

OECD case study on innovation in energy technologies

Fuel Cell Innovation in Germany

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Fraunhofer ISI

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Content

1. Background and framework conditions
2. Organization of fuel cell innovation in Germany
actors / networks / initiatives
3. Policy instruments and options - lead markets?
4. Conclusions and outlook (measuring R&D productivity?)

Sources

- OECD secretariat bibliometric analysis
- Database* at Fraunhofer ISI of 474 hydrogen related projects and patents with German participation
- Specific recherches on patents, publications and university research (via internet) in Germany plus official statistics
- Several projects and continuous monitoring of trends in fuel cell technologies at Fraunhofer ISI

1. Background and framework conditions



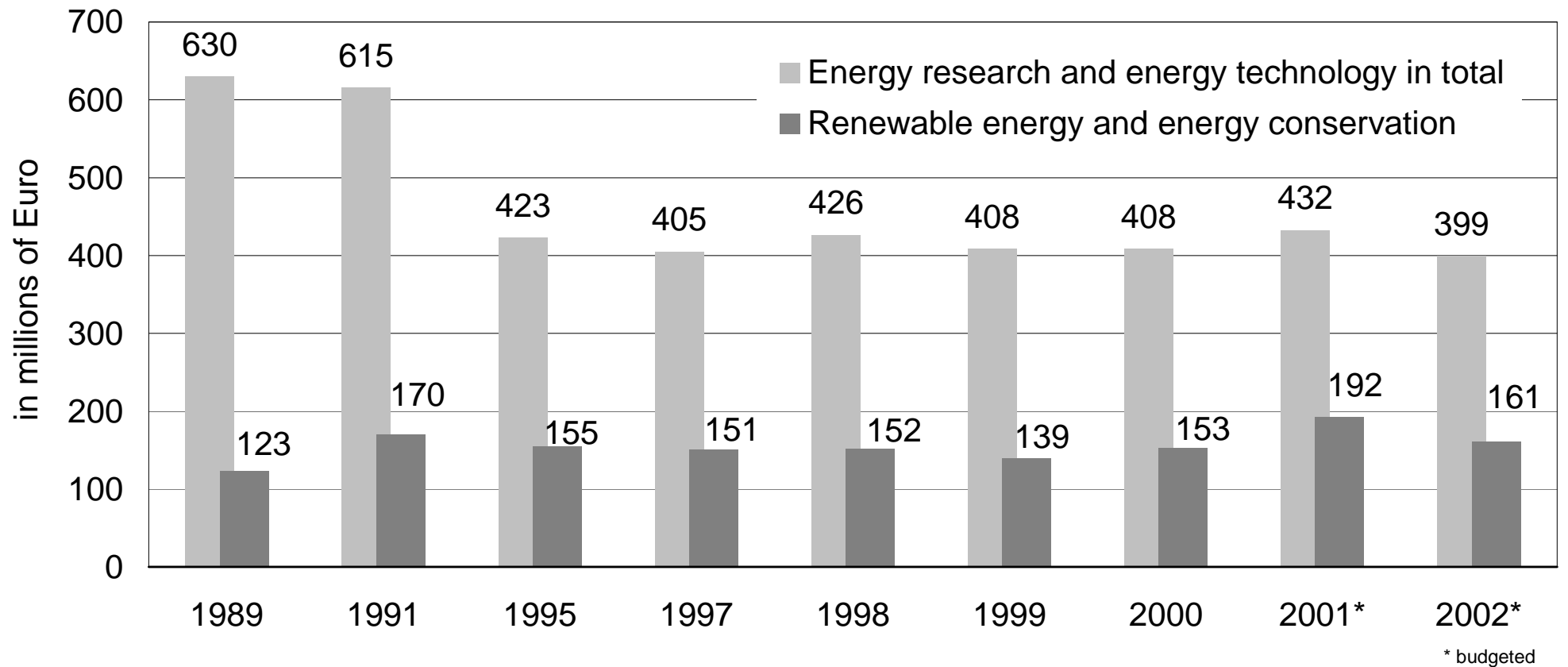
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Characteristics of the German Innovation System

- highly differentiated and **decentralized** (e.g. universities)
- **no** extensive **priority setting** (e.g. with respect to subsidies)
- **strength in advanced technology branches**: automobile, mechanical engineering, chemical industry
- **weakness to link up** with leading edge technologies: information technology, new materials
 - ➔ fuel cell technology roots in all above fields
- **decreasing long term** orientation
 - ➔ no short term market introduction of fuel cells expected
- **national orientation** of R&D, technology policy dominates
- private **industry performs more than 60% of research**
- **classical strengths** are getting less important
 - ➔ lead markets will become more significant



German Federal Expenditure on Science, Research and Development in Energy Technologies



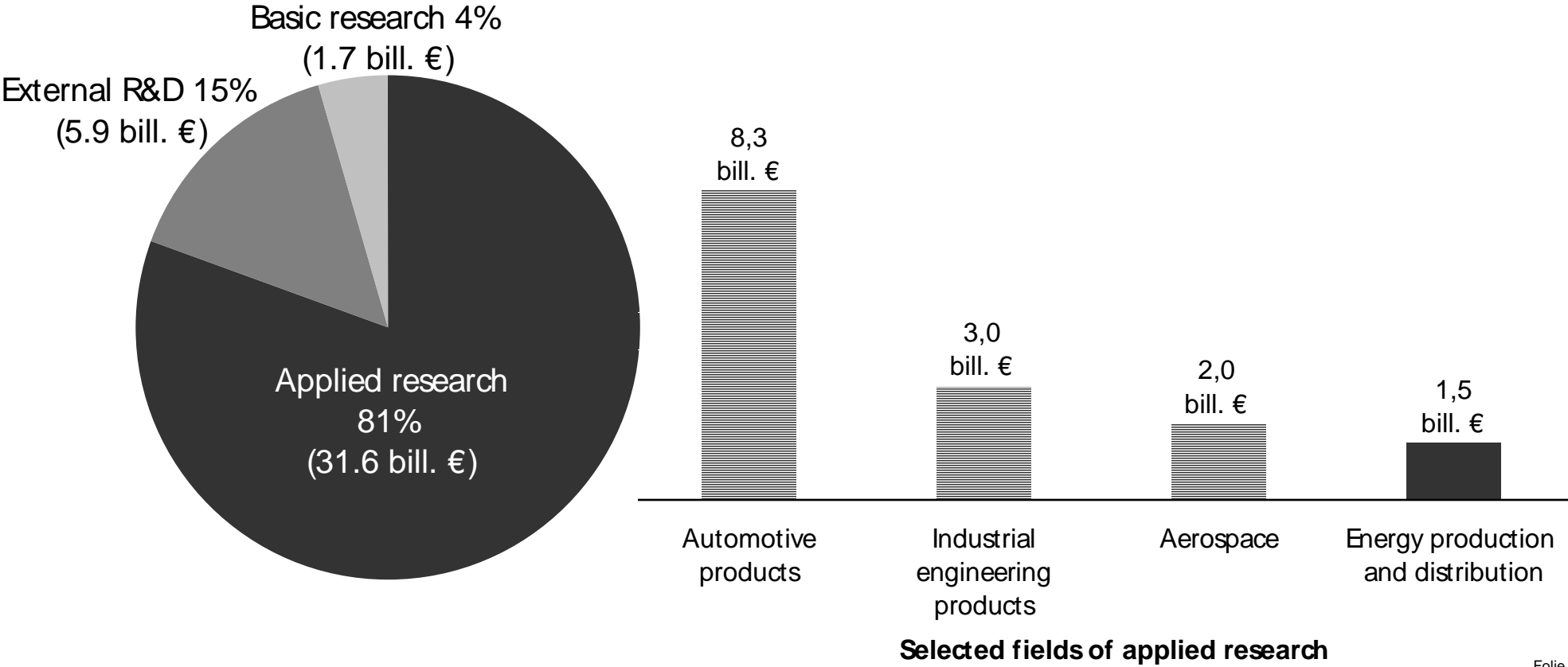
Folie 5

Source; BMBF fact report research 2002



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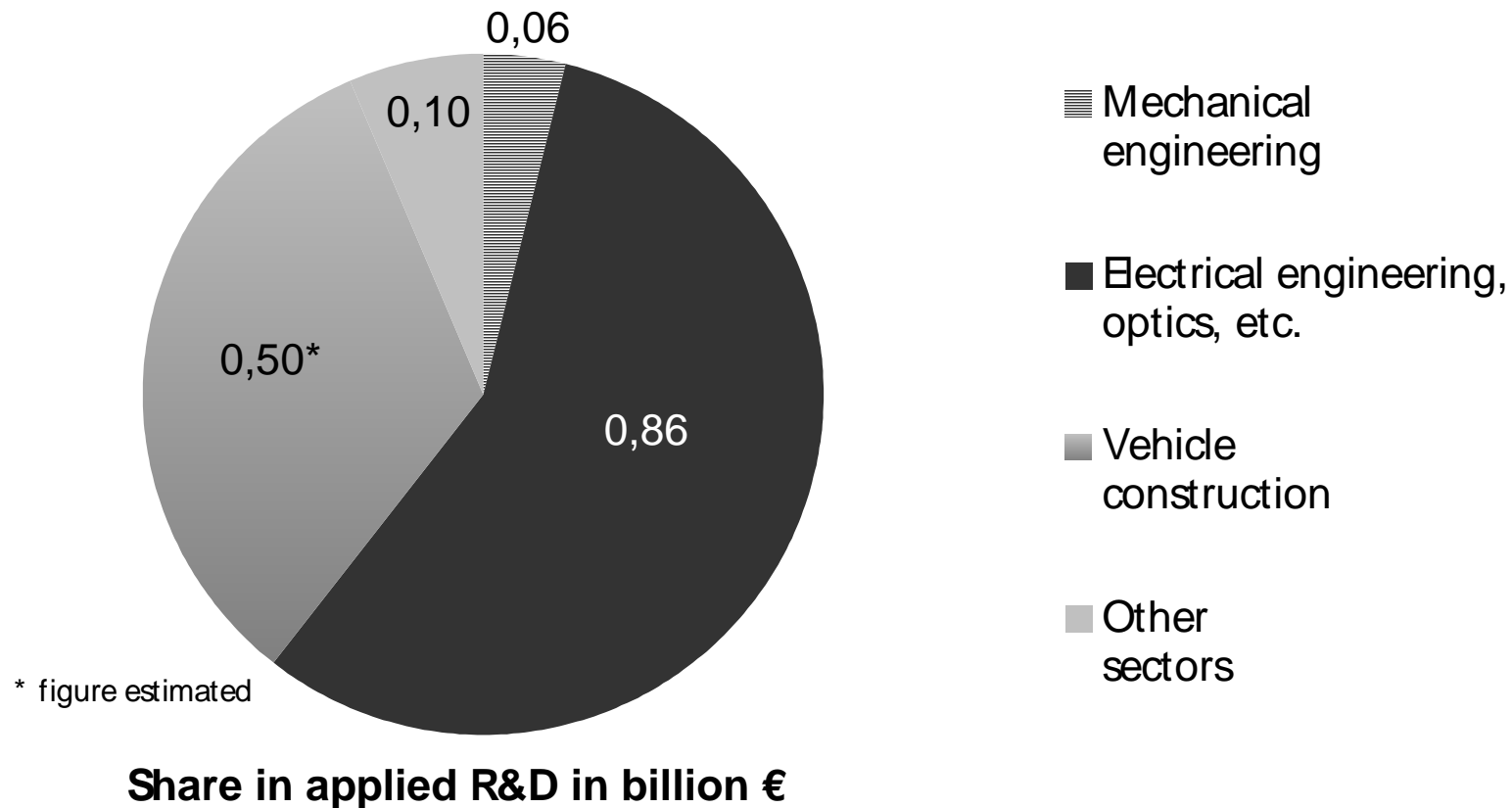
German Industry's R&D Expenses 1999 and Their Distribution Over R&D Fields



Folie 6

Source; Stifterverband Wissenschaftsstatistik 1999

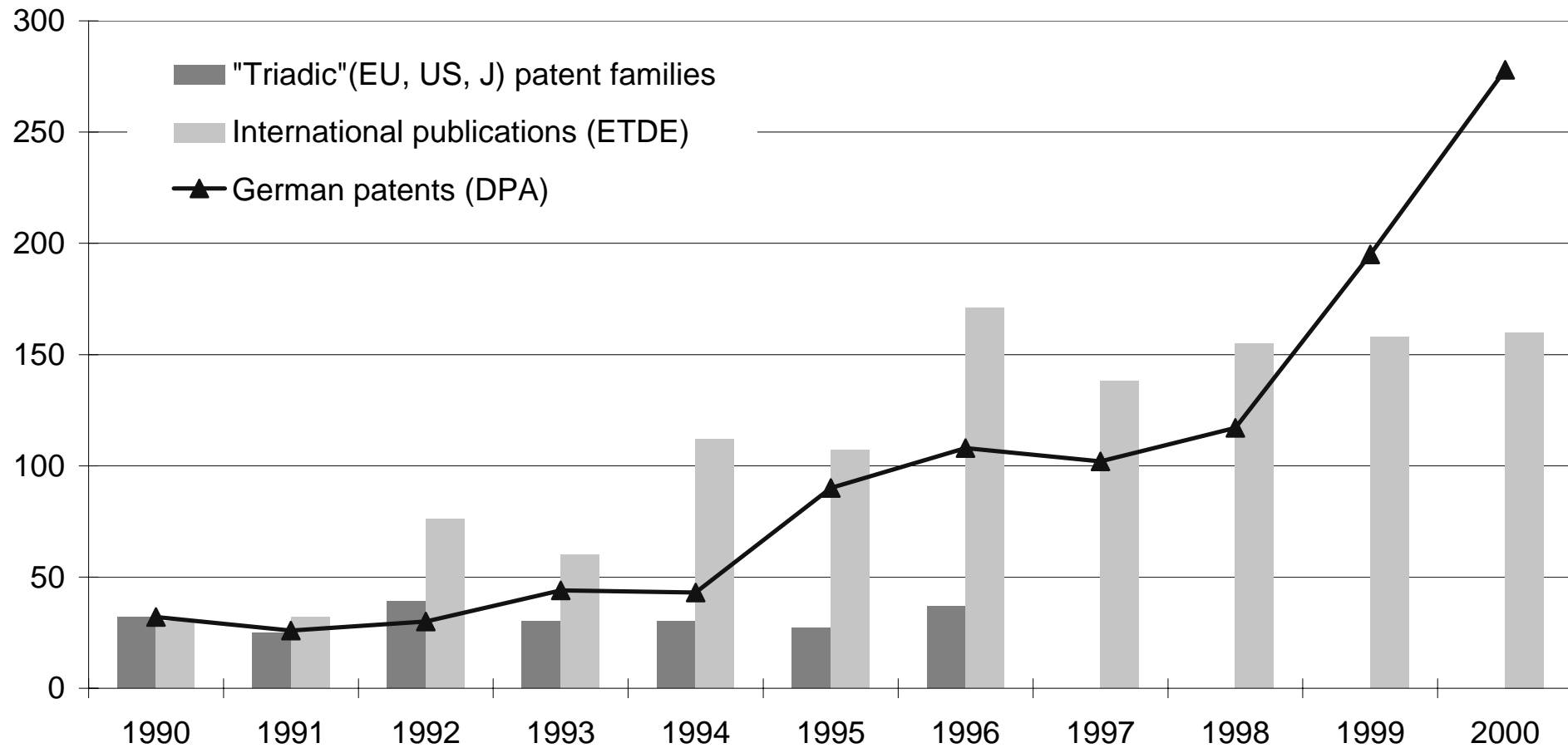
Contribution of Different Sectors to Applied R&D on Energy Production and Distribution Products



Folie 7

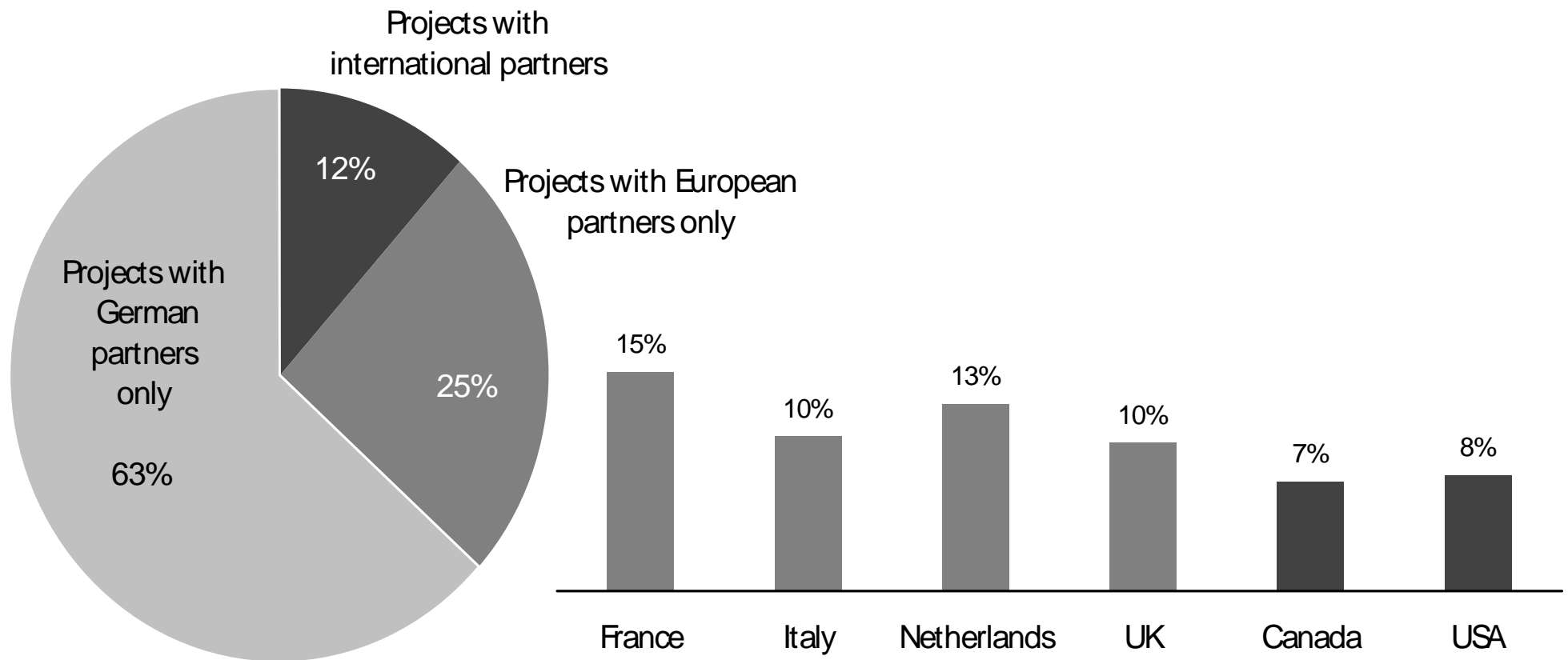
Source; Stifterverband Wissenschaftsstatistik 1999

Development of Patents and Publications in the Area of Fuel Cells



Folie 8

International Orientation of Hydrogen or Fuel Cell Projects with German Participation



Folie 9



Germany's Innovation Strategy in the Fuel Cell Area According to Publications and Patents Analyses

and differences to ...

Japan

- industry strongly contributes to scientific knowledge

Germany

- work on all types of fuel cells, AFC and MCFC German specialties
- average player in the international network focus on EU
- highest number of publications and patents in EU but internationally low
- rather low output per population but increasing
- strong public research centres
- business internal links dominate

USA

- „spider“ in international networks
- strong industry-public interaction

Folie 10



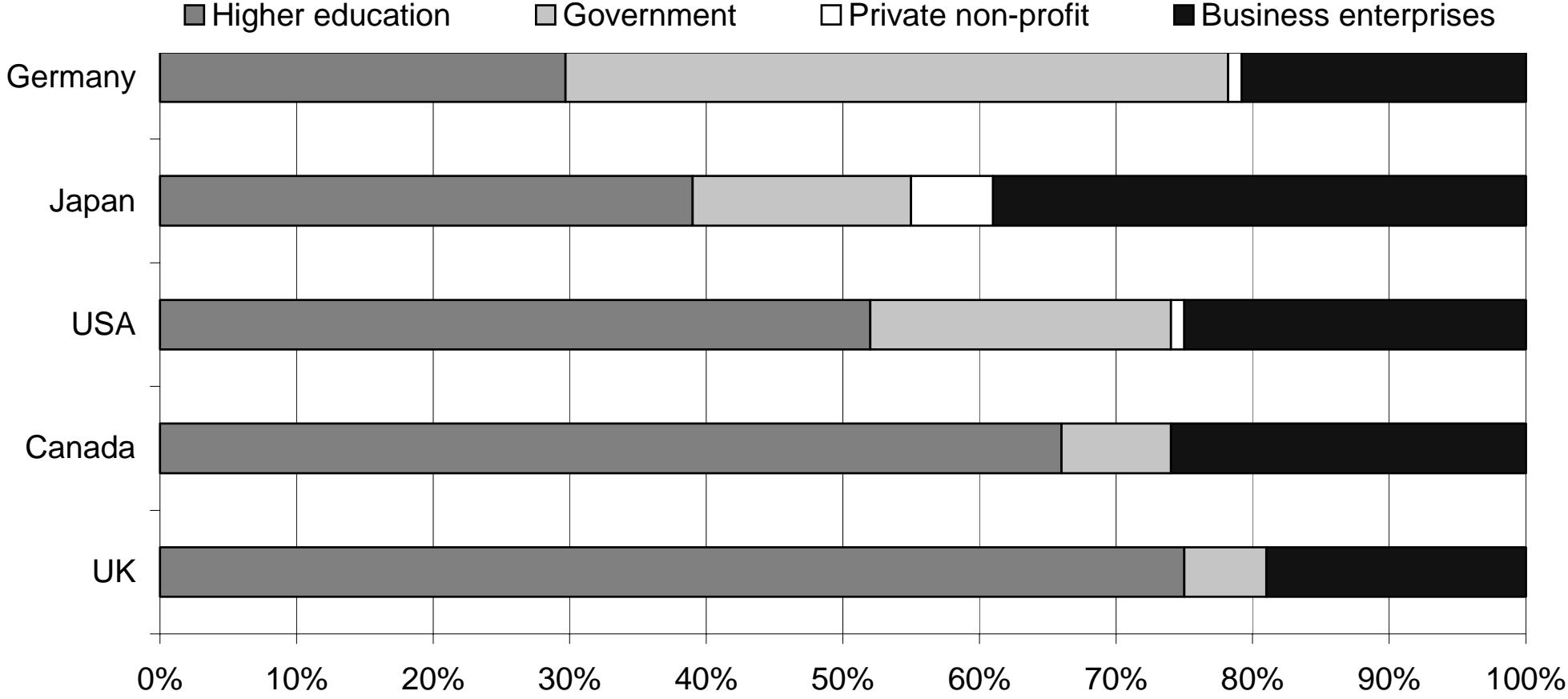
2. Organization of fuel cell innovation in Germany

- actors



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Distribution Among Institutional Sectors of Fuel Cell Publications 1990-2000 in Selected Countries



Folie 12



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Source: Draft working paper of OECD secretariat 7/2003
in the framework of OECD/TIP case study on innovation
in the energy sector

German Scientific Research Related to Fuel Cell Technologies

Around 30 % of German universities pursue fuel cell related research activities (status 7/2003):

HAW Hamburg	Uni Bochum
HTW Saarland	Uni Bonn
RWTH Aachen	Uni Duisburg-Essen
TH Karlsruhe	Uni Freiburg
TU Berlin	Uni Göttingen
TU Clausthal	Uni Hannover
TU Darmstadt	Uni Kiel
TU Dresden	Uni Magdeburg
TU Hamburg-Harburg	Uni Mainz
TU München	Uni Paderborn
Uni Bayreuth	Uni Stuttgart
	Uni Ulm

Leading German actors in fuel cell related research by number of publications between 2000 -2002 contained in SCI:

Research Centre Jülich - Werkstoffe und Verfahren (80)
German Aerospace Center, DLR (32)
Max-Planck-Institute - Festkörperforschung (20)
Technical University Munich (14)
Centre for Solar & Hydrogen Research, Ulm (12)
Technical University Karlsruhe (12)
SIEMENS AG (11)
University Ulm (10)
Hahn-Meitner-Institute (10)
University Stuttgart (9)
Fraunhofer Institute Solar Energy Systems (9)
Research Centre Jülich - Festkörperphysik (9)
Max-Planck-Institute - Kohlenstoffforschung (7)

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Source: Fraunhofer ISI enquiry of university websites and <http://www.forschungsportal.net>, analysis of SCI/ISI databank

Leading German Actors in Fuel Cell Research by Patents (DPA until 2001 in the fuel category)

Number	Organisation
96	SIEMENS AKTIENGESELLSCHAFT (MUENCHEN)
48	BALLARD POWER SYSTEMS AG (KIRCHHEIM / TECK-NABERN)
45	FORSCHUNGSZENTRUM JUELICH GMBH (JUELICH)
29	DAIMLERCHRYSLER AG (STUTTGART)
22	EMITEC GESELLSCHAFT FUER EMISSIONSTECHNOLOGIE MBH (LOHMAR)
15	OMG-Degussa AG & CO. KG (HANAU)
10	BAYERISCHE MOTOREN WERKE AKTIENGESELLSCHAFT (MUENCHEN)
10	MTU GMBH (FRIEDRICHSHAFEN)
9	ATECS MANNESMANN AG (DUESSELDORF)
8	ROBERT BOSCH GMBH (STUTTGART)
7	CELANESE VENTURES GMBH (FRANKFURT)
7	ELRINGKLINGER AG (DETTINGEN)
6	FRAUNHOFER-GESELLSCHAFT E.V. (MUENCHEN)
6	MANNESMANN AG (DUESSELDORF)
5	BASF AKTIENGESELLSCHAFT (LUDWIGSHAFEN)
5	XCELLSIS GMBH (KIRCHHEIM/TECK-NABERN)

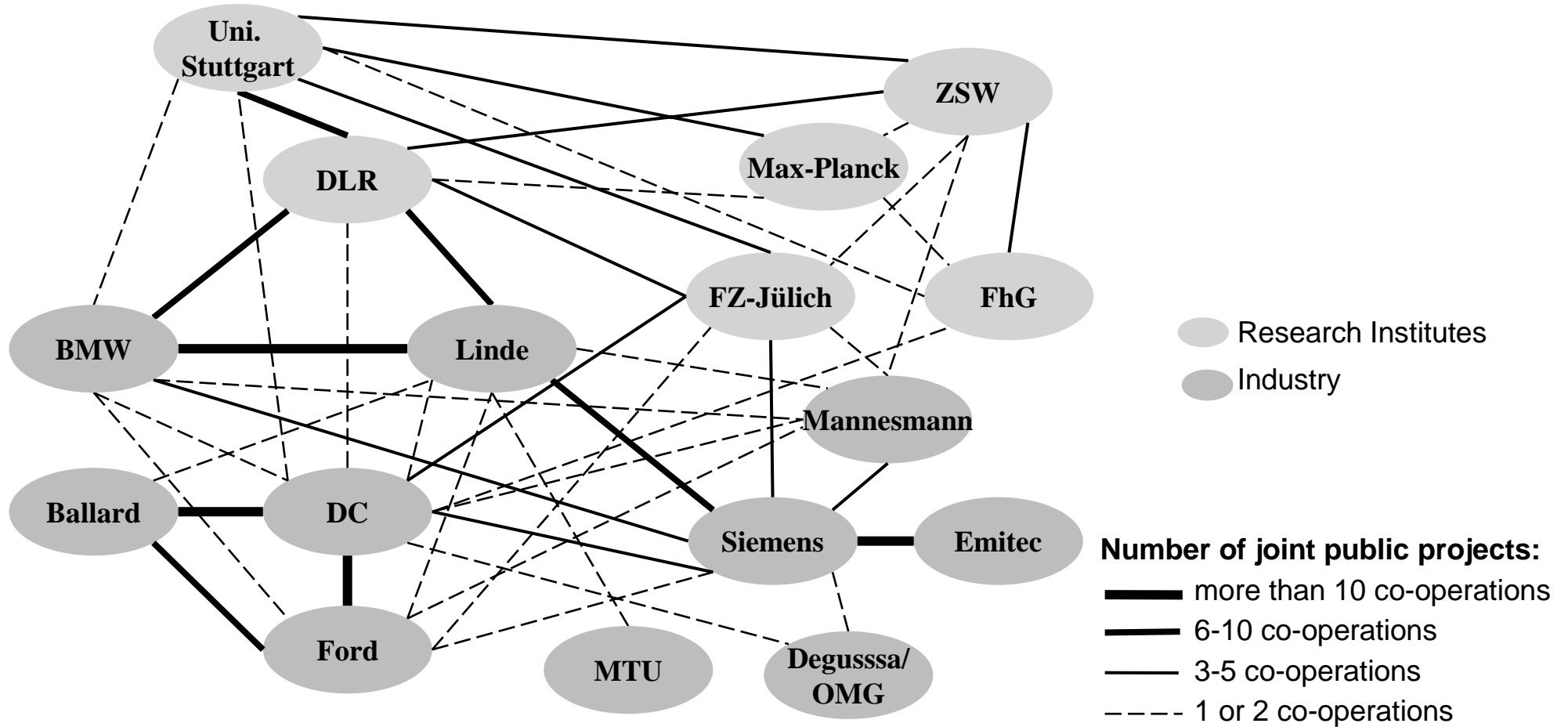


2. Organization of fuel cell innovation in Germany

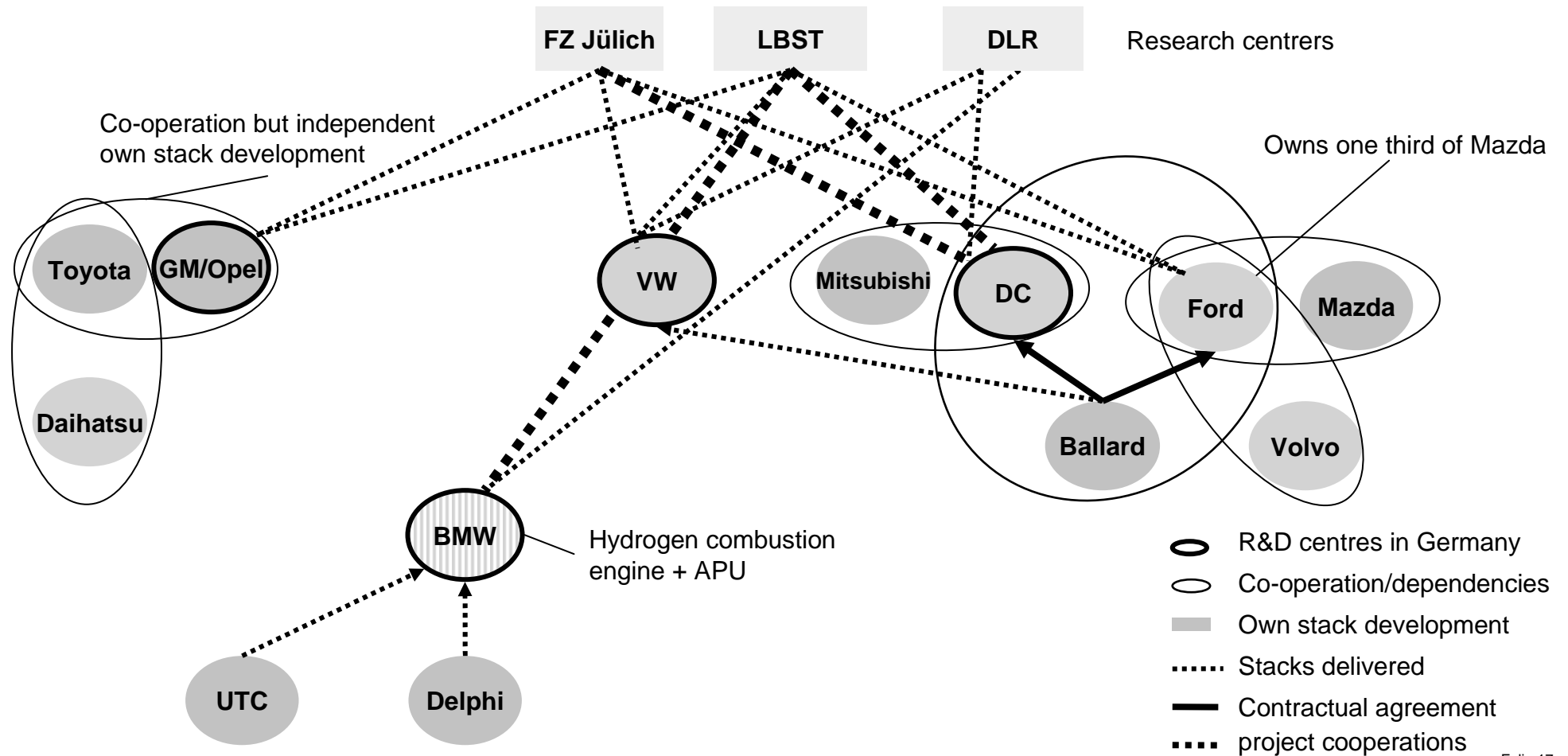
- actors
- networks



Co-operation Between Major Players in Fuel Cell Research



Fuel Cell Strategies of Passenger Car Manufacturers (Date 2003)



2. Organization of fuel cell innovation in Germany

- actors**
- networks**
- initiatives**



Efforts and Clustering of Fuel Cell Activities in Germany

European Union Framework Programmes on Research

Research and demonstration
projects of federal government (ZIP)

Länder government subsidies for
research and demonstration

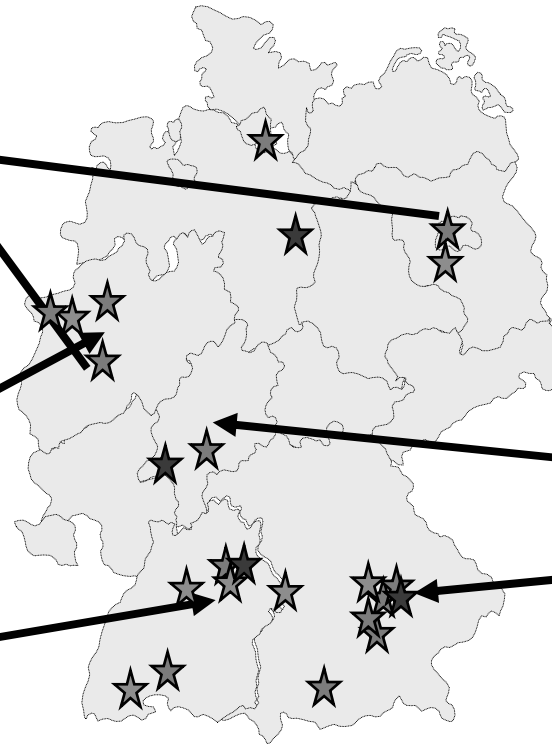
Competence Network
Fuel Cells, Northrhine-Westfalia

Research Alliance Fuel Cells,
Baden-Wurttemberg

Important actors
★ industry
★ research centres
★ automotive groups'
research centres

Hydrogen and Fuel
Cells

Initiative, Hassia
Hydrogen
Initiative, Bavaria

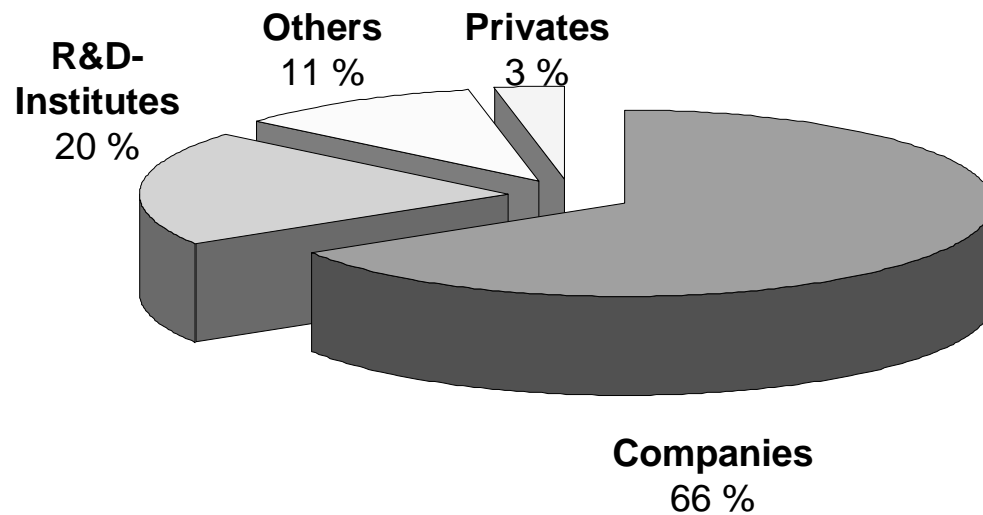


The Fuel Cell Network NRW

www.fuellcells-nrw.de



Kompetenz-Netzwerk Brennstoffzelle NRW.



Founded 2000, 280 members, about 40 NRW-funded fuel cell projects (volume of 77 Mio. €, 42 Mio. € public funding).

- Strengthening of the industry and science in NRW in the field of fuel cell technology.



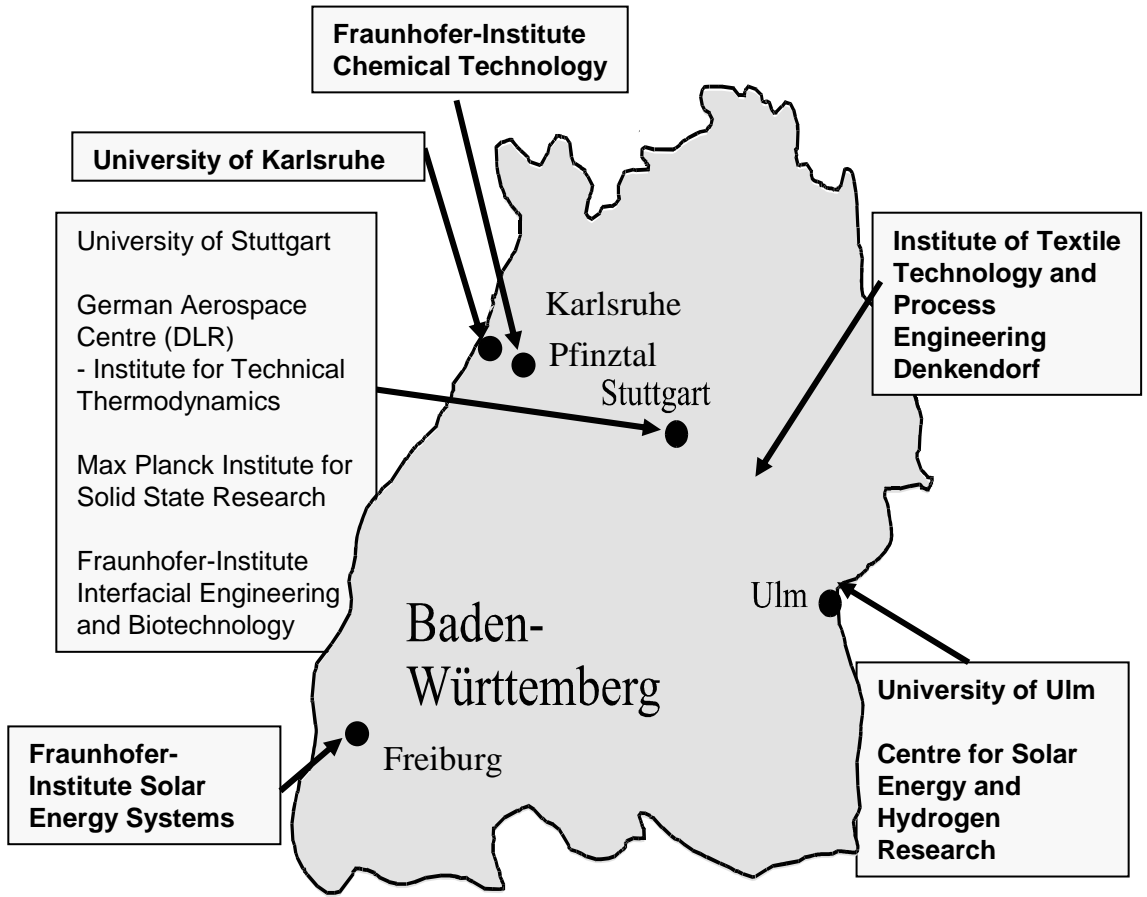
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Source: Landesinitiative Zukunftsenergien NRW

Fuel Cell Research Alliance Baden-Württemberg

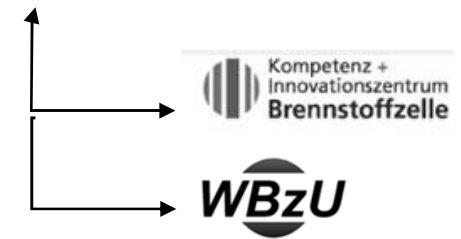


<http://www.brennstoffzellen-initiative.de/root/index.php>



Founded 2000, 14 members

- Coordinating research activities
- Strengthening technology transfer



Source: FABZ secretariat



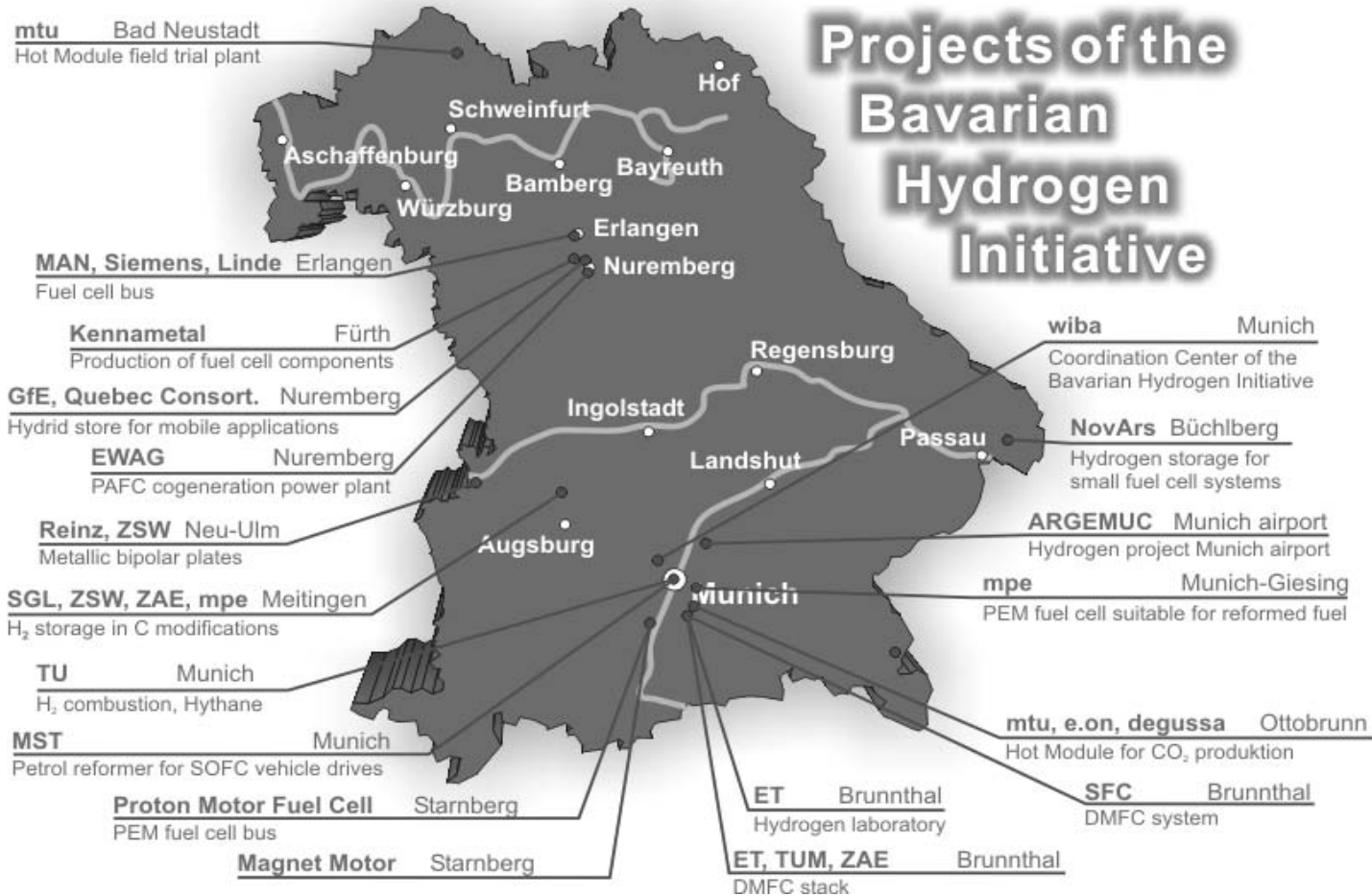
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The Bavarian Hydrogen Initiative

www.wiba.de



Projects of the Bavarian Hydrogen Initiative



Founded 1996,
30 projects with
a total financial
amount
of € 70 Mio.
(ca. 50 % public
funding).



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Source: wiba secretariat

Promotional Networks Led by Industry in Germany



Joint undertaking of four companies. Their common goal is to make "compact", natural-gas-fueled **stationary** fuel cells for residential needs technically and economically competitive.

Fuel Cell Initiative (IBZ)

Transport Energy Strategy (TES)

The **Transport Energy Strategy (TES)** is an initiative launched by the vehicle manufacturers **BMW, DaimlerChrysler, General Motors Europe (Opel), MAN and Volkswagen** and the energy suppliers

ARAL, BP, RWE, Shell and Total FinaElf, supported by the Federal Government, with the **Federal Ministry of Transport, Building and Housing**

acting as central coordinator, with the aim of developing and implementing a strategy for the medium-term, nationwide market introduction of an alternative fuel for transport



Initiative on portable applications



Initiatives for Vocational Training in Germany in the Context of the Innovation Process of Fuel Cells

- Future investment programme (BMW-ZIP): 7 projects referring to training on fuel cells, among these: support of competence centers in Ulm (ZSW) and Jülich (Research Center), study about the demand of information and training for craftsmen (HPI, L-B-Systemtechnik, Fraunhofer ISI)
- Elektroausbildungszentrum Aalen e.V. (eaz): Preliminary study: Fuel Cell – Challenge and chances for the craftsmen
- Network for fuel cell training (www.bz-bildung.de)
- BIBB, Forschungsgruppe Praxisnahe Berufsbildung (FPB): *Arbeitskreis „Qualifizierungsoffensive Brennstoffzelle“*
- IBZ: Initiative of gas and energy supplier (<http://www.initiative-brennstoffzelle.de>)

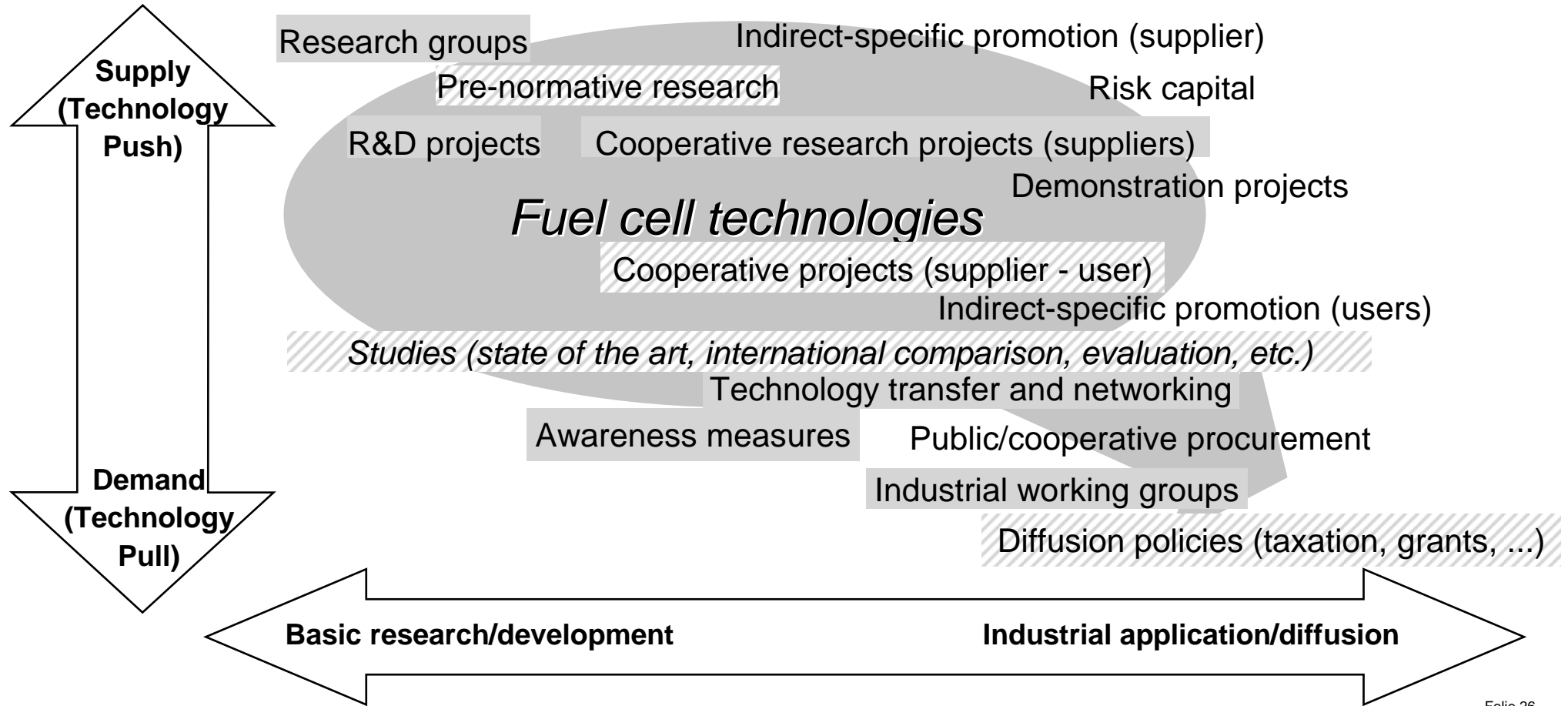


3. Policy instruments and options - lead markets



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The Innovation Policy Tool Box and Fuel Cell Technology



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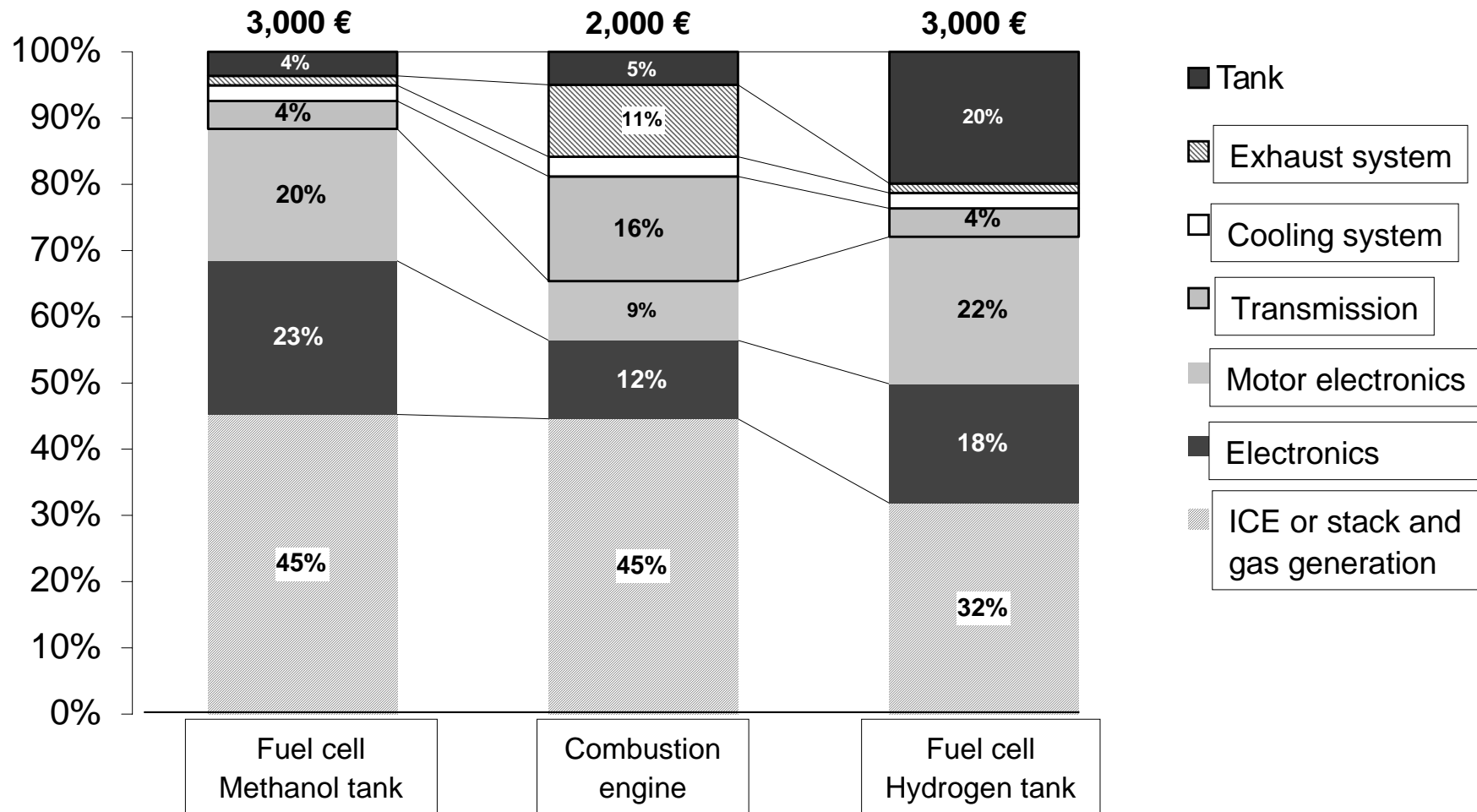
Lead Markets for Fuel Cell Applications? - the Example of Cars

General characteristics of lead markets					Remarks on current situation in automotive
	D	EU	USA	J	
Demand for innovations relatively independent of price	+	+	+	+	Only in high-end segment
High income per capita	+	+	+	+	True for all the countries here
High (consumer-) readiness to adopt innovations	++	-	+	+	Germany often shows early diffusion of new technical features in cars
High quality expectations	++	-	-	+	
Beneficial accreditation systems	?	?	+	?	Systems differ, California takes lead in FC cars
Pressure for innovative change	-	-	?	+	Emissions in urban areas / strong dependence on oil, but consumptions per car decreasing
Working system of market development	-	-	-	-	Implementing the infrastructure still missing everywhere
Favourable tax and political framework conditions	?	?	-	?	No trend in taxation predictable, low taxation of gas in USA not advantageous

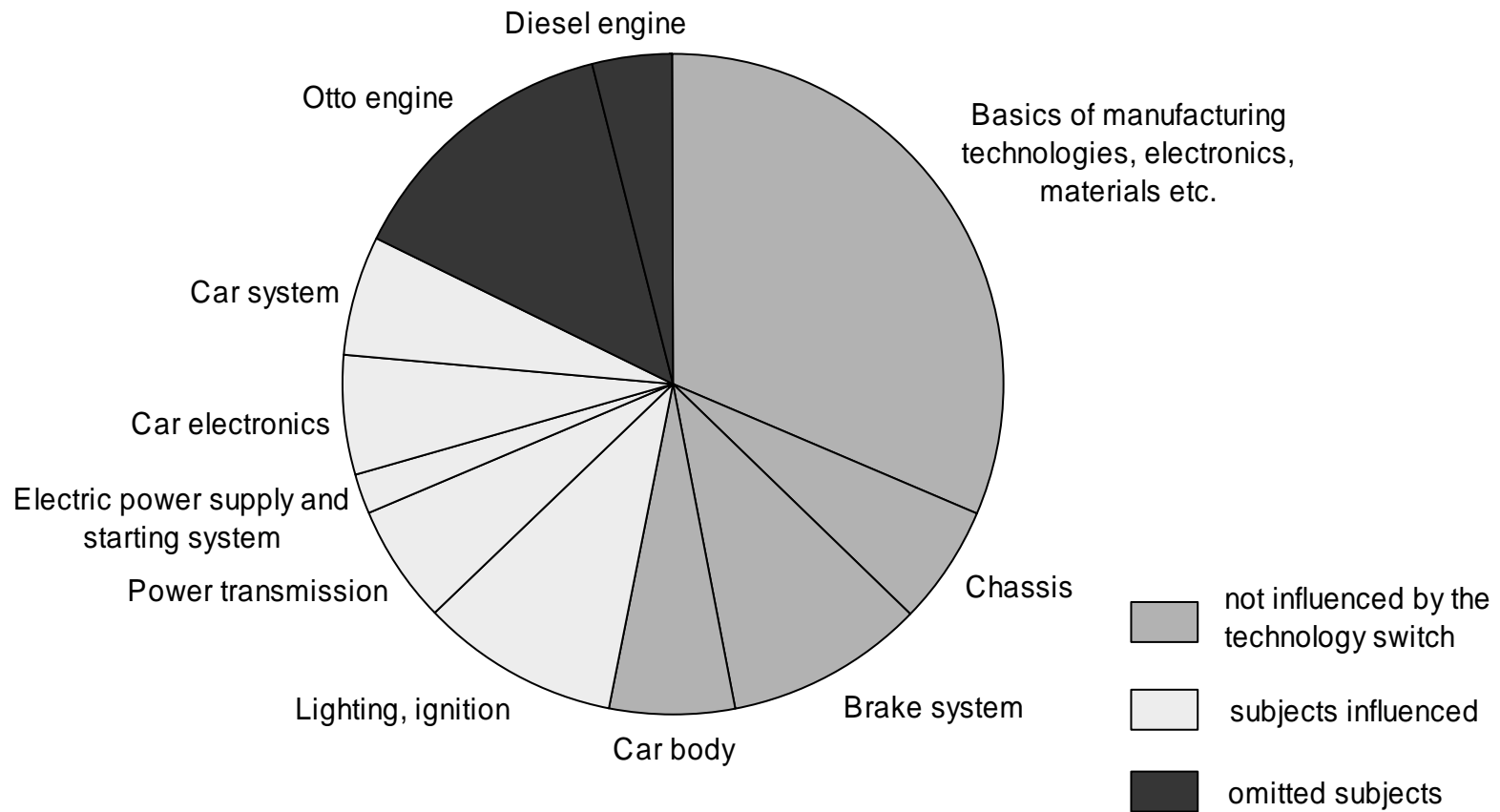
Folie 27



Potential change in the component structure of the propulsion



Changes in Vocational Training of Automotive Mechanics in the Context of Automotive Application of Fuel Cells



4. Conclusions and outlook



Conclusions

- Scientific (publications) and technological (patents) **output on fuel cell technologies** is (still) on the rise. In Germany, the growth seems superproportional.
- According to patents and scientific publications, Germany is among the **key players**.
- The **technological focus** in the last decade has been on PEMFC and SOFC but DMFC, AFC and MCFC are recognised options.
- **International co-operation** seems to be very broad in the USA while Germany's overseas network is almost completely based on DC and GM/Opel activities.
- **National Innovation Systems** in the area of fuel cell technologies differ. In Germany, public research centres play an important role. Industry concentrates on technology and internal linkages. In fuel cell innovation **Sectoral Systems** interact.
- It is not yet clear which and where **lead markets** will evolve but there are candidates.
- **Public promotion**: extension from technology push towards demand oriented measures to be put on the agenda, yet limited use in Germany.

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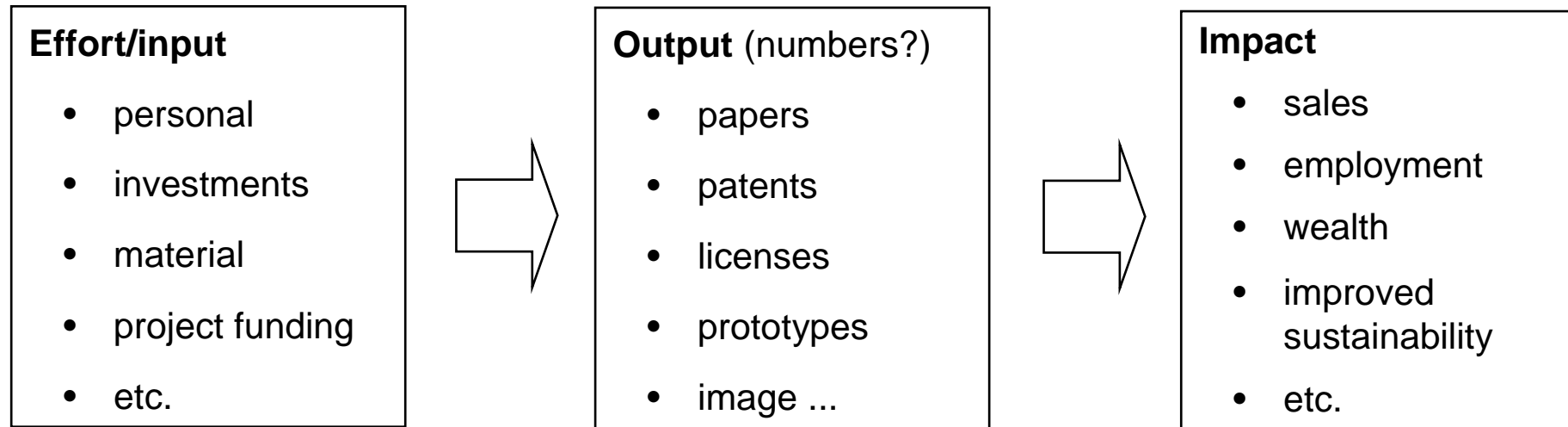


Questions

- What could be the role of Germany in the technological and commercial race towards fuel cell applications within the European Union?
Does the current input (subsidies, RTD personal, investments, ...) relate well enough to the output (publications, patents, products, ...) ?
- Should and could international co-operation be improved ?
How and in which areas (standards, science, particular technological fields, ...) ?
- What could be transition paths towards the long-term vision of the hydrogen society ?
How could lead markets be developed?



Considerations on Fuel Cell R&D Productivity Assessment in Germany



- Full picture of R&D expenditures/effort hardly to achieve.
- Distinction of input (publications?) and output (patents?) depending on perspective.
- More relevant would be impact but - apart from consensus about criteria - there is hardly any impact, yet.



Cases in niche markets? Industry survey on efforts to date and assessments.



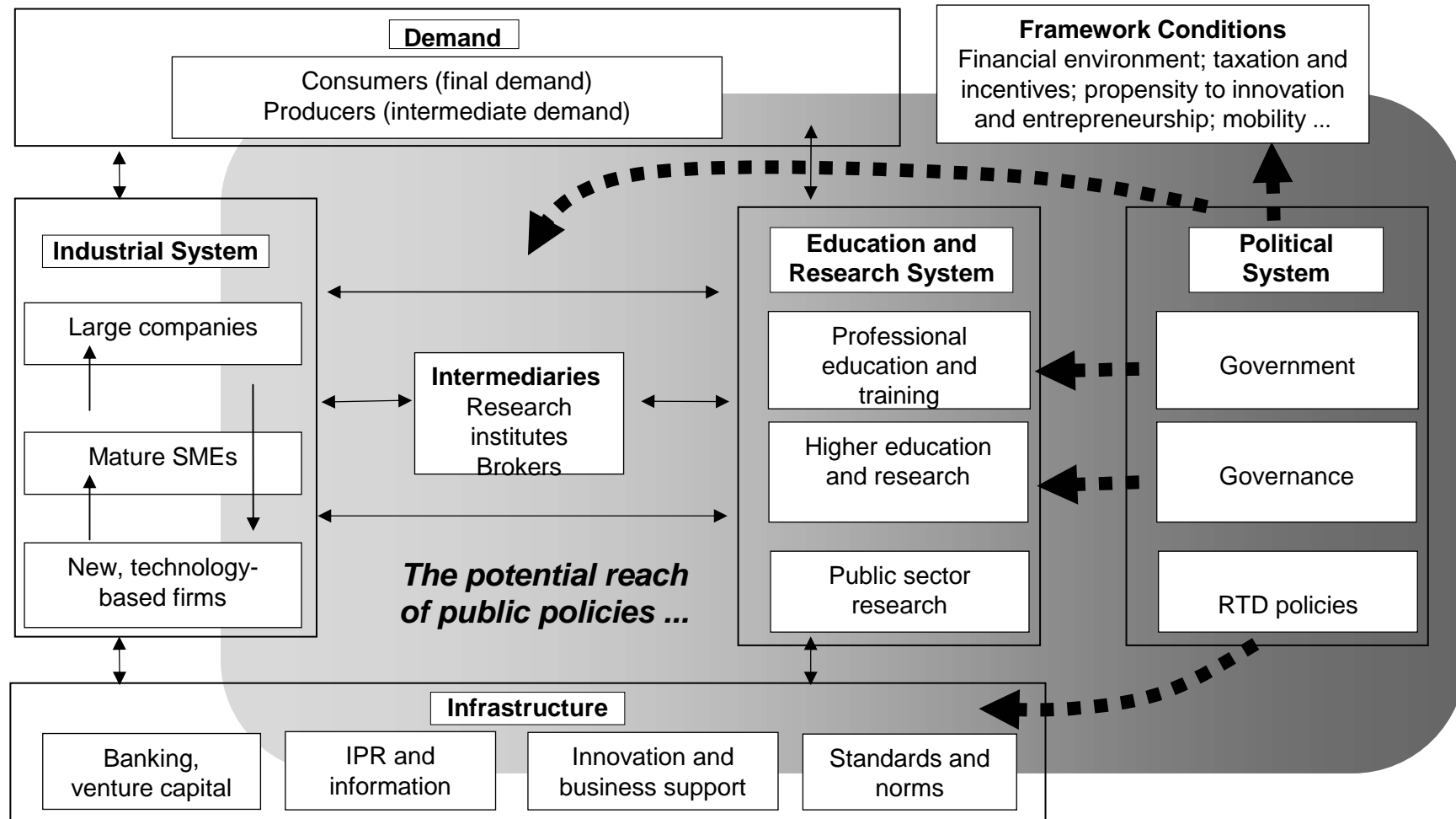
Thank you for your attention.

Additional overheads



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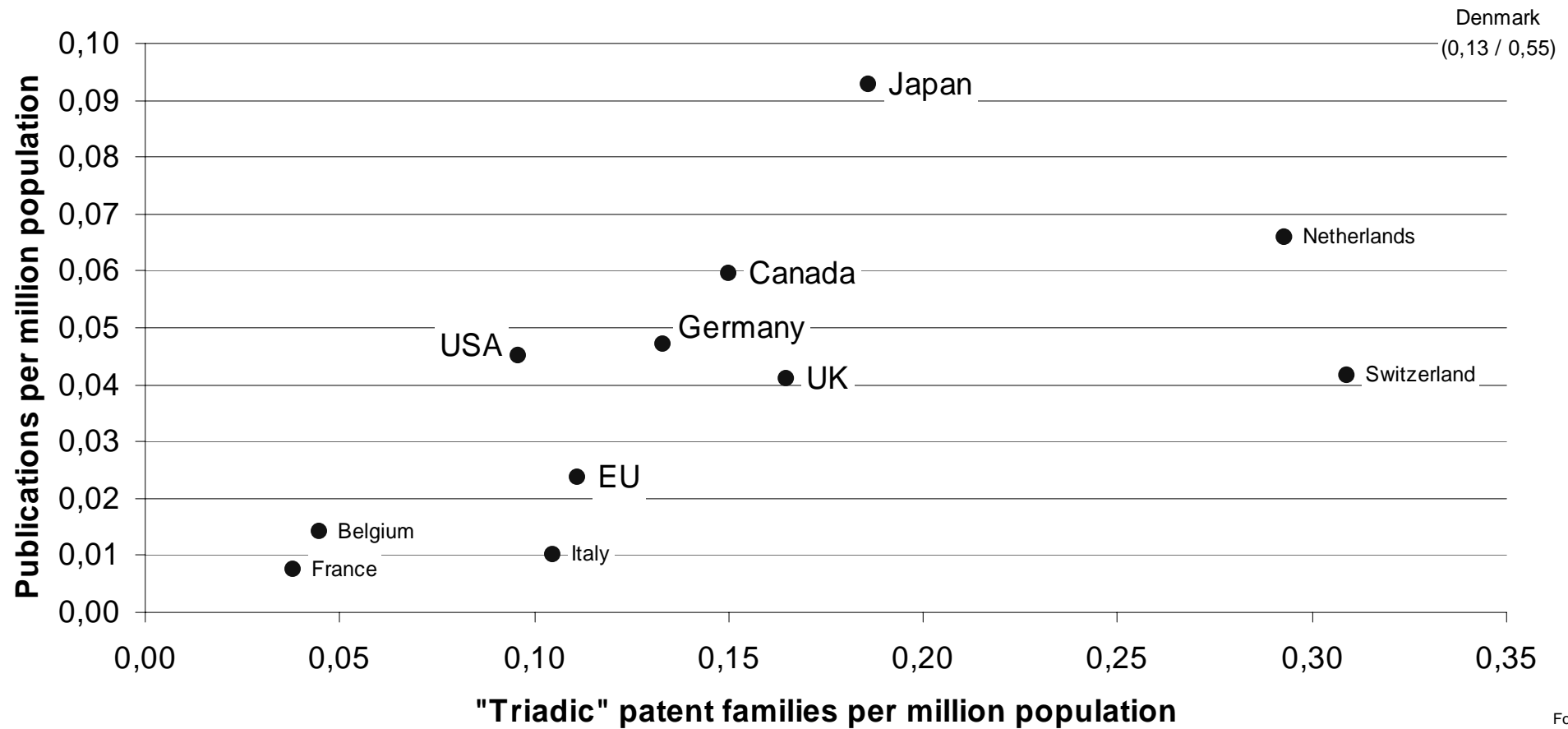
Theoretical Background - Innovation System Approach



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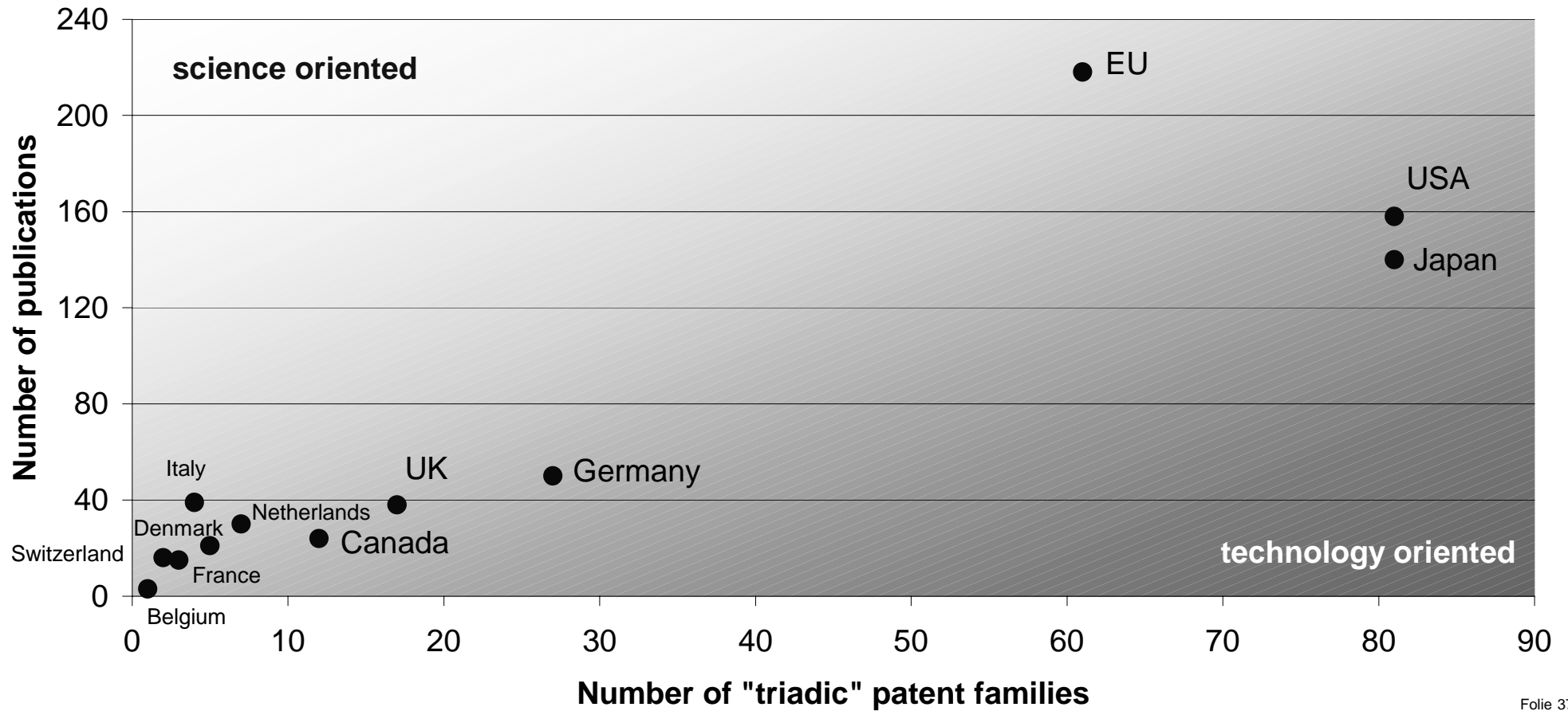


Relative Output of Patents in Relation to Publications on Fuel Cells in Selected Countries 1990 - 1996



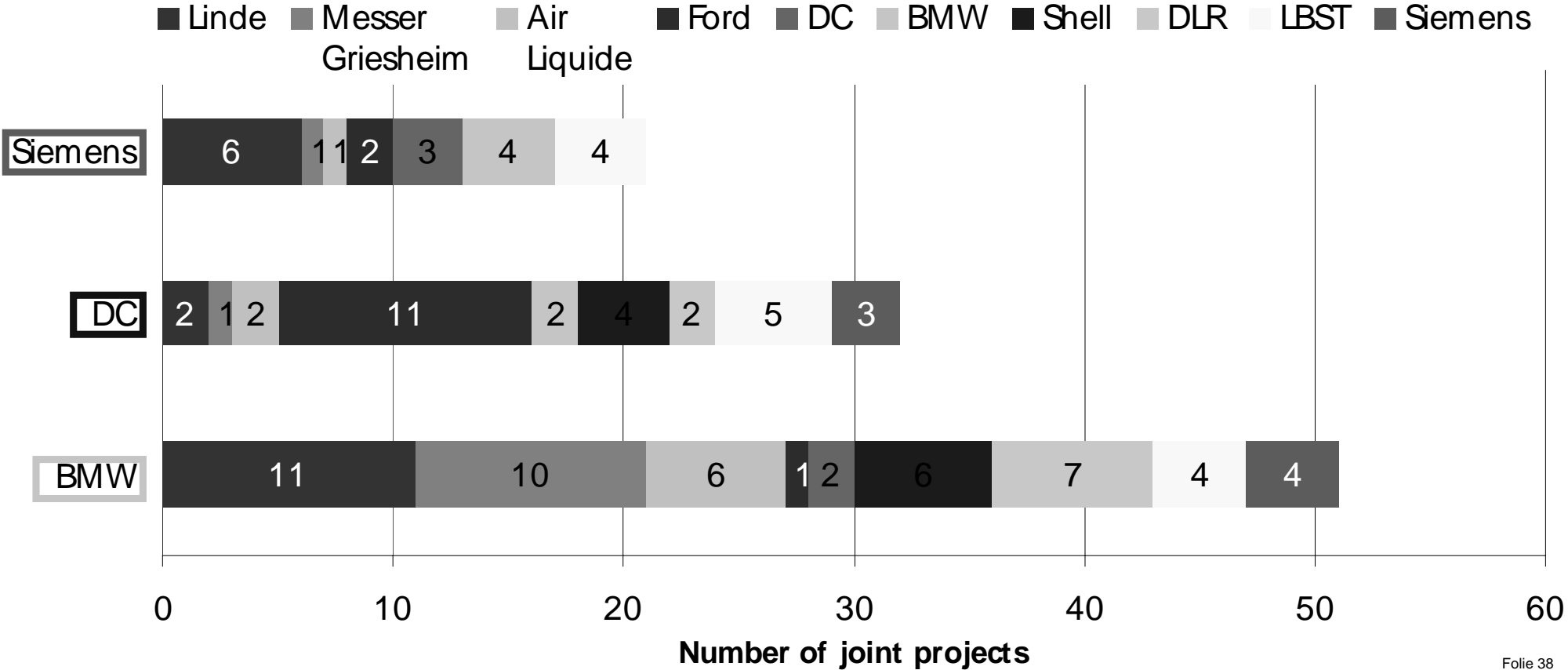
Folie 36

Output of Patents in Relation to Publications on Fuel Cells in Selected Countries 1990 -1996

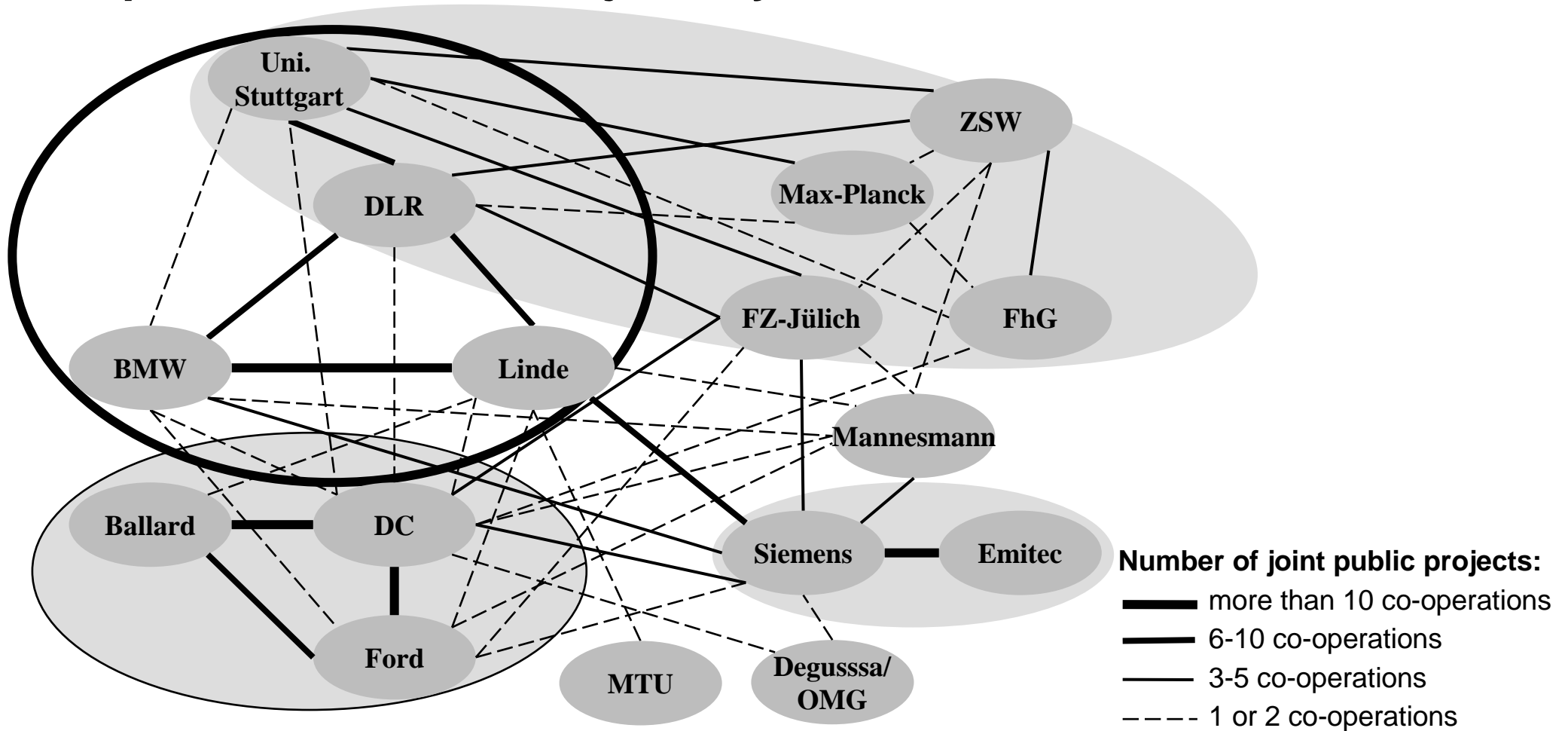


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Co-operation Between Major Players in Fuel Cell Research

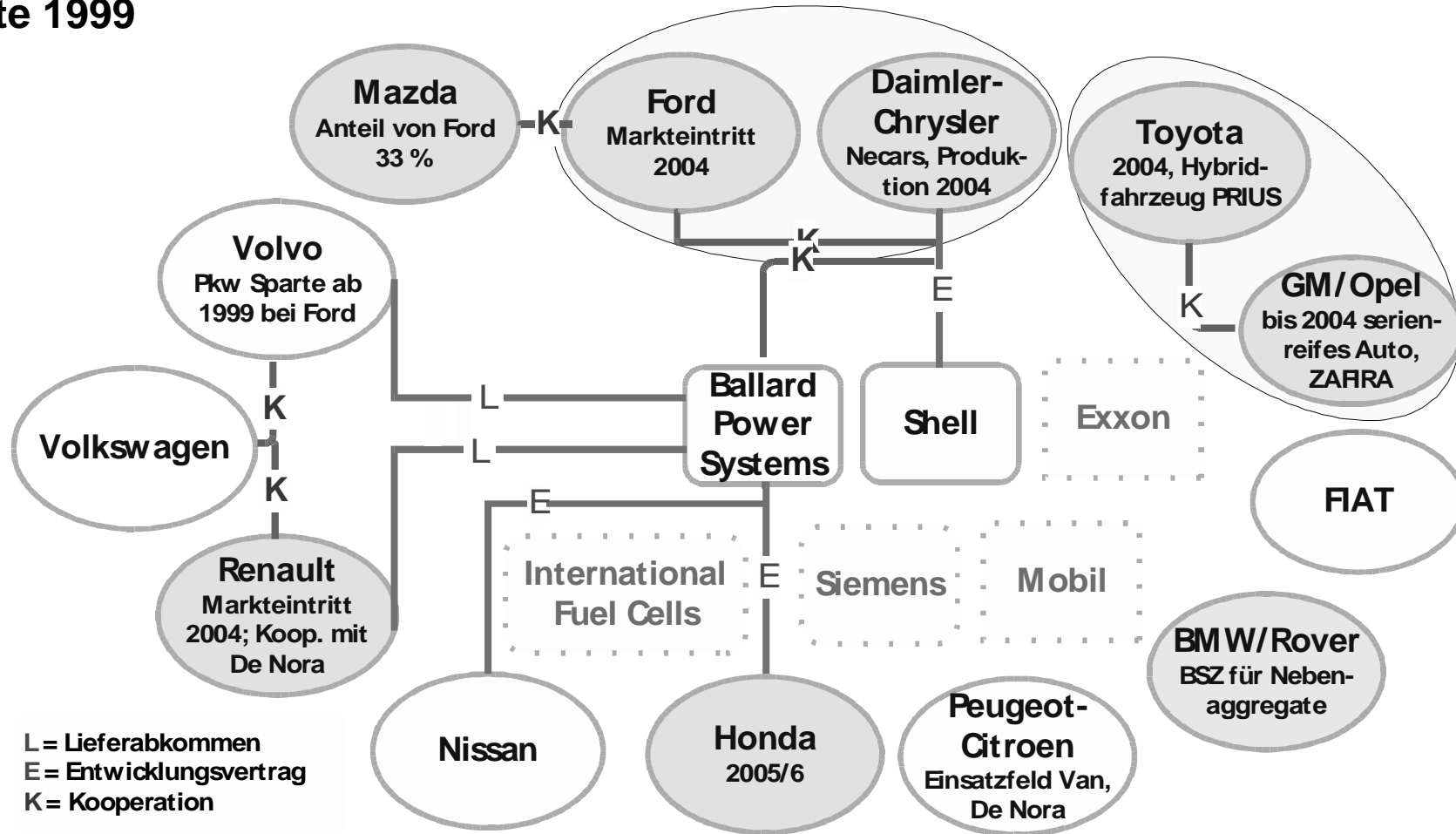


Co-operation Between Major Players in Fuel Cell Research



Fuel cell strategies of automobile manufacturers

Date 1999



Fuel cell strategies of automobile manufacturers

Date 2001

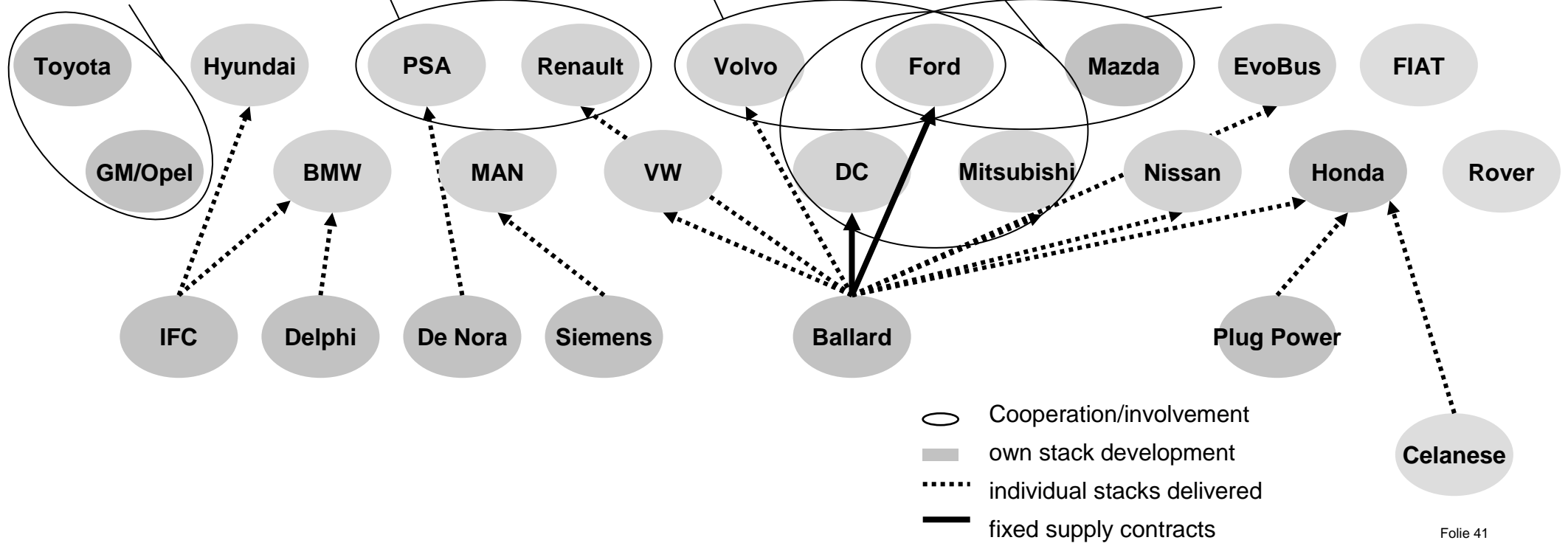
Close cooperation
but each own
stack development

French
research initiative

Car production at Ford

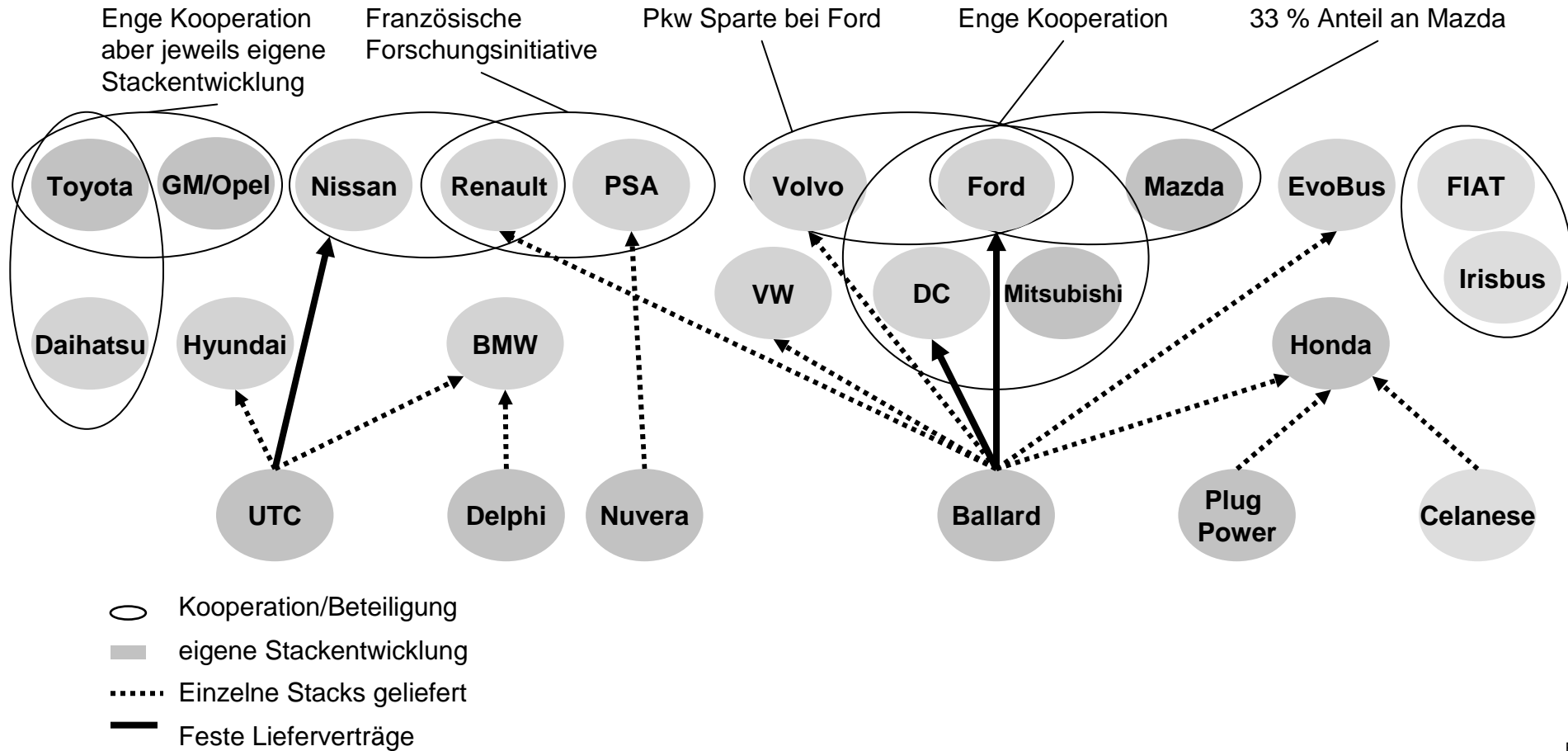
Cooperation, shares
Ballard, Ecostar, Xcellsis

33% share in Mazda

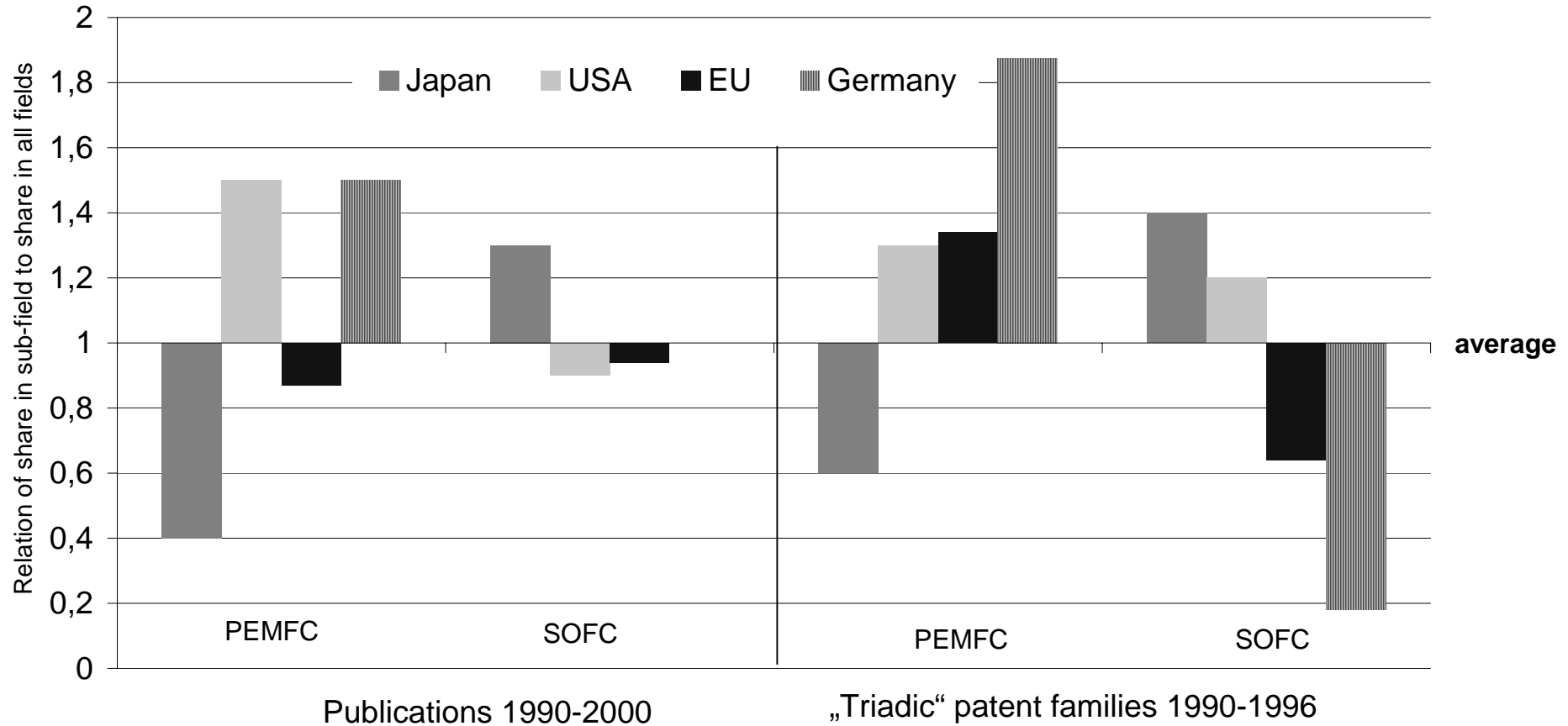


Fuel cell strategies of automobile manufacturers

Date 2003



Relative Scientific and Technological Specialization Profiles of Japan, USA and EU Towards PEMFC and SOFC (out of a range of 7 types)



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Potential changes in supplier structure

