

Preliminary Findings for Innovation Case Study on Canadian Fuel Cell Technology

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Leading the way to a hydrogen economy

- Canada's performance has extended over three decades of innovation
- Arguably, the largest cluster of fuel cell and hydrogen expertise in the world is in British Columbia
- Innovation drivers have changed appropriately over the industry's evolution – this is key to Canada's leadership position today

- Entrepreneurship
- Partnerships; both domestic and international
- Climate Change





Presentation outline

1. The Evolution of our Industry – A timeline illustrated over three decades
2. The Players
 - Industry
 - Government
 - Academia
3. Knowledge Creation and Flow – Knowledge flow diagrams illustrated over three decades
4. Next Steps for OECD case study



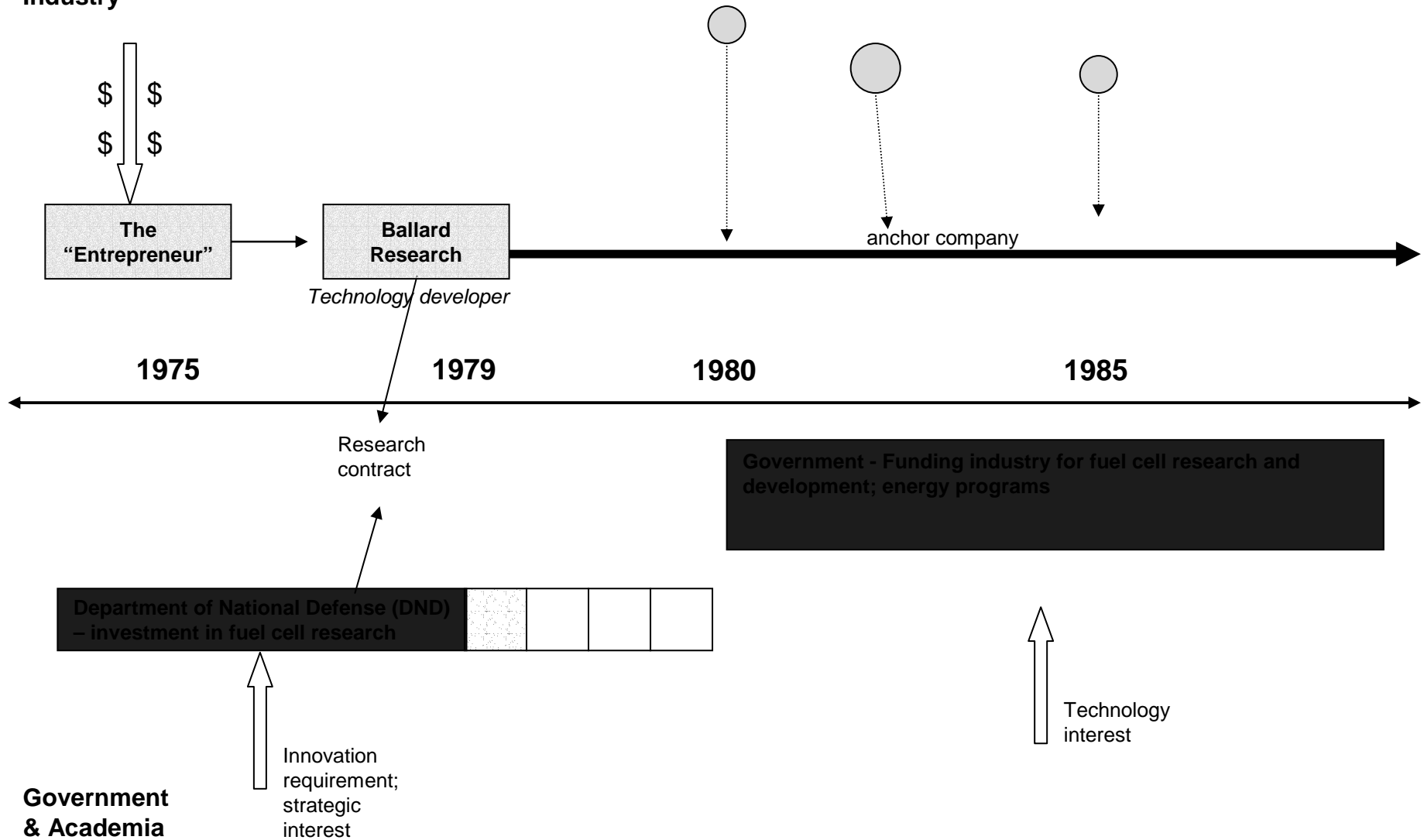


The Evolution of our Industry

Late 1970's – Early 1980's



Industry



ANCHOR ● FIRM ○ SUPPLIER ● OEM - - - - partnership ○ cluster



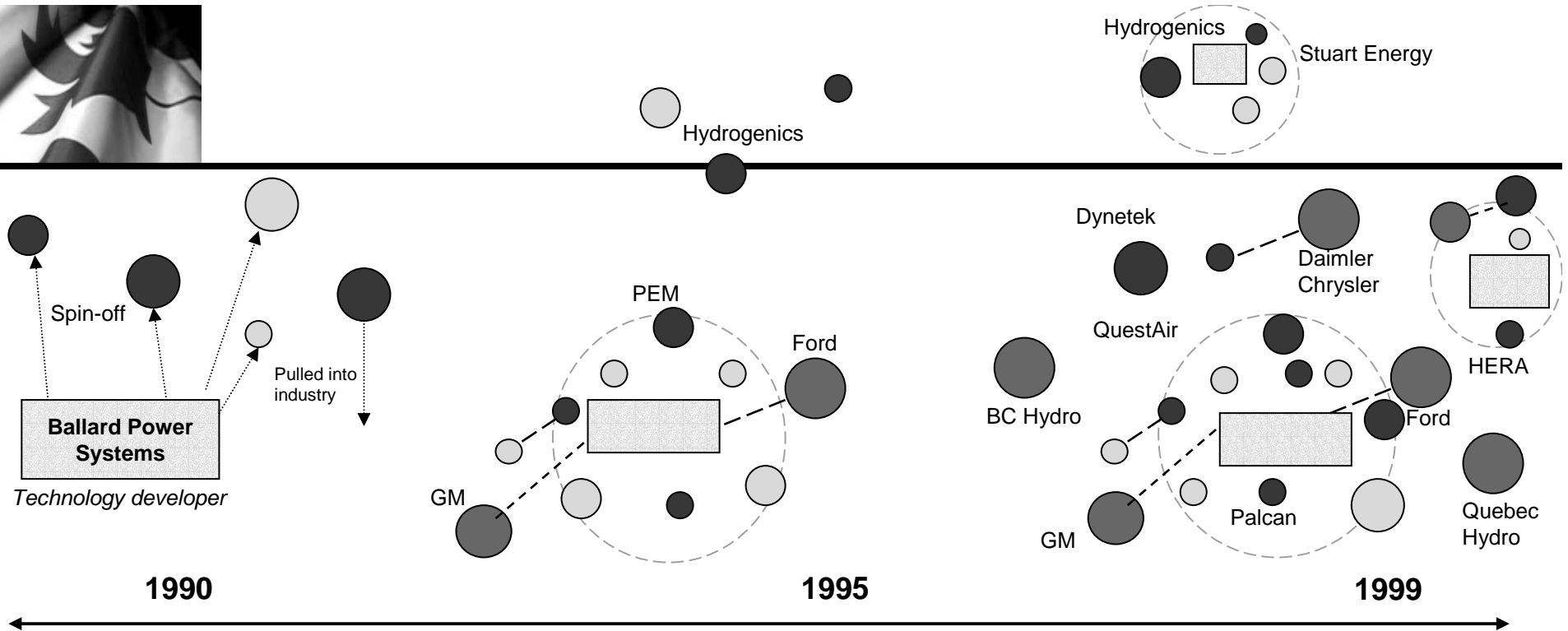
Key themes

- The anchor company is the primary instigator and driver of innovation
 - Entrepreneurship driven by enthusiasm and profit potential
 - Anchor firm displays early leadership
- Federal government also plays a vital role in industry's inception
 - In response to the perceived oil supply crisis, federal gov't funnels money into National Energy Program → strategic interest for the DND
 - Funding is allocated to alternative energy technologies
- Early collaboration between industry and government
 - Anchor company wins proposal for DND research funding for fuel cell technology



The Evolution of our Industry

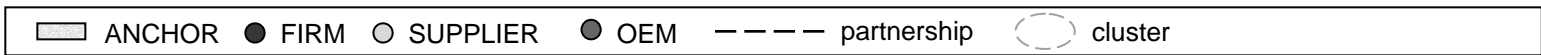
1980's – 1990's



Government – research and development, demonstration, deployment

University of Victoria – Institute for Integrated Energy Systems (IESVic)

Universit  du Quebec a Trois-Rivieres – Hydrogen Research Institute (UQTR)





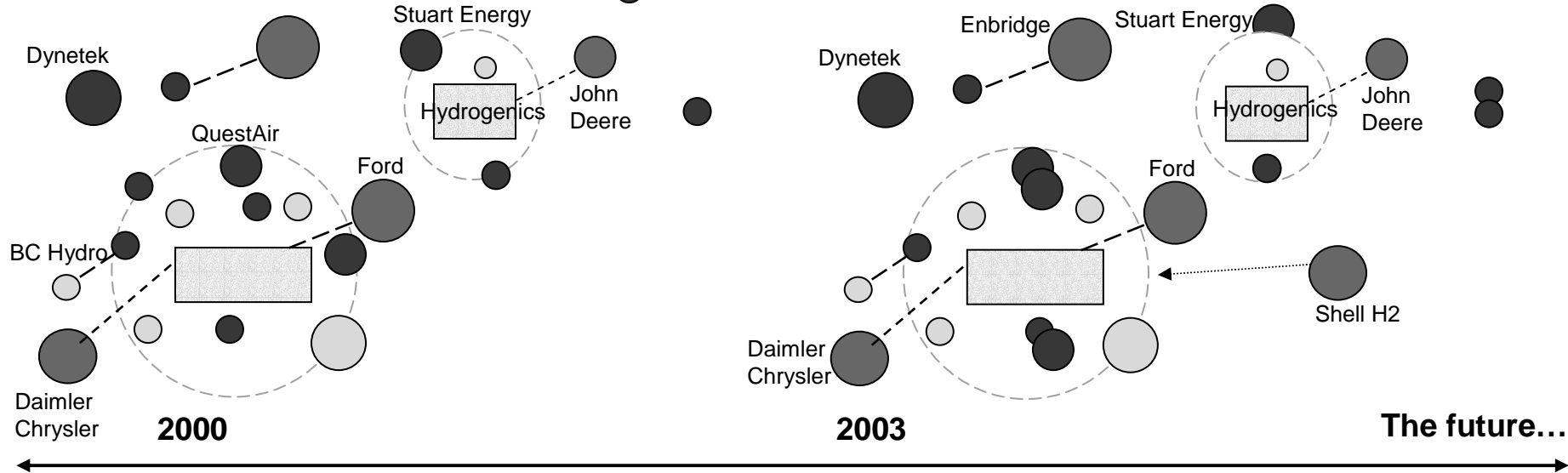
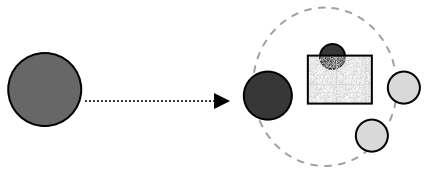
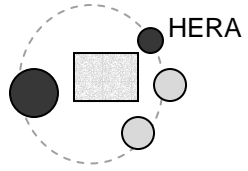
Key themes

- Anchor company is successful; remains the key driver of innovation for the industry
 - Pulls suppliers and new technology developers into the industry; supply chain forms
 - Driven to enter the industry based on success of the anchor company; profitability potential
- OEM's are attracted to the industry
 - Seeking a cleaner, more efficient transportation technology
 - Partners with technology developers to provide 2-way leverage channel
- Additional federal departments join in support efforts
 - Driven by purely a technology interest, then climate change takes over
- The US
 - Strong influence on technology innovation
 - Extends reach to Canada for fuel cell technology through CaFCP, California Air Board, US Department's (Energy, Environment, Defense)



The Evolution of our Industry

The 21st Century



Government – research and development, demonstration, deployment, tax incentives, research centres

**University of Victoria – Institute for Integrated Energy Systems (IESVic)
 Universit e du Quebec a Trois-Rivieres – Hydrogen Research Institute (UQTR, HRI)
 Royal Military College (+ +)**

ANCHOR
 ● FIRM
 ○ SUPPLIER
 ● OEM
 - - - - partnership
 ○ cluster



Key themes

- The further development of clusters support innovation of small technology developers
- Energy distributors and energy users form key partnerships with small firms
 - Much like the OEM partners in the last decade, these alliances allow for further growth through increased resources (financial and human), application and market knowledge
- Government priorities align
 - R&D, industrial development, innovation, climate change
- The academic community begins contributing more specifically to industry
- Partnerships
 - Strategic alliances critical for application and market knowledge, financial and human resources leading to accelerated commercialization time-lines



Evolving as a leader

Canada's leadership position today is based upon key characteristics throughout the industry's evolution:

- The presence of anchor company
- Industry evolution and growth is strongly driven by entrepreneurialism since inception
 - Climate Change, the driver of the 21st century
- Continued support from the federal government
 - Increasing, broadened support in recent year in terms of funding and other aid
- Active participation in international jurisdictions (US, Europe, Japan)



Measuring innovation performance

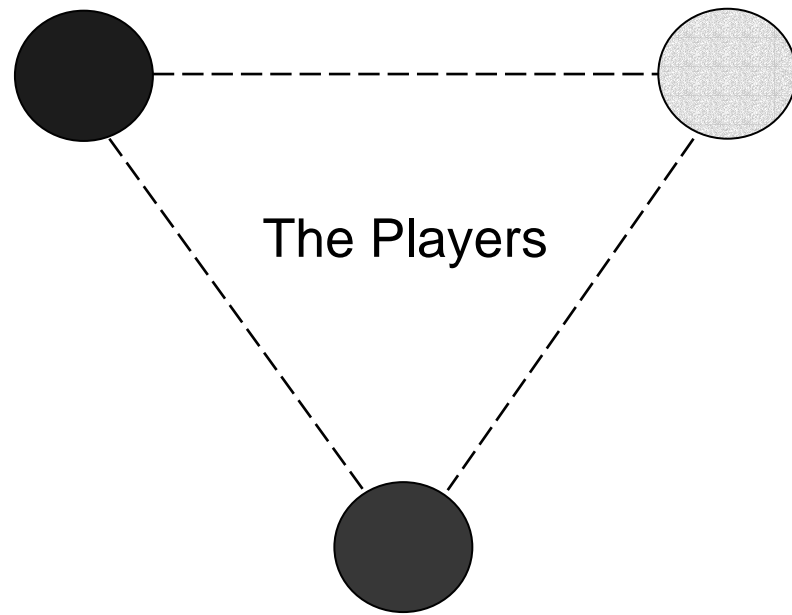
- “Canada’s Innovation Strategy” reflected that Canada’s overall innovation performance was near the bottom of the G-7 countries
- Innovation performance measurements (ranking in G-7):
 - External patent applications (5)
 - Human capital devoted to R&D (5)
 - Business-funded R&D (6)
 - R&D intensity (6)
 - Technology balance of payments (5)
 - National patent applications (5)
 - Government expenditure R&D (7)





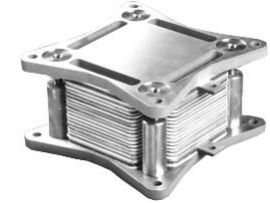
R&D expenditure

- Qualitative evidence points to the fact that industry leads in patent application authors and the R&D investment made by Canadian industry
- Industry R&D expenditures were approximately \$179 million; R&D projections for 2003 were \$358 million
 - Larger firms account for the majority of R&D expenditure (88:12)
- For every \$1 that the public sector invests in R&D, the industry invests \$29
- The Canadian government has provided approximately \$150 million to the industry for research and demonstration, amounting to an average of \$7.5 million per year
- Total direct government and corporate investment amounts to roughly \$115,000 of R&D expenditure spent per employee in the fuel cell and hydrogen sector



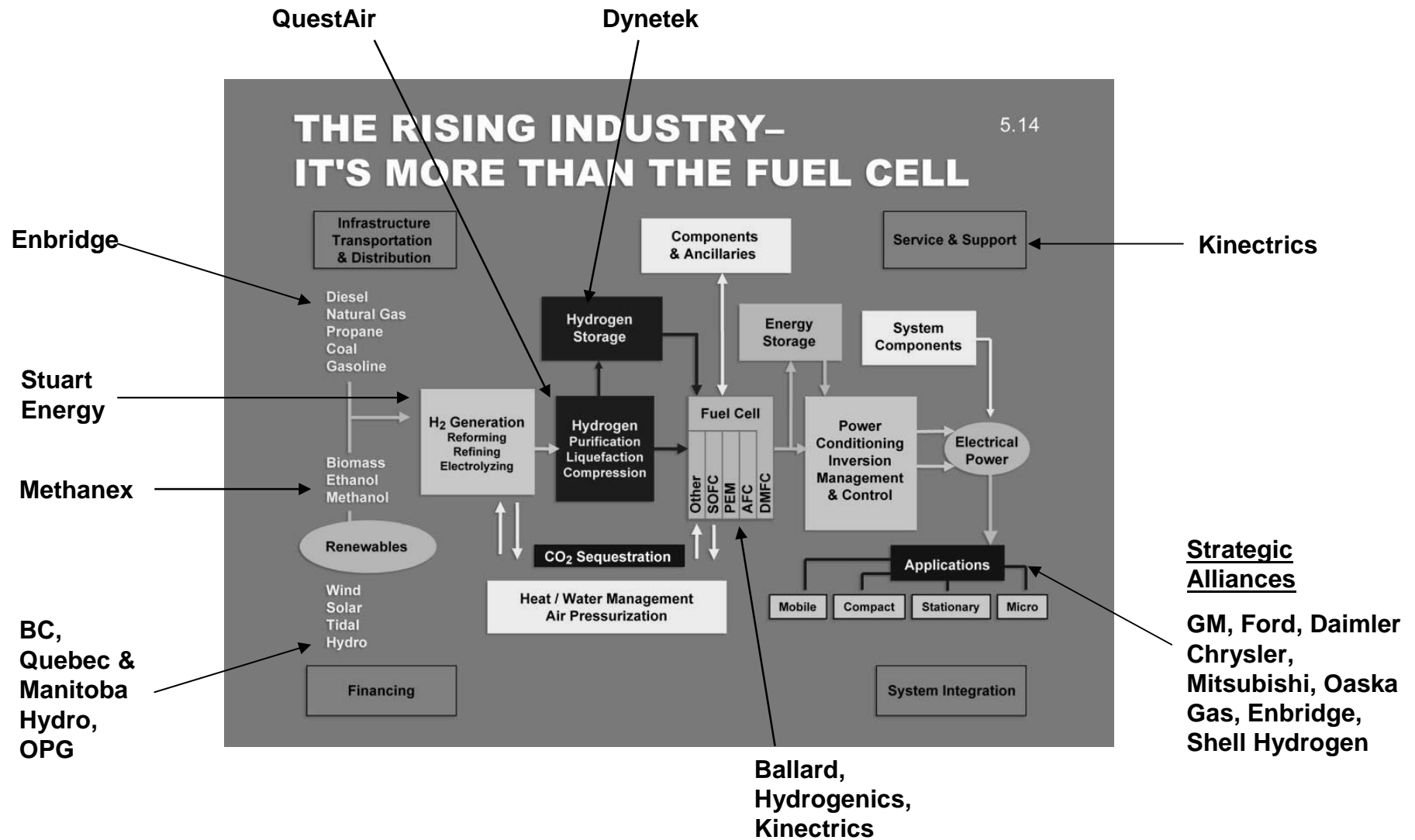


Industry



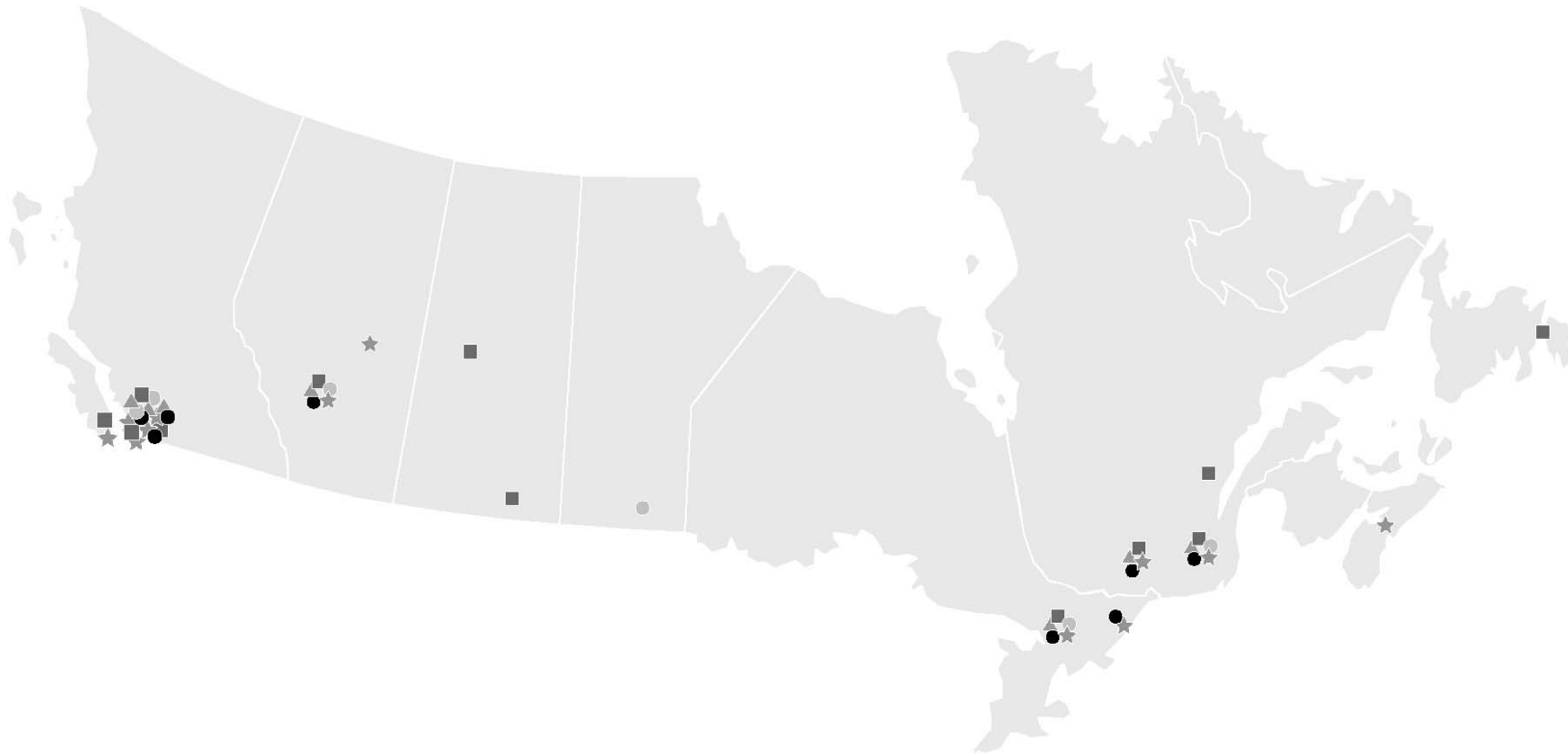
- There is an estimated 1,800 people directly employed by the Canadian fuel cell industry
- Revenues reached \$96.9 million
- Private sector R&D expenditures were \$179 million and representing almost \$100,000 per employee
- The vast majority of Canadian fuel cell companies are small, employing less than 500 people
- Total Canadian industry revenue reached \$96 million; projected to exceed \$165.2 million in 2003
- Structure:

• Engineering services	36 percent
• Hydrogen production equipment	29 percent
• Testing equipment	25 percent
• Fuel cell stacks	25 percent
• Electrical components	21 percent





**A cluster of fuel cell companies exists in Vancouver,
with other clusters growing in Calgary, Toronto,
Kingston and Montreal**





Government

R & D Activity	Legislation (tax, user subsidy, environmental standard)	Demonstration Projects	Funding Programs
National Fuel Cell Research & Innovative Initiative \$30M - NSERC, NRC, IC	BC Sales Rebate on purchase/lease of alternative fuel vehicles (\$1000) and buses (\$5000)	Canadian Transportation Fuel Cell Alliance - \$23M, NRCAN	Technology Partnerships Canada - approximately \$60 M allocated to fuel cell industry to-date (Ballard, Stuart Energy, QuestAir and Dupont Canada)
2000 Western Economic Partnership Agreement - \$6.5 M to industry and Fuel Cells Canada	SRED Tax Credits (Federal and Provincial)	WED Western Fuel Cell Demonstration Project \$6.5 M	NRC - Industrial Research Assistance Program
			IC - Fuel Cells Commercialization Roadmap
NRC Innovation Centre - \$40 million over five years	Climate Change Action Fund Kyoto Protocol Targets Building the Hydrogen Economy \$130 million	TEAM Initiatives \$8 million + including the Fuel Cell Vehicle Program	Natural Resources Canada – CANMET, Program of Energy, Research & Development (PERD)
			WED Operating Support to Fuel Cells Canada

Climate Change Funding, Budget 2003

- \$1 billion towards the implementation of the Climate Change Plan
- Part of the Budget 2003 allocation and builds on the \$1.7 billion the Government of Canada has invested over the past 5 years
- Highlights:
 - \$250 million – development of longer term climate change technologies
 - \$80 million – fuel cells and other technologies for the emerging hydrogen economy
 - \$65 million – technologies for cleaner fossil fuel production, conversion and combustion
 - \$40 million – energy efficient technology that can be used in the industrial, commercial, community and transportation sectors





What is the role of Government?

- Government policies, legislation and incentives are key drivers for the development of fuel cell technologies
 - Pollution reduction, greenhouse gas amelioration, the need for energy security, and the need to reduce healthcare costs will continue to be critical macro drivers for widespread adoption of fuel cell technologies
- It is assumed that government regulations are likely to become increasingly important as fuel cell technology improves and enters into the market phase of commercialization





- Active with industry since 1990's



- University of Victoria - Institute for Integrated Energy Technology
- Université du Québec à Trois-Rivières - Hydrogen Research Institute
- Royal Military College
- University of Windsor – Auto21
- Queen's University – Centre for Advanced Materials Manufacturing (late 1990's)
- University of British Columbia – Clean Energy Research Centre (2000/2001)



- Successful in leveraging resources with industry in partnerships

- Why is their role becoming increasingly important in this industry?

- There is an increasing demand from industry for highly skilled employees
- Additional funding from government allows for partnership opportunities
- There are now many more ties between fuel cell technologies and external drivers (climate change, energy efficiency, innovation)
- Key Canadian industries are well positioned to contribute to innovation: automotive sector and energy sector, including natural gas and hydro

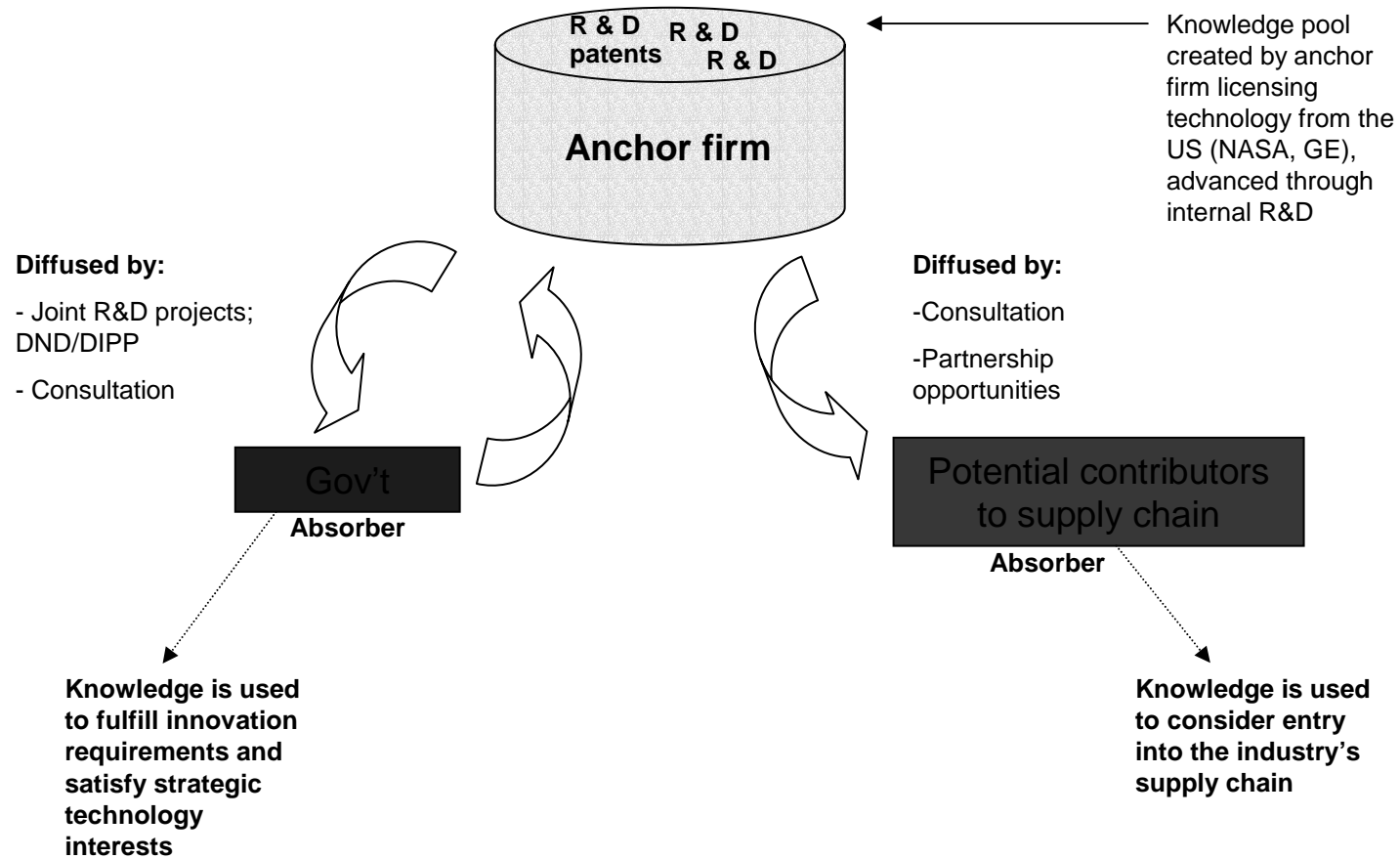


Knowledge Creation & Flow

Late 1970's – Early 1980's



Late 1970's – Early 1980's





Key themes

- Knowledge creator = the anchor firm
 - Creates knowledge by licensing key technology from the US; builds on that knowledge using internal R&D capabilities and government seed money
- Diffuses knowledge to government through collaboration on R&D projects
- As anchor firm increases internal R&D, the firm diffuses knowledge to potential corporate additions to the industry supply chain

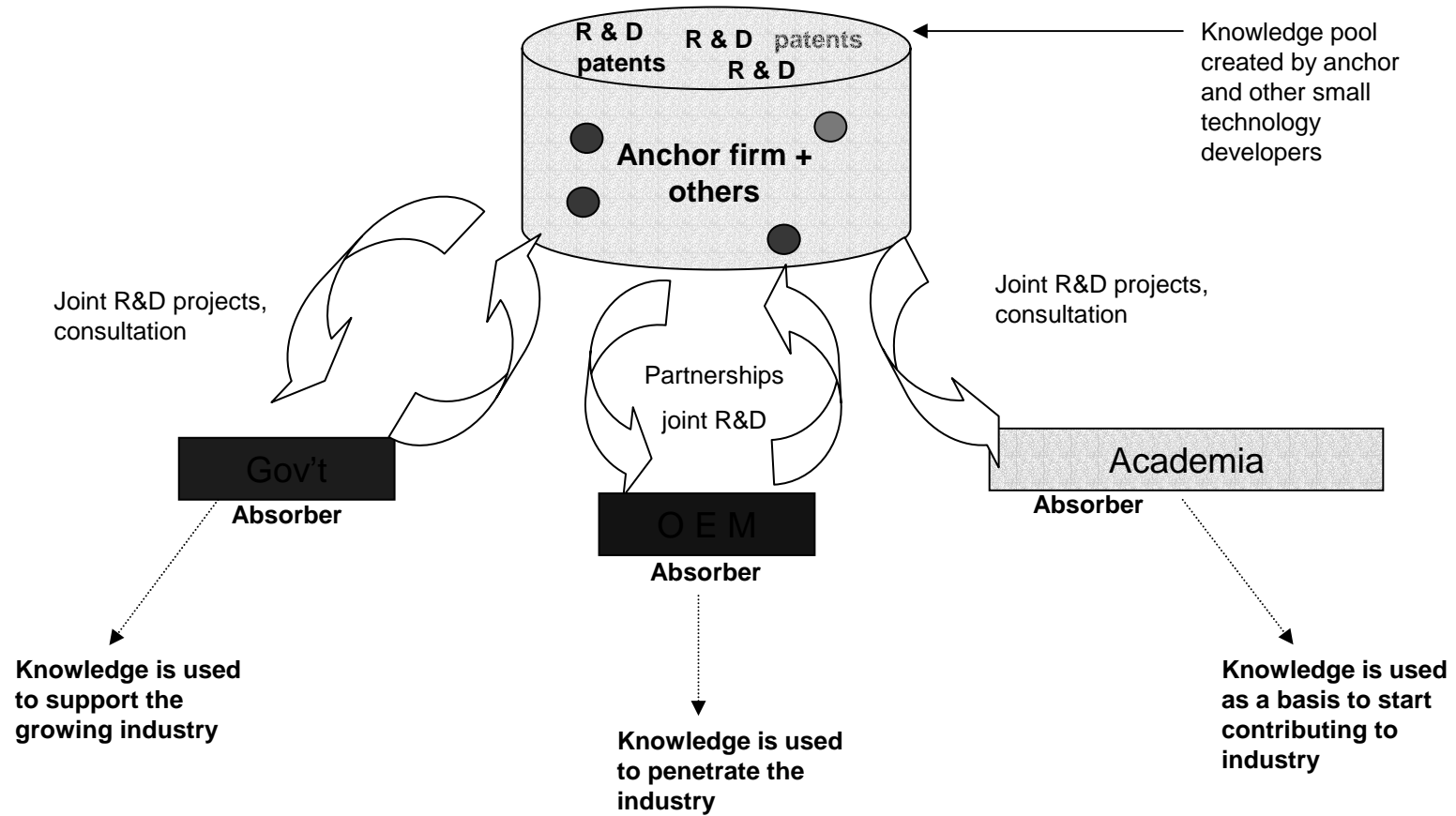


Knowledge Creation & Flow

1980's – 1990's



1980's – 1990's





Key themes

- Knowledge creator = still the anchor firm
 - However, joined by other technology developers in the industry
- Now diffusing knowledge to the OEM
 - OEM using this knowledge to penetrate the industry
 - Partnerships between the technology developer and the OEM are being formed as a two-way leverage mechanism
- Academia is beginning to partner with industry in joint R&D projects
 - Knowledge flow is mainly only one way from industry to academia

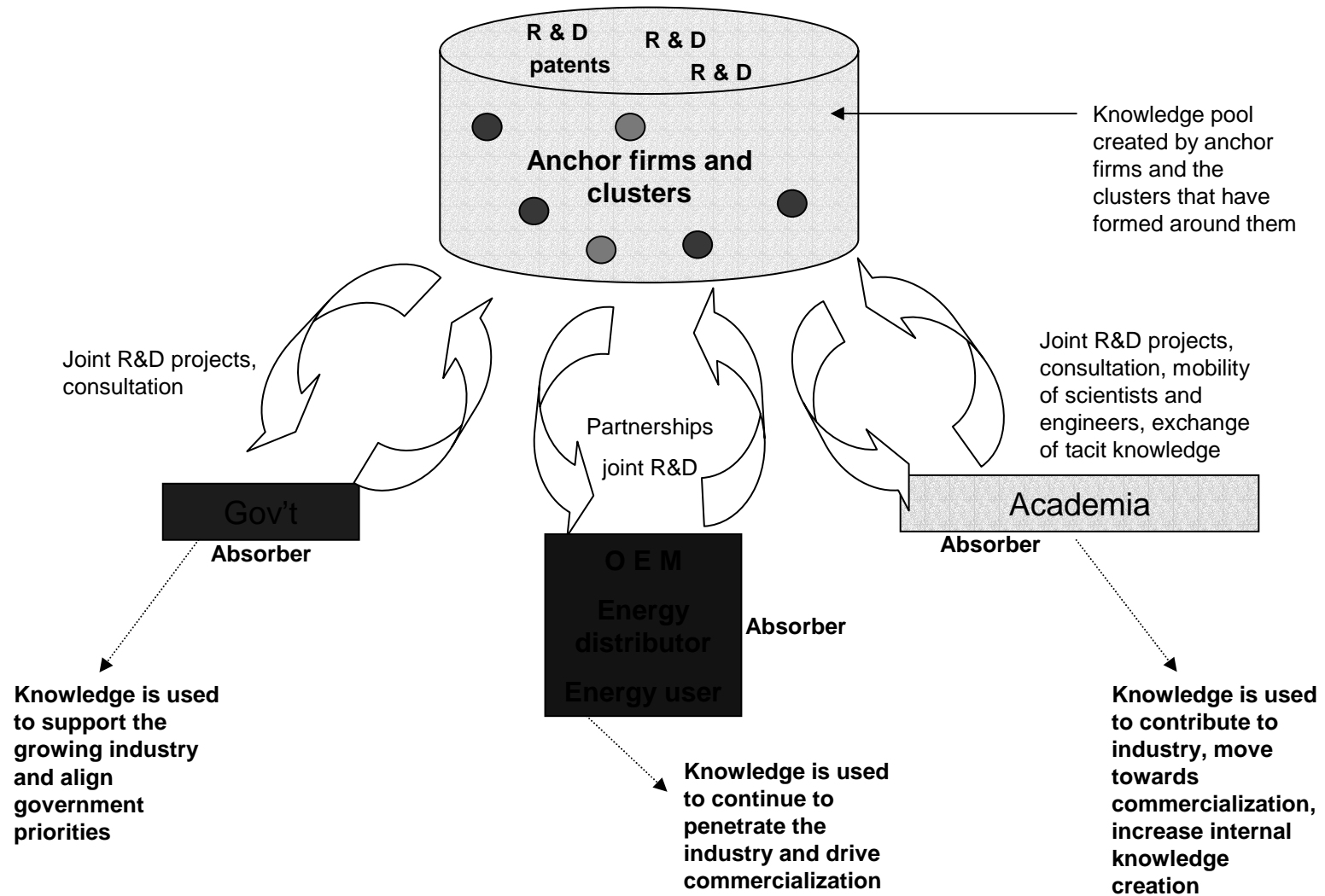


Knowledge Creation & Flow

The 21st Century



The 21st Century





Key themes

- Knowledge creator = the industry
 - Generated by internal R&D, joint partnerships
- Diffusion of knowledge extends to the energy companies
 - Much like the OEM, large energy companies now wish to enter the industry
- Government increasing its support of industry's innovation
 - R&D funding, demonstration, tax incentives
 - Government continues support for industry's creation of knowledge due to climate change (Kyoto signatory), innovation, energy demand drivers



Next steps for OECD study

- Ultimate goal – gather more information from a relatively silent industry
 - Pursue insight, feedback and endorsement
- Currently gathering more comprehensive data on patent activity
 - Results expected mid-fall
 - Evaluation of IP activity in both the private and public sector
- Distribute interim report findings to key stakeholders for review
 - Build on preliminary analysis to ensure scope of final report is achieved

Canada

