Drivers of Innovation in Energy and Fuel Cell Technology: Supply-Demand and R&D

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Overview

- Drivers of energy technology innovation
  - Sustained increase in demand
  - Diversification of sources of fossil fuel supply due to growing security and economic concerns
  - Fuel switching and development of new fuels due to efficiency and environmental concerns
  - De-regulation and increasing competition
- Increasing importance of R&D and technological innovation
- How the energy innovation system works
- Focus on fuel cells

Part I

Supply, Demand, and Investment Trends

Role of Fuel Cells in the Energy System

International Energy Agency

- Established in 1974 in response to the oil price shocks within the framework of the OECD
- 26 member countries, plus the European Union
- Basic aims:
  - maintain and improve energy security
  - promote rational energy policies in a global context
  - improve the world's energy supply and demand structure by developing alternative energy sources and increasing efficiency
  - assist in the integration of energy and environmental policies
- http://www.iea.org

Today's Energy Challenges

- **Energy security to fuel economic growth and mobility**

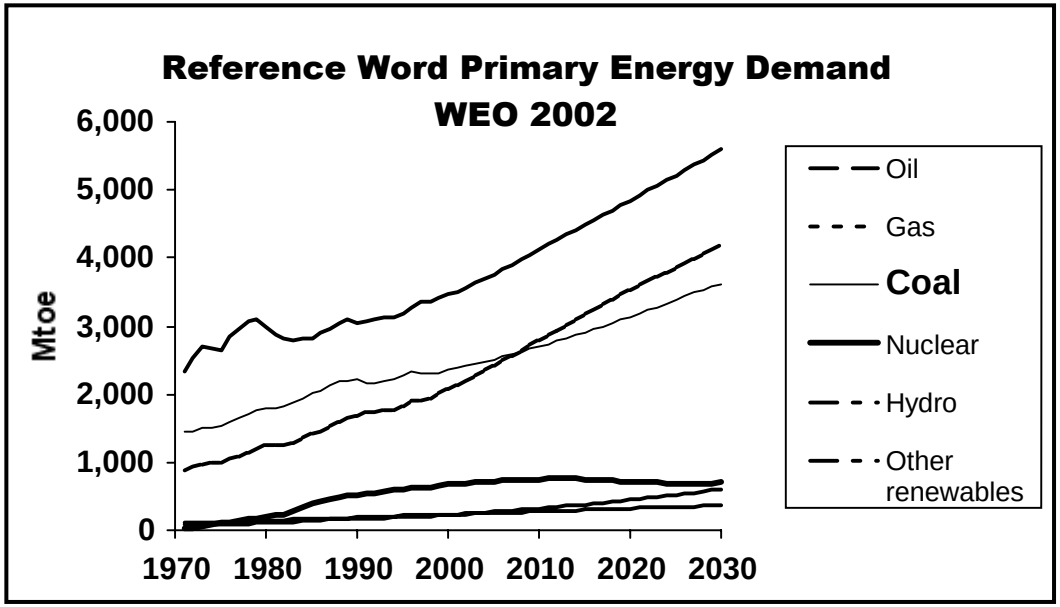
  and

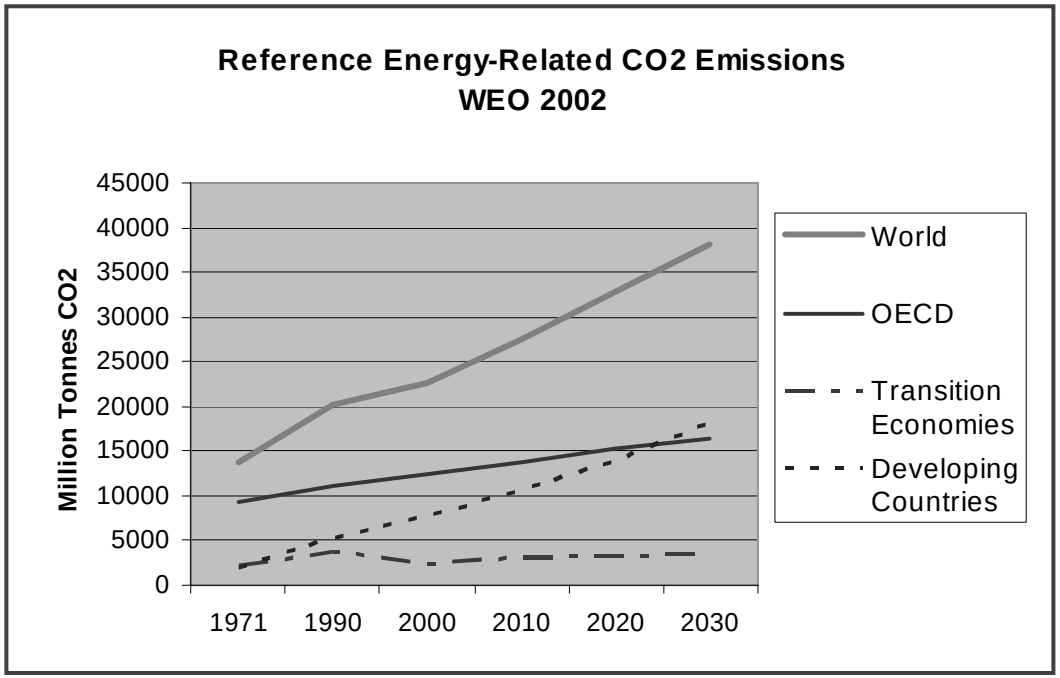
  curbing environmental and climate damage from energy use

  - *"business as usual" energy demand is rising inexorably*
  - *greenhouse gas emissions also*
  - *stronger policies stabilize OECD emissions only after 2020.*

- **Access to modern energy for all**
  - *1.6 billion people have no access to electricity, 80% of them in South Asia and sub-Saharan Africa*

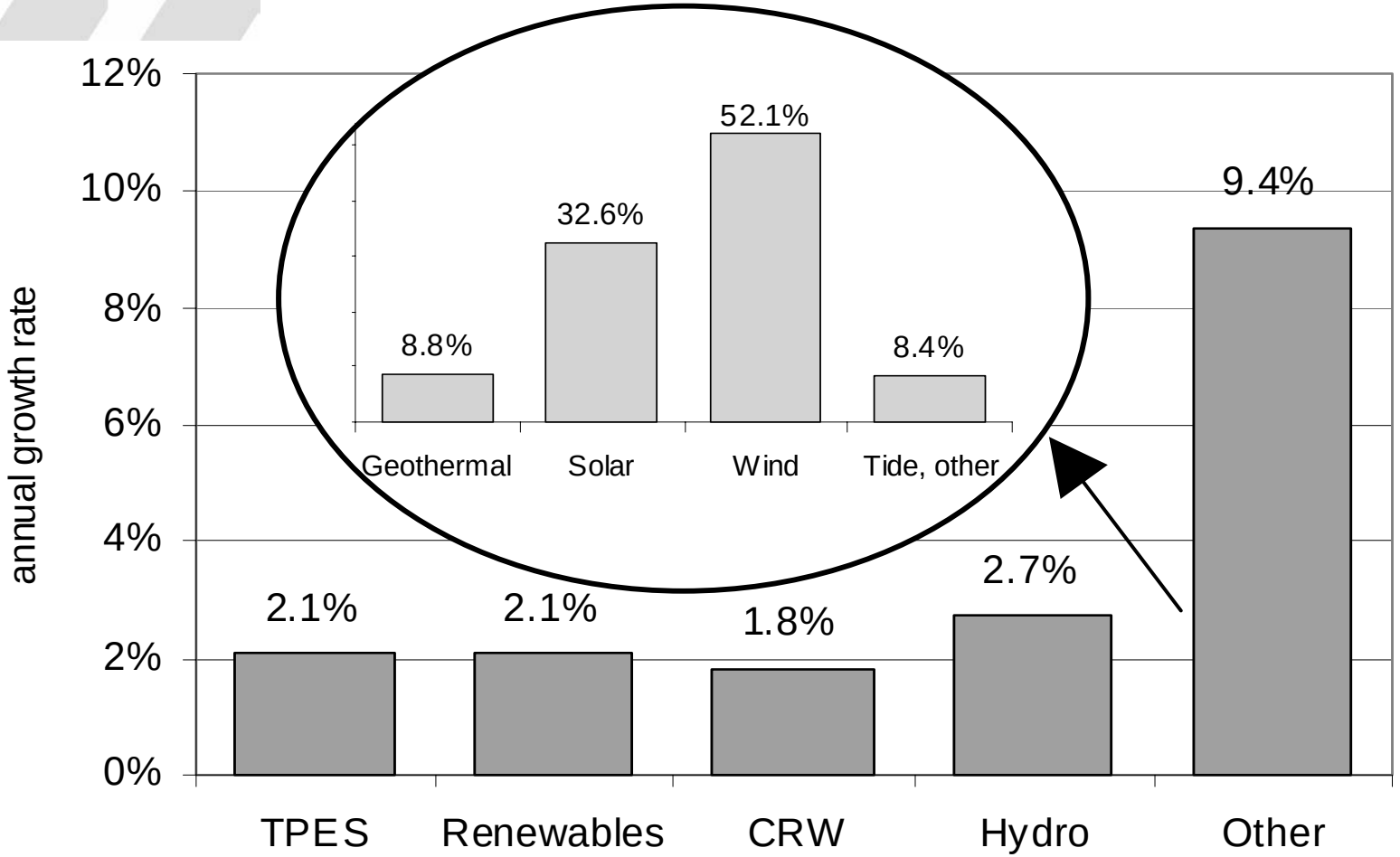
- **Lower costs in deregulated markets; infrastructure stresses**





Renewables Growing Fast, but From a Low Base

Growth of Renewables Supply from 1971 to 2000



TPES: total primary energy supply
CRW: combustible renewables and waste
Source: International Energy Agency

Meeting the Challenges: What Does it Take?

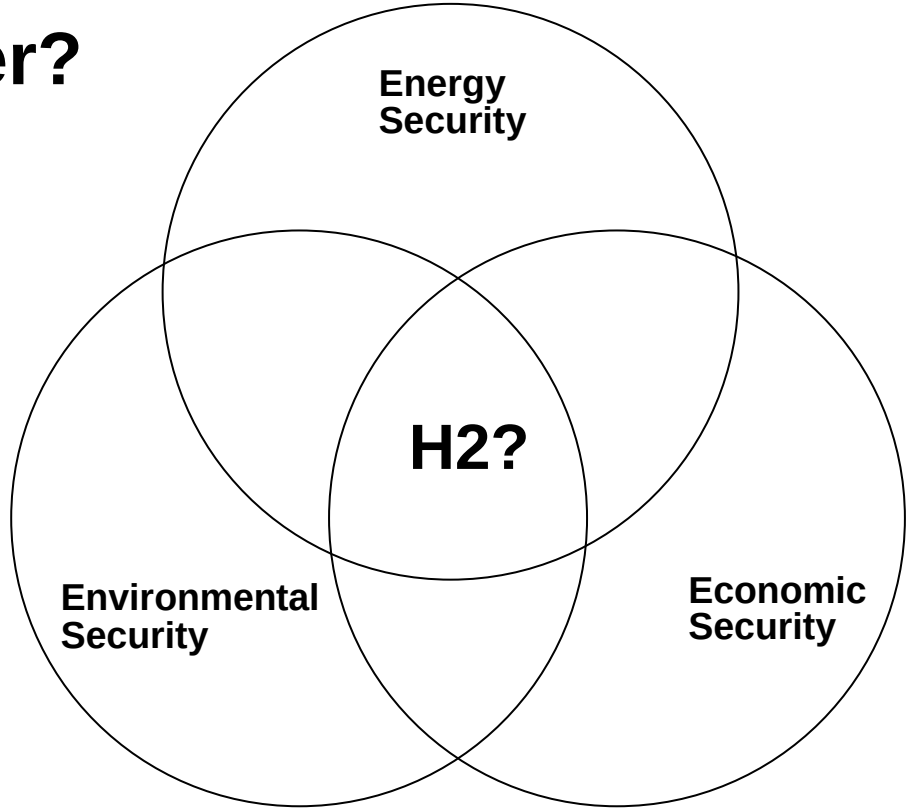
- **Faster progress in energy technology development is an essential element:**
  - more cost-effective solutions
  - capitalize on capital stock turnover as it occurs
  - costs depend on not only development and investment costs but also the extent to which capital stock is retired early

- **How?**
  - more resources for technology R&D and demonstration and underlying sciences; identify and fill gaps ***(as usual)***
  - fostering of public/private partnerships, and of international collaboration, especially for large demonstrations ***(as usual)***
  - support and facilitation of technology uptake ***(as usual, but connection to R&D and technology learning sometimes missed)***
  - other efforts to foster and facilitate innovation – ***more specific policy advice to governments***

What Can Hydrogen Offer?

A number of IEA member countries have made commitments to accelerate the development of the hydrogen energy economy:

- Energy security: reduced dependence on imported fuels *(depending on the source)*
- Climate change: potentially near-emissions-free vehicles and distributed generation *(carbon sequestration required if fossil-based; lower-cost production essential)*
- Investment: some heavy demands promising enormous dividends



Two main strategies for dealing with climate change:

- Europe: renewables, energy efficiency
- North America: carbon capture and storage
- **Both** pursuing hydrogen – from fossil fuels, nuclear energy, renewable energy

Roles for Fuel Cells – Stationary, Distributed Generation

Local and system benefits, including storage to back up intermittent renewables

TODAY:

- ***niche markets --*** telecommunications, back-up power systems

TOMORROW:

- ***Natural gas fuel cells:*** significant contribution to energy supply expected after 2020 -- primarily stationary applications (WEO 2002)
- ***Competitive fuel cells (distributed generation):*** expected when
  -- capital costs fall below $ 1,000 /kWe (~75% reduction)
  -- efficiencies approach 60% (>50% increase)
- ***Natural gas reforming first --*** coal, biomass, water electrolysis
  not expected to be economically feasible before 2030
- ***Fuel cell/gas turbine combined cycle --*** over 70% efficiency?

Roles for Fuel Cells

Vehicles: transport is responsible for over half of world oil demand

- fuel cells in vehicles expected to become attractive only around 2020 (WEO 2002)
- by 2030, only a small share of the vehicle fleet; even under alternative (stronger) policies, less than 5% of the OECD fleet
- difficult to supply substantial quantities of hydrogen for vehicles before 2050 unless carbon sequestration is applied on a large scale -- only fossil fuels could achieve this at reasonable cost
- any increase in renewable or nuclear electricity before 2050 would probably best be used to reduce emissions in the power sector

Investments in Developing a Hydrogen Economy

- ***Iceland, Singapore, others:*** committed to introducing hydrogen and fuel cell products in the electric utility and transport sectors
- ***European Union:*** recently announced a long-term, 2 billion euro R&D program in hydrogen energy, ren. energy technologies
- ***United States:*** recently announced a five-year, $ 1.2 billion hydrogen energy technology and infrastructure program.
- ***Japan:*** fuel cell and hydrogen technology research program has tripled since 1995, reaching over $ 200 million in 2002

- ***Others:*** e.g., Italy, Canada, United Kingdom have accelerated and expanded their investments.
- ***China:*** has an organized program intended to lead to development of fuel cell vehicles
- ***Private sector:*** investments in hydrogen energy technology, fuel cells have grown dramatically over the past decade *(in developed and developing countries)*
- ***Several developing countries:*** financing for demonstrations of hydrogen fueling stations, fuel cell-powered buses

Part II
Innovation in energy and fuel cell

How can innovation influence energy supply and demand?

- More efficient use of primary energy sources (e.g., combined cycle power generation)
- Increased efficiency in end-use (e.g., electric appliances, lower-consumption cars)
- Harnessing emerging sources of energy (e.g., solar, wind, biomass)
- Developing technologies that address efficiency and environmental concerns (e.g., fuel cells, advanced turbines, advanced exploration and extraction)
- Putting in place infrastructure that can deliver new energy services (e.g, hydrogen)

How can innovation in energy technology be stimulated?

- Assuring well-functioning markets
- Assuring well-functioning innovation system
  - Innovation takes place in a system of inter-linked actors,
  - In both public and private sectors.
  - Depends on government policies to:
    - Fund R&D and demonstration including through public-private partnerships,
    - Supply highly qualified S&T human resources and ensure mobility,
    - Put in place appropriate framework conditions including regulations, competition policy and intellectual property protection,
    - Stimulate use of emerging organisational innovations, e.g., industrial clusters and venture capital

What are the characteristics of energy technology innovation system?

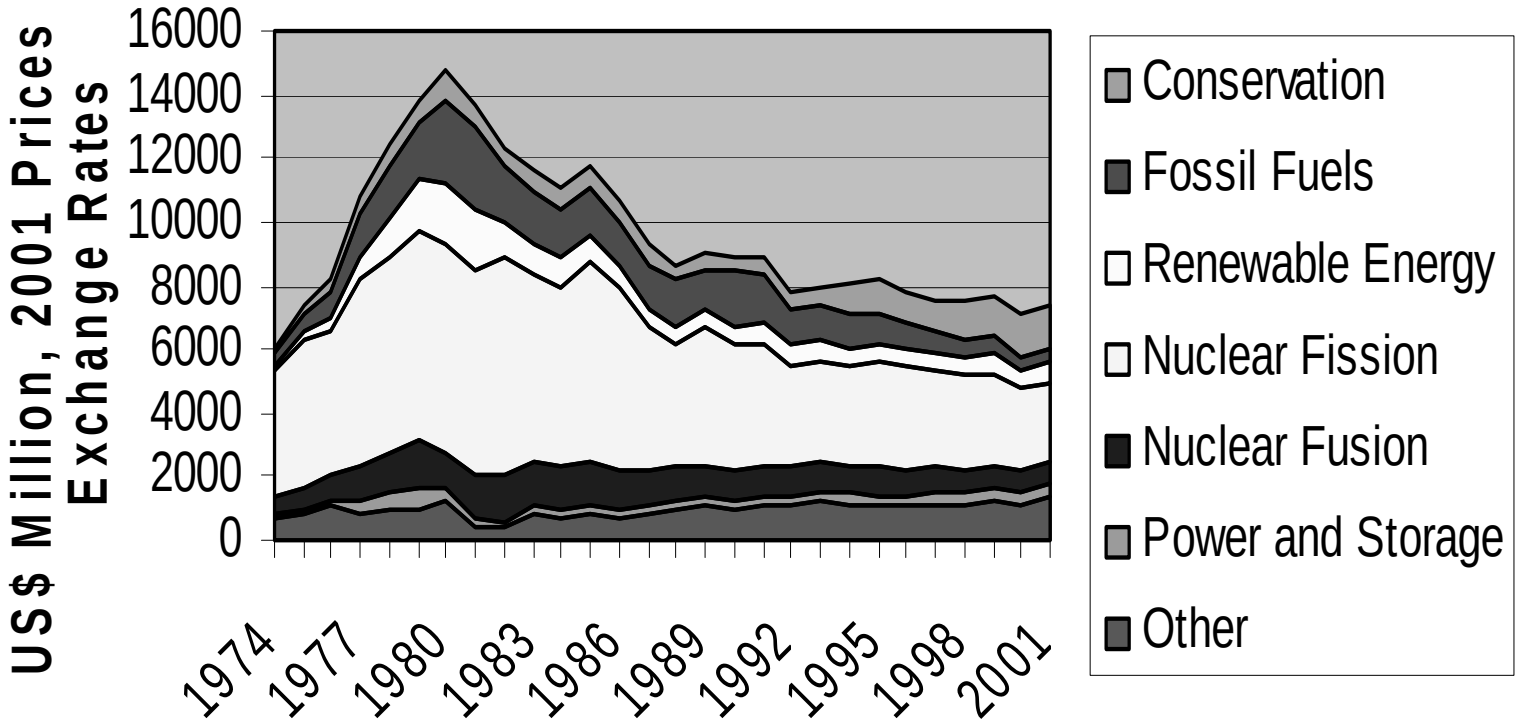
- The sector itself is diverse - there is no one characteristic type of innovation system
- Traditionally a large role of the public sector, but the private sector is growing in importance.
- Technology rapidly becoming more diverse and complex (nuclear fusion, renewables)
- Important role of R&D and innovation
- Requires long time horizon for development and commercialisation
- Infrastructure dependent – tendency for technology lock-in.

What are the characteristics of fuel cell innovation system?

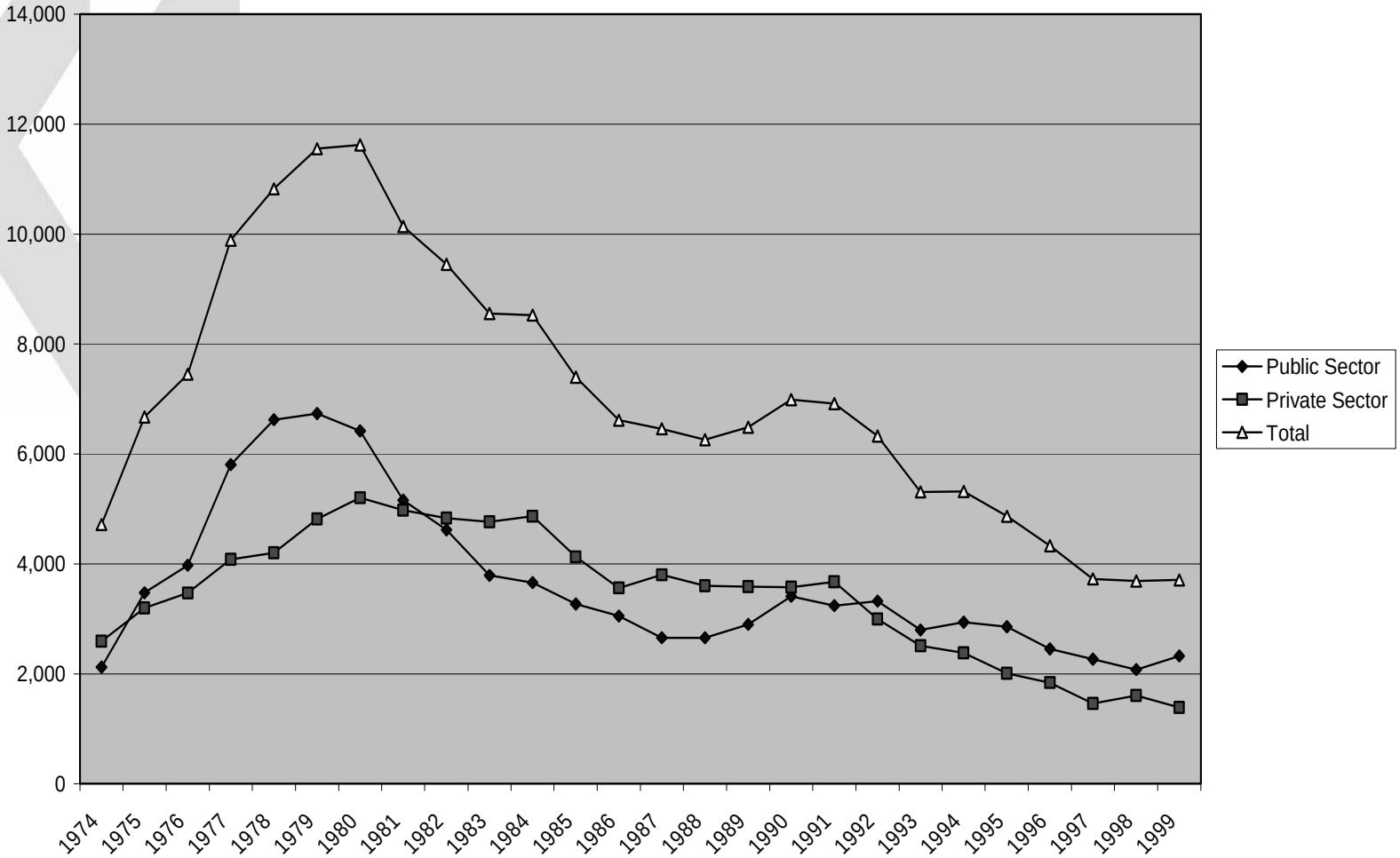
- Rapidly growing energy technology sub-sector for stationary, mobile and portable applications,
- Co-existence of mature and emerging technology -the innovation system is changing fast,
- Actors include diverse industrial sectors outside the energy sector, firms of differing sizes and specialisation, and diverse scientific disciplines,
- Many government programmes and research consortia,
- Further development highly dependent on a well-functioning innovation system.

Public and private energy R&D trends

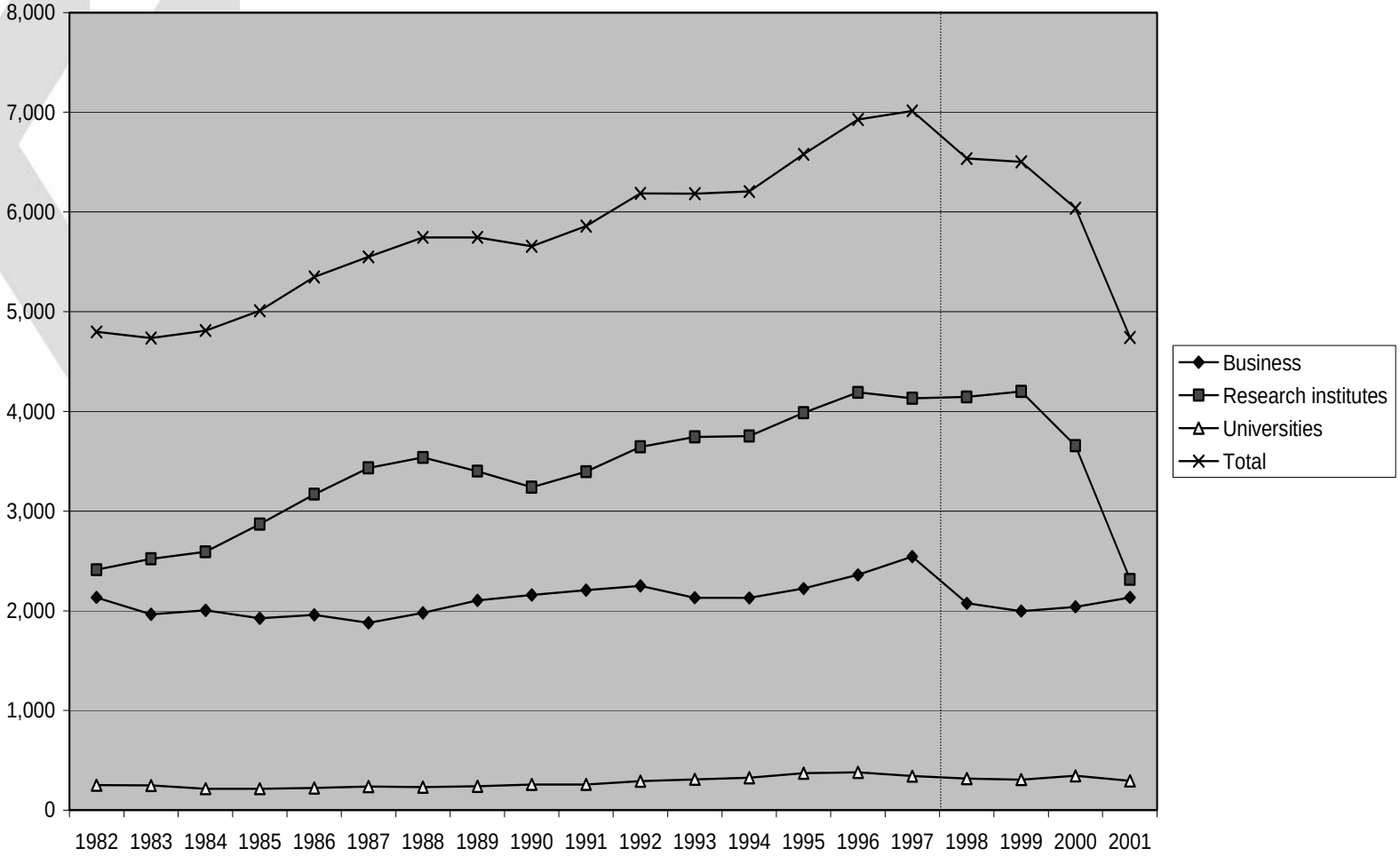
Figure 2 IEA Government Energy R&D Budgets, 1974-2001



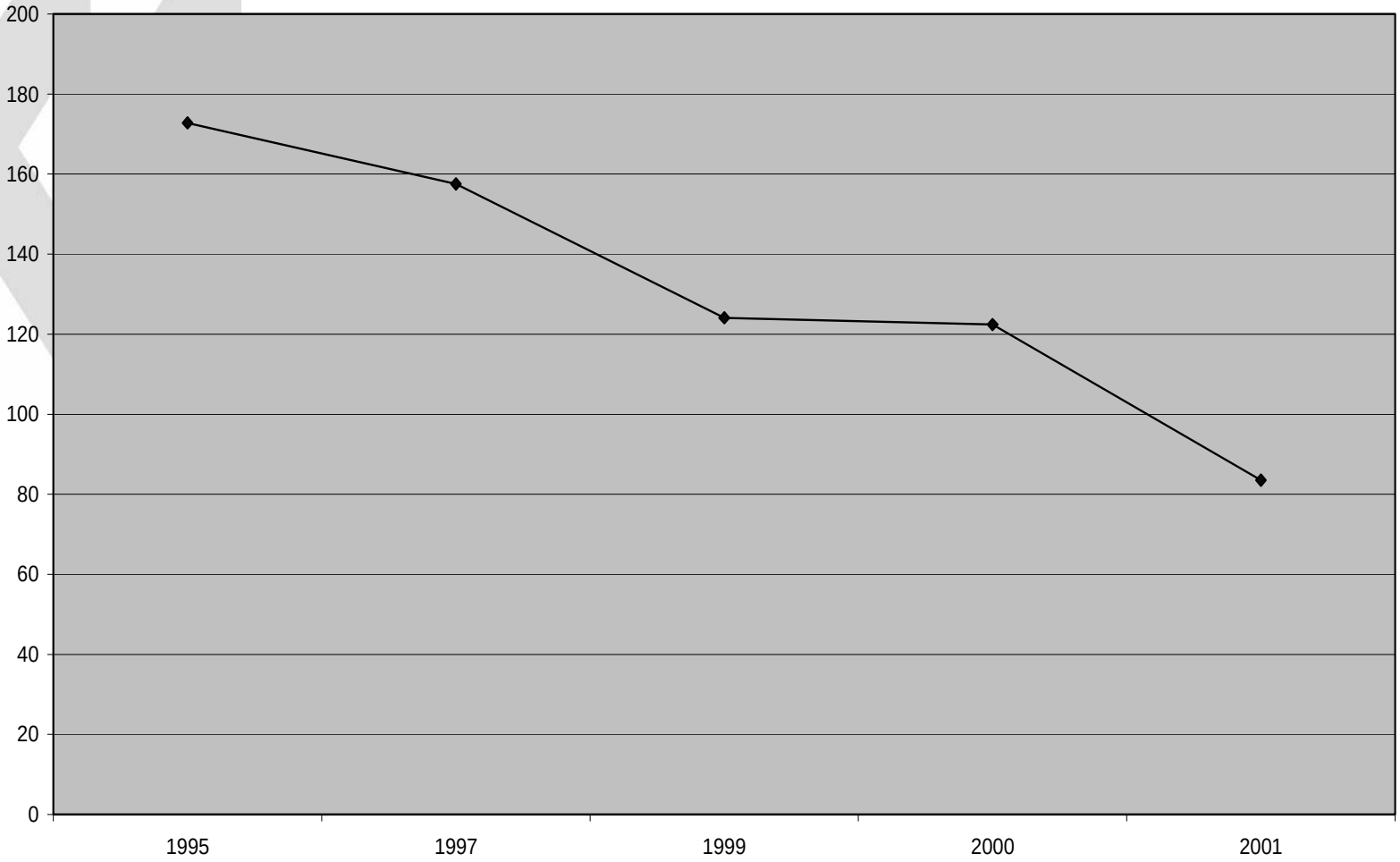
Energy R&D Expenditure in the U.S. (in millions of constant 1995 $)



Energy R&D Expenditure in Japan (in millions of constant 1995 PPP $)



Private R&D Expenditure of the German Energy Sector (in millions of constant 1995 PPP $)



Challenges in enhancing innovation in energy and fuel cells

- Sustaining R&D investment levels, in view of the decreasing overall R&D in both public and private sectors,
- Efficiently channelling R&D funds through public/private partnerships and research consortia,
- Taking measures to stimulate networking, in view of actors that are dispersed in diverse sectors in the innovation system,
- Extending the innovation system globally, including non-OECD member economies.