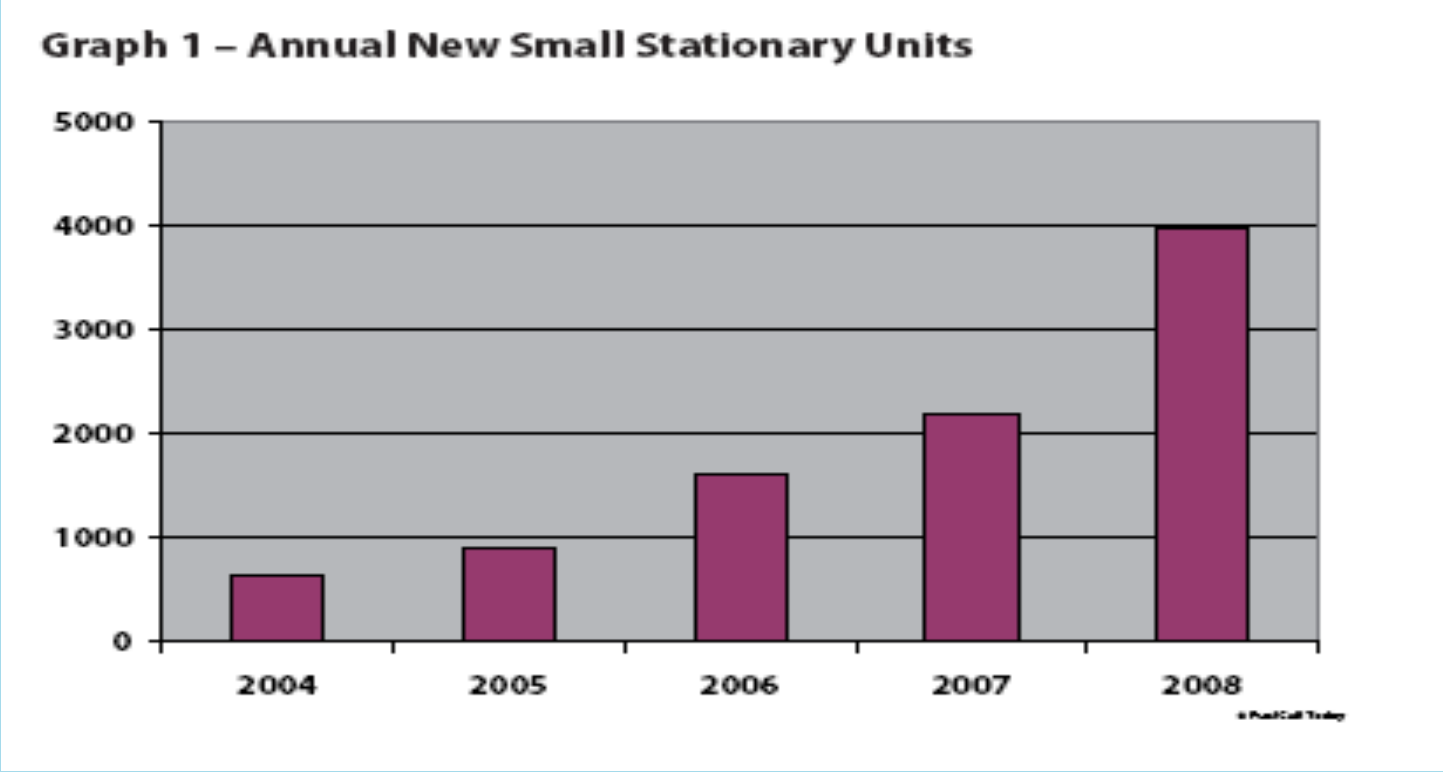
Global industry focus on commercialization

- Over past three years, annual growth rate of 59%
- From 2006
  - Revenues increased 59% to $416M
  - 2016 Global Sales estimated to be $8.5 billion
  - R&D consistent at $213M
  - Employment increased by 10%
  - Market capitalization increased 20% to $3.8B
  - Increasingly developing strategic relationships with OEMs and energy providers
  - Supply chains needed for volume production and focus on generating near term revenues
  - No company is profitable – firms share net losses of $644M
- Cost reductions averaging 10% to 20% per year

Source: International Partnership for the Hydrogen Economy

Global Sales of Fuel Cells (<10kW) in Stationary Markets



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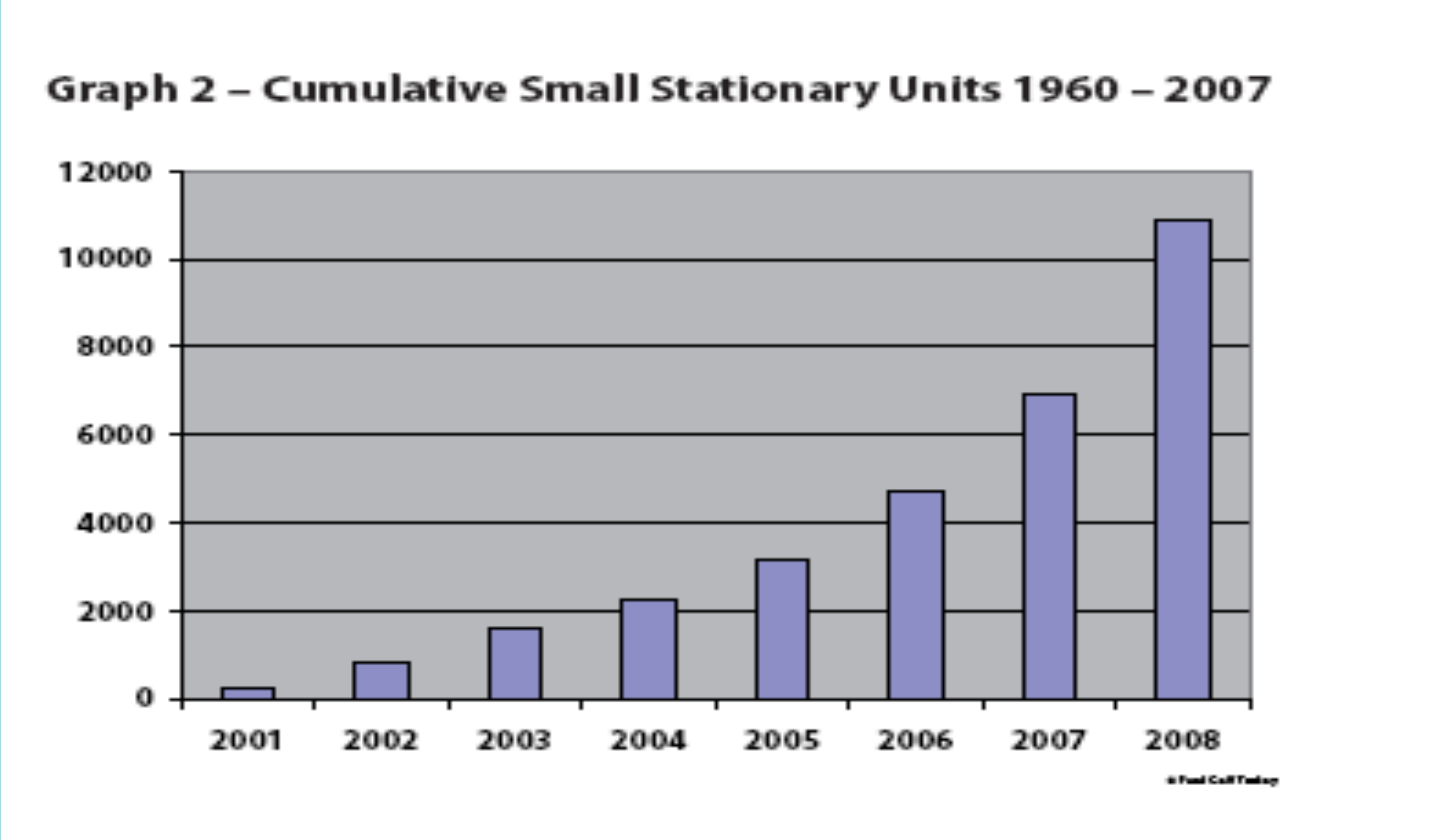
Cumulative Small Stationary Units 2001-2007



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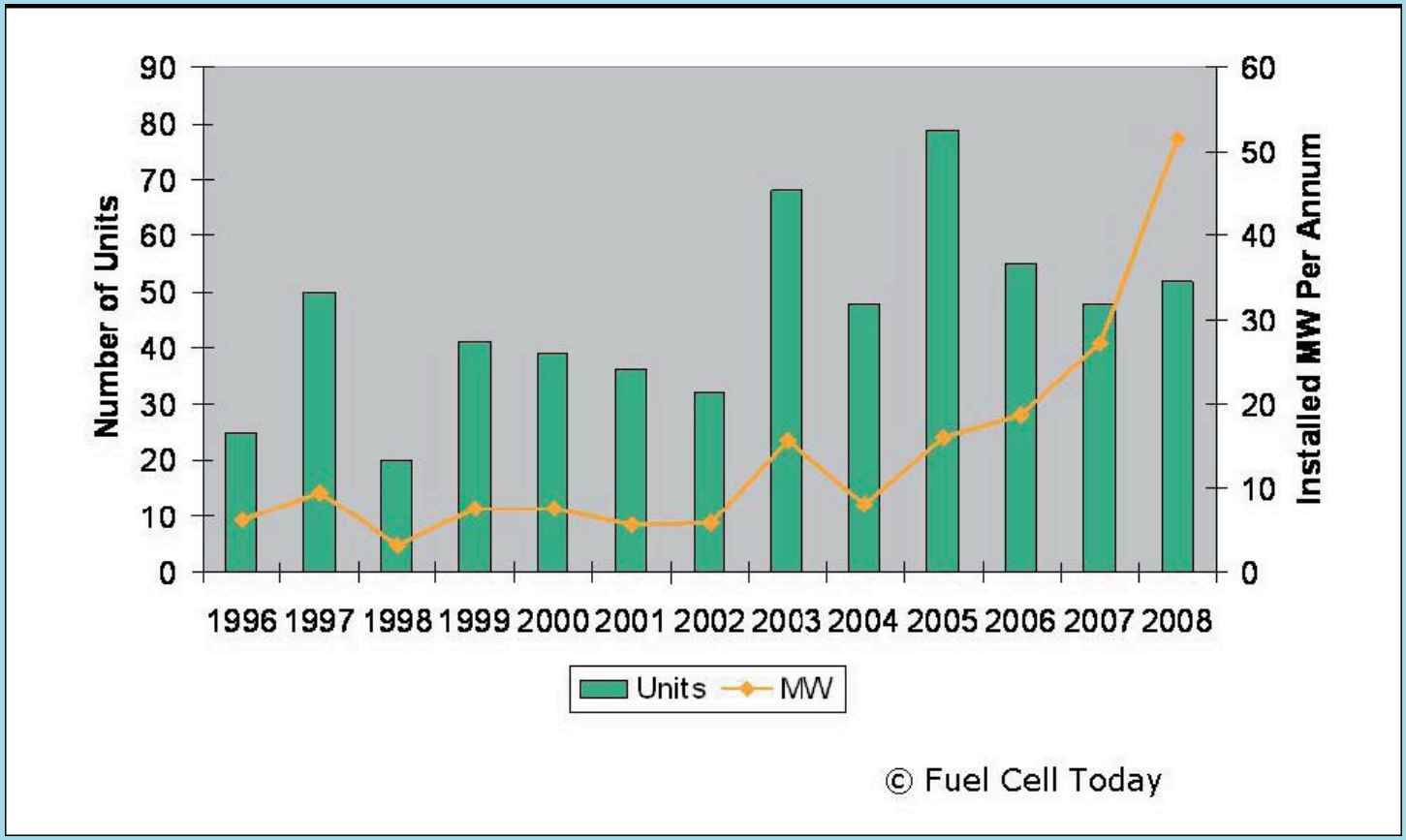
Global installations of large fuel cells >10 kWe



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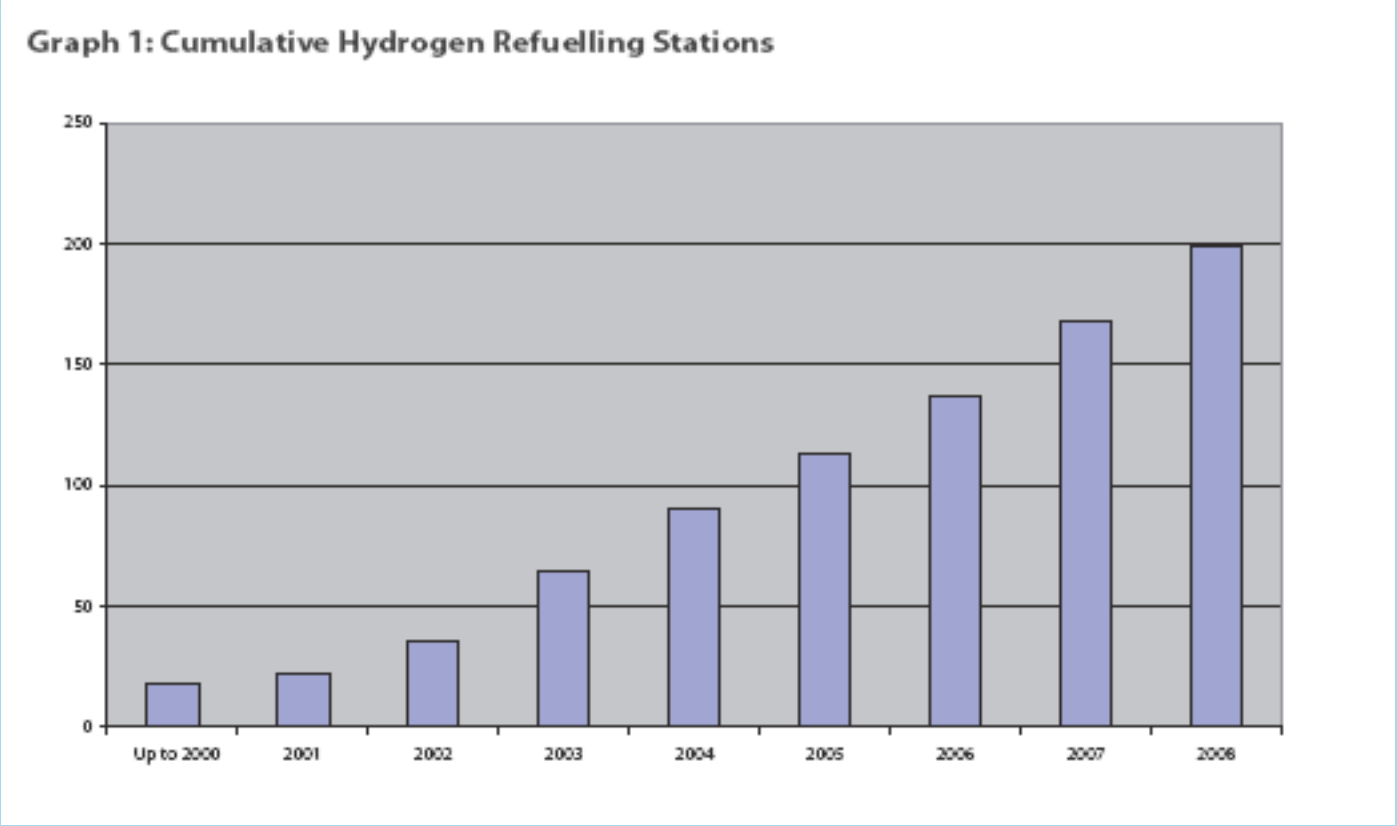
Hydrogen refuelling stations



Source: Fuel Cell Today

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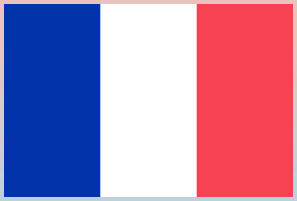
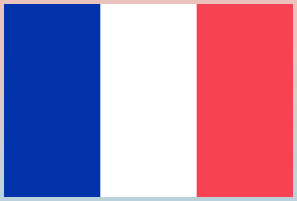


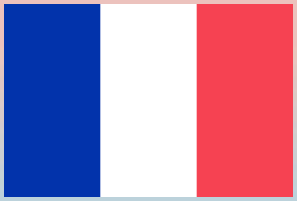
France

- Government Action
  - Current R&D funding: ~ €45M (~63M USD)/year
  - €67M granted to new deployment project
- Push for a National H2 Roadmap
  - At national level H2 & FC don't have strong support
  - A national platform was recently organized to:
    - A) bring together stakeholders to give H2 stronger visibility at the national level and
    - B) develop and propose a French hydrogen roadmap
  - Goal: promote H2 & FC technology and apply for grants from the new €1 billion energy fund



France

- Hydrogen Production
  - Electricity generation: 80% nuclear, 13% renewable
  - There is a big research project to see how H2 can be produced from nuclear-powered electrolysis
    - Issue: economic competitiveness of this method
  - There are projects to show that H2 can be a way to store energy from intermittent sources like wind
- Main challenge to commercialization of hydrogen and fuel cell technology: complex codes and standards in France



France

- Support in French Regions
  - Rhône-Alpes: a study was carried out on how H2 & FC can be developed in the region
  - Nord-Pas-de-Calai, Midi-Pyrénées, and Lorraine expressed interest in developing and demonstrating early market H2 &FC applications
  - Aix-en-Provence: demonstration projects and early market applications in use
  - Northern France: small demonstrations of backup power fuel cells for telecommunication systems

Germany

- Government Action
  - The National Innovation Program (NIP) for Hydrogen and Fuel Cell Technology
    - It is a “strategic alliance” between the government, industry and academia
    - Total budget: €1.4B (2B USD) over 10 years (2007-2016) – 50-50 government-industry funded
    - Markets / Applications:
      - Transport & H2 Infrastructure
      - Stationary Applications
      - Special Markets

Germany

- The National Organization Hydrogen and Fuel Cell Technologies (NOW)
  - The government-owned program management organization responsible for the implementation and coordination of the individual projects, demonstration activities, and international collaboration under NIP
  - GermanHy: provides NOW with info regarding H2 infrastructure (R&D-needs, demo projects) and identifies opportunities and limitations of H2
- The German H2 & FC Association (DWV)
  - DMV brings stakeholders together, supports R&D, creates project proposals, advises in the regulations process, disseminates information about H2 initiatives around the world, informs the public and political decision-makers, and works with associations and institutions in other countries

Germany

- Public Perception
  - It varies occasionally but it has been high in the last few years
  - The current “electric-drive hype” has caused some difficulties because, although batteries are required for longer-range HFCV, there is a misconception that batteries are the only requirement/option for zero-carbon transportation
  - Even so, it is difficult to educate and train people and there is a need for more public interest

Germany

- Support in German Federal States
  - Berlin and Hamburg: Clean Energy Partnership
    - 40-50 H2 passenger cars
    - 15 H2 buses
    - several public H2 fueling stations
    - H2 ship
  - North Rhine-Westphalia
    - Provides €10-15M/year for H2&FC RD&D
    - Essen is the host city for WHTC 2010
    - Center of FC Technology (Dusseldorf)
  - Baden-Württemberg
    - Center of Solar and Hydrogen Technology (Stuttgart)

Italy

- Hydrogen organizations
  - The Italian Hydrogen Forum
  - The Italian Hydrogen and Fuel Cell Association

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Italy

- Government Action
  - National agencies involved in H2 & FC: Ministries of Transportation, Environment, Energy, & Infrastructure
- National H2&FC R&D Program
  - Funding: €128M (180M USD) between 2005-2008
  - 36 research centers
  - Projects in FC applications and new materials, and H2 production, storage and distributed generation
  - Ended 6/30/09; final report expected 10/09

Italy

- Moving towards a National Plan on H2&FC
  - Objectives: Define a R&D&D strategy to support the development towards a sustainable hydrogen economy
  - The proposal is under discussion within the new Administration.
    - Anticipated budget: €600M (844M USD) for 3-year program
- Challenges
  - Industry wants to play the main role, but company interests are often in conflict
  - Defining a National Plan requires an advanced knowledge of hydrogen systems and experience in the field
  - The cost of hydrogen infrastructure will be the most serious challenge to commercialization

Italy

- Support in Italian Regions
  - Most of the hydrogen initiatives are promoted by individual regions (particularly in Piemonte, Lombardia, Toscana, Veneto, and Lazio), rather than the national government
- Public perception
  - Mostly positive, but there is a general lack of knowledge about hydrogen

Brazil

- Hydrogen Road Map
  - Phase I: 2004-2005
    - Develop Roadmap
  - Phase II: 2006-2007
    - Structuring Projects for Action Plan
  - Phase III and IV: 2008
    - Hydrogen Plan Launching
  - Phase IV: 2008-2025
    - Implementation of Activities

Source: Hydrogen Initiatives in Brazil by Fernando Baratelli Junior, Intelectual Property Manager, PETROBRAS / CENPES

Brazil

- Hydrogen Production
  - Energy policy is predicated on the huge potential of hydropower, oil, natural gas, and ethanol from sugar cane
  - The main difficulty is showing that H2 has to be part of our energy matrix and establishing policies to promote H2 initiatives
  - Ethanol, oil and natural gas are potential raw materials for producing H2
  - In the next 10 years, Brazil will be a net producer of ethanol, oil and natural gas.

Brazil

- Public perceptions of H2 & FC technology
  - Hydrogen is unknown to the public as source of energy
  - Stakeholders believe it is important to begin a process of education in terms of showing that the potential of hydrogen is very large
  - Because of lack of information, the program still doesn't have the support of local leaders.

Canada

- Moving Towards a National Roadmap
  - Canada has two main publications:
    - "Towards a National Hydrogen and Fuel Cell Strategy for Canada" discussion document (2007)
    - "Canadian Fuel Cell Commercialization Roadmap Update" (2008)
    - There are several other publications, including a guide to H2&FC codes and standards and an analysis of GHG reduction and economic growth opportunities through H2 deployment
  - The federal government has not adopted the proposed actions

Canada

- Government Funding (**2008 funding levels*)
  - H2 & FC programs: $25M CAD ($21M USD)
  - R&D in academia and government labs: $20M CAD ($17M USD)
  - Industry demonstration programs: $5M CAD ($4M USD)
  - Government does not provide any incentives for developing or purchasing hydrogen technology
  - The provinces of British Columbia, Ontario, Québec, and Prince Edward Island also have their own H2 & FC strategies and funding programs
- Agencies Involved in H2 & FC
  - Natural Resources Canada
  - Industry Canada
  - Transport Canada
  - National Science and Engineering Research Council

Canada

- Industry investment and revenue trends
  - Industry comprised of 80 relatively small, knowledge-based enterprises
  - $200M ($171M USD)/year (average) in RD&D in H2 & FC (~1/3 total energy industry R&D expenditure in Canada)
  - Canada exports more than 90% of their H2 & FC products, esp. to countries that have incentives: Japan, US, Germany

Canada

- Hydrogen Production
  - Steam methane reforming is used to produce H2, but there is a need to find low/zero carbon methods
- Barriers to hydrogen development
  - Low electricity costs; bountiful energy sources: hydro, oil, nuclear
  - Lack of government incentives and funding
  - Federal government hasn't adopted a H2 strategy plan
  - Lack of foresight to see the future role H2 can play

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Canada

- Vehicles Demonstration
  - BC Hydrogen Highway: network of technology demo projects: vehicles, fuelling stations, micro, portable and stationary power applications
  - Toronto Hydrogen Village: public-private partnership to support demo projects, provide early purchaser opportunities, and overcome challenges to commercialization
  - Vancouver: 5 Ford Focus FCV operating in their 4th year
  - 2010 Winter Olympics: BC Transit will operate a shuttle fleet of 20 H2FC buses in the Whistler area; GM will also bring 8 Equinoxes

Canada

- Emerging Markets
  - Prince Edward Island Wind-H2 Village: demonstrate wind-powered electrolysis and stationary H2FC power
  - Montreal Airport Project: testing H2 technologies and infrastructure: passenger transportation, cargo handling, various power sources and refueling
  - Many companies have refocused R&D towards near-term markets: materials handling, backup power, transit buses, and portable electronics
  - Significant progress made in: cost, performance and reliability targets and infrastructure development
  - Major project to recover waste H2 (200,000 tons/year) for use in stationary and vehicle applications

United States

- National Roadmap
  - The U.S. has several guiding documents:
    - “The National H2 Energy Roadmap” (2002)
    - “A National Vision of America's Transition to a Hydrogen Economy - to 2030 and Beyond” (2002)
    - “Hydrogen Posture Plan” (2006)
    - California Fuel Cell Partnership: “Hydrogen Fuel Cell Vehicle and Station Deployment Plan” (2009)
  - These provide a blueprint for the coordinated, long-term, public and private efforts required for H2 energy development and summarize the potential role for H2 systems in America.

United States

- Government Action
  - Congress planning to appropriate between $193M - $204M for FY2010 Department of Energy H2&FC Program (approximately equivalent to FY2009 levels)
    - RD&D: H2 production, delivery, and storage, as well as FC technologies for transportation, distributed stationary power, and portable power applications
    - Addresses safety concerns and develop model codes and standards
    - Educates key stakeholders
  - Current focus on advanced batteries for EV

United States

- H2 R&D Interagency Task Force: Agriculture, NASA, Transportation, Commerce, State, Defense, Environmental Protection Agency, and the National Science Foundation
- Stimulus Funding
  - Tax breaks have been available for some time for alternative energy sources (incl. hydrogen)
  - Recently, as part of the economic recovery effort, federal agencies and states created numerous government funding opportunities for H2 &FC projects
    - Ex: payments for qualified FC property in lieu of tax credits: $1,500 for each 0.5 kilowatt of capacity

United States

- Regional Support
  - Hydrogen action in 37 states
    - New York: developed a state H2 Roadmap, conducting outreach and education, revamping applicable codes, and supporting RD&D projects
    - California: developed and implementing H2 Highway Blueprint Plan (2005), $6.5M/year for demo projects: refueling stations, vehicles and buses
    - South Carolina

United States

- Vehicle Demonstrations
  - 300+ HFC vehicles have been placed on U.S. roads
  - H2 Road Tour: 2008 - cross country; 2009 - Mexican border to Canada
  - Honda plans to deliver ~200 FCX Clarity H2 cars to customers in the first 3 years of their FC lease program
  - AC Transit's HFC program: 3 H2 buses (with plans to operate 13 more by the end of the year), a fleet of FC cars, on-site H2 production and fueling, public education and safety training
  - BurbankBus operating a plug-in FC transit bus

United States

- Vehicle Demonstrations (cont.)
  - SunLine Transit operating a H2 FC hybrid bus, a H2 hybrid ICE bus, a H2+NG station, and sponsored a cross-country tour of a FC-assisted truck
  - Auburn University testing a FC bus
  - Rochester Institute of Tech. testing 3 H2 Ford trucks
  - GM's Project Driveway: 100 Equinox FCV deployed in three geographic areas: California, the New York metropolitan area and Washington D.C.

United States

NHA Fueling Station Database

- Infrastructure
  - 62 operational H2 refueling stations
    - Major station clusters in Los Angeles, San Francisco, and New York City
  - 38 more stations planned
  - California plans to deploy 4,300 H2 cars and 20 buses by 2014
    - The CA FC Partnership's action plan calls for 46 retail H2 stations in 6 key communities at a cost of ~ $180M over 4 years

United States

- Emerging Markets
  - Materials handling – in demonstration/pre-commercial deployment phase:
    - Defense Logistics Agency: operating 20 forklifts in a warehouse depot in PA
    - Nestle: operating 32 forklifts with plans to convert entire warehousing operations to FC power in PA
    - Bridgestone: operating all-H2 fleet with 43 forklifts in SC
  - Portable power units
  - Stationary power for buildings and telecommunication infrastructure
  - Combined heat and power systems

Interim Conclusions
The World View

- Regional support often stronger than national
- Public perceptions generally positive, but education of the public and decision-makers is crucial
- Small-scale niche markets: fuel cell applications are successfully entering commercialization
- Buses: widespread demonstration; full-scale deployment feasible because of centralized refueling
- Cars: biggest growth potential, but heavily depends on coordinated and clustered infrastructure buildup and strong public and government support

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Interim Conclusions
The World View

- Common need for international collaboration: R&D, information exchange, trade/business development
- Common challenges in driving down cost of infrastructure and vehicles, developing codes and standards, bringing stakeholders together, and getting government support
- SMR is the prevalent production method, but strong interest in zero-carbon production, and hydrogen-renewables integration
- Hydrogen economy development progresses best when stakeholders work closely with government to secure funding, coordination of projects and financial incentives

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What Next?

- Looking for lead sponsors to fund expansion and completion of the report on “Global State of Hydrogen Energy”
- Use report to encourage support of all national industry and education efforts

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