OECD Case Study in the
Energy Sector:

Innovations in fuel cells and related hydrogen technology in Norway

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Outline – topics

- Characteristics of the Norwegian energy sector's innovation system
- Status of fuel cells technology and related hydrogen technology
- Systemic efficiency and policy implications
- System openness and innovations
- Demand side factors
- Policy options – 3 scenarios

Characteristics - Norwegian energy sector's innovation system

- Drivers of innovation
  - Deregulation of Nordic energy markets
  - Norway's gas "problem"
  - Environmental policy and advocacy
  - Fuel cells and hydrogen as an emerging market
  - Visions of a future "Hydrogen Society"
  - R&D: small, but strong, in niches
  - High level policy initiatives for promotion of RD&D in fuel cells and hydrogen technology

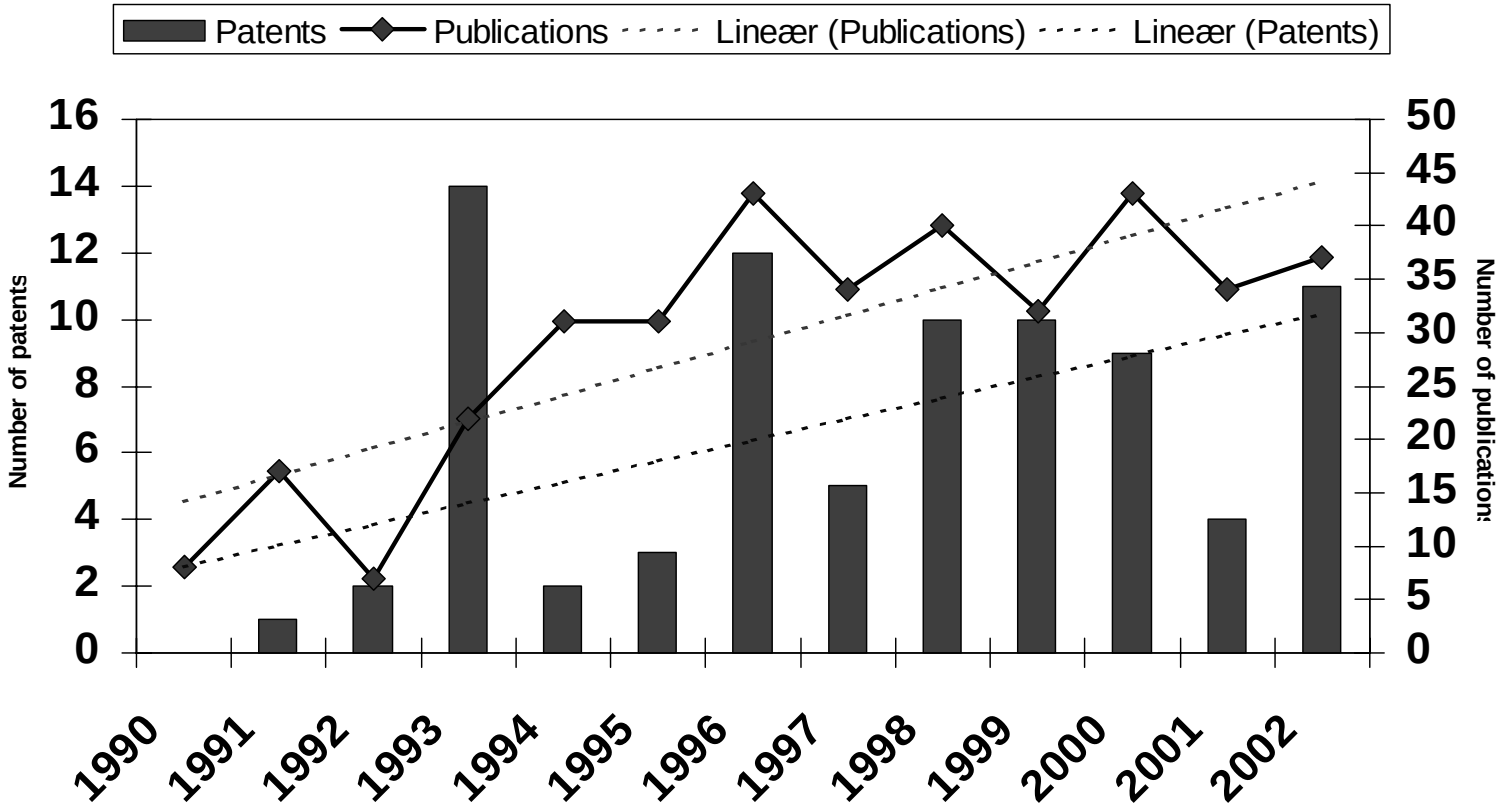
Status of fuel cells technology and related hydrogen technology – 1

- Actors and networks:
  - Industry – a few, large energy companies dominate – oil & gas companies
  - R&D institutes – few, specialized, semi-public
  - Universities – closely aligned with R&D-institutes
- Knowledge profiles and characteristics:
  - Small R&D entities – highly cohesive networks
  - Specialized, focused on a few, but strategic areas
  - "Fast second mover" strategy in industry

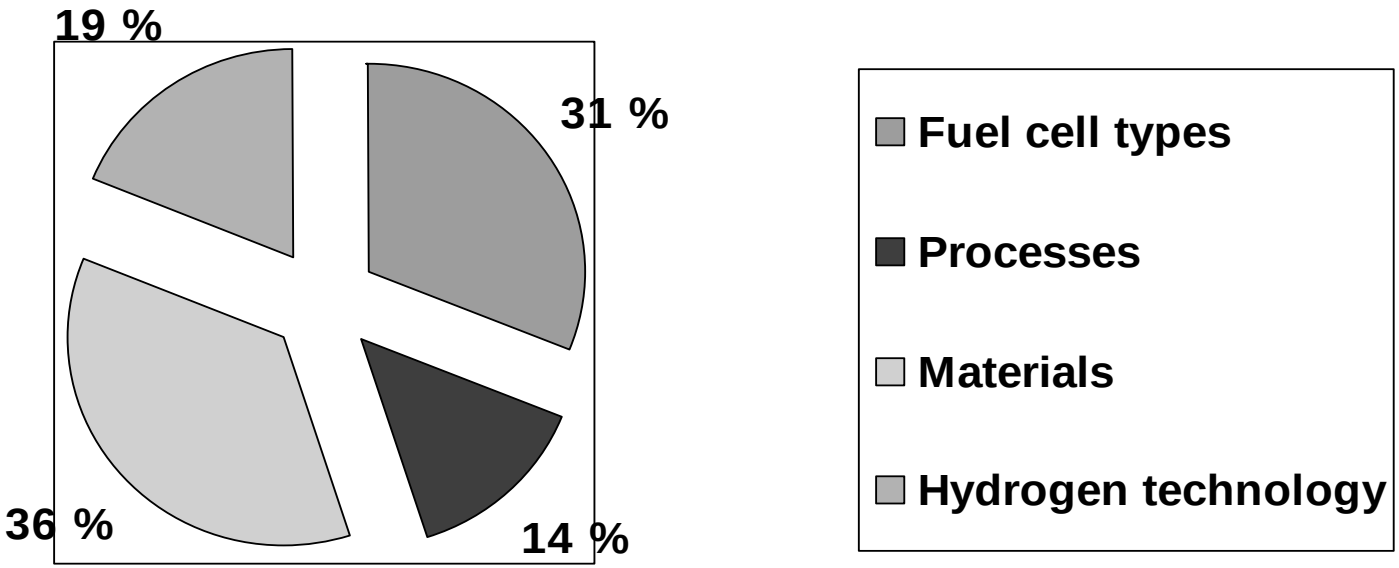
Status of fuel cells technology and related hydrogen technology – 2

- Collaborative R&D&D
  - Total size: US$ 80 millions (present, multi-annual portfolio)
  - Approximately 100 projects – majority small, but a few are large
- Bibliometric and patent analysis:
  - Specialized, but high quality science base – citation index has been higher than 1,0 in 1989-2002
  - Few patents – spin-offs from a few successful projects
- Results from R&D&D:
  - ***Knowledge benefits*** – important, crucial for making important break-throughs
  - ***Options benefits*** – high, supports ”Fast second mover” strategy
  - ***Economic benefits*** – negligible so far, but expectations are long-term

Norwegian publications (N=379) and patents (N=83) 1990-2002 with trends



Distribution of subject groups in Norwegian fuel cell and related hydrogen technology publications 1990–2002 (N=421)



Systemic efficiency and policy implications

- ”Systemic efficiency”:
  - Difficult to define and operationalize
  - ”Proper” balance of roles and tasks in an innovation system + consensus of goals
- Systemic imperfection:
  - Promotes risk aversive strategies in industry,
  - Makes ”Fast second mover” an attractive strategy
- Decoupling: Implication of present policy
  - Public R&D agendas ”science”-driven
  - R&D in industry – promotion of ”Fast second mover” strategy
  - In combination: Systemic imperfection? Or, ”stimulating” rivalry and competition?

System openness and innovations

- Observation: Paucity of SMEs in Norwegian fuel cells and hydrogen technology field
  - are the entry barriers too high?
  - Few SMEs = low level of innovations?
- Industry structure: No automobile manufacturing industry
- Large energy companies dominant
  - focus on energy production for large technological systems
  - Focus on future emerging energy markets

Demand side factors

- Demand for energy will continue to increase in the future
  - Supply conditions and future prices are uncertain (OPEC, nuclear power, etc)
- Geo-political, environmental policy measures may make ”clean” energy sources attractive,
  - Tax on gas emission, emission quotas, etc uncertain
- Future ”Hydrogen Society” will require a radical shift in infrastructure – enormous investments
  - Decentralized and more flexible energy systems
  - Importance of reliability and robustness in energy systems will increase

Policy options – Scenario 1

- **Neutral in terms of specific technologies**
  - Policy should be general:
    - Stimulate market competition – markets promote creativity and entrepreneurship → innovations
    - Create a favorable investment climate
    - Remove detrimental barriers and monopolies (deregulate)
  - Policy should not ”pick winners” – markets are more efficient
  - Public money → used for avoiding ”market failures” and promotion of public goods – indirect innovation support
- **1990s: ”Acid test” of this policy – mixed results?**

Policy options – Scenario 2

- **International innovation regime for a "Global Hydrogen Society"**
  - Policy should define a "roadmap" for promotion of RD&D in fuel cells and related hydrogen technology:
    - "Hydrogen Society" defined as a pre-competitive and pre-normative global project – creation of a viable technology platform
    - No single nation or company will be able to achieve "Hydrogen Society" alone – co-operation will be required
    - Cost-sharing and reduction of infrastructure costs + speed
  - Institutional framework: Existing international organizations and policy making mechanisms
  - Public money → used for financing international cooperative RD&D collaboration
- **Likelihood for success: Difficult, but remember GSM and Internet**

Policy options – Scenario 3

- **National innovation system for "Hydrogen Nation"**
  - Policy should be aligned with a national strategy for promotion of RD&D in fuel cells and related hydrogen technology:
    - "Hydrogen Nation" defined as a national strategy – resulting from a framework of a horizontal innovation policy
    - Focus will be set on goals that will promote national comparative advantage and leverage present assets and potentials.
    - Policy will become "heavy-handed" in terms of coupling private sector R&D with public sector R&D
  - Institutional framework: Existing national R&D funding and public policy in collaboration with private sector.
  - Public money → used for financing public R&D coupled with R&D-subsidies to private sector.
- **Likelihood for success: Difficult, but perhaps feasible – each nation has a unique potential that may be leveraged.**

System imperfections and policy considerations

- Imbalance and decoupling salient features in present system
- However, the situation is paradoxical:
  - Each system element ruled by different rationales
  - High-level rivalry & competition, but strong ties and consensus within R&D-community
  - Potential for creating strong, coherent innovation regimes should be favorable
- Judgment/prediction:
  - Scenario 2 is best, but maybe utopian, idealistic
  - Scenario 3 may emerge in some nations
  - Scenario 3 may also promote Scenario 2
  - Scenario 1 is politically very correct and convenient – and efficient?