

Comparing Innovation in Fuel Cells and Oil&Gas

Innovations in upstream oil and gas: the Norwegian experience

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*International Conference of Innovation in Energy
Technologies*

Washington D.C. September 29-30 2003



Outline of presentation

1. Characteristics of the Norwegian oil and gas innovation system
2. The production of knowledge relevant to oil and gas innovations
3. The diffusion of knowledge relevant to innovations in oil and gas
4. Evidence from bibliometric analyses of three technological fields in upstream oil and gas



Characteristics of the Norwegian oil and gas innovation system

- Several governmental bodies involved in funding petroleum R&D
- A small set of public petroleum research institutions located in regional centres
- Oil companies drivers of innovation,
- ... but service companies emerging as drivers of innovation in some technological fields



Characteristics of the Norwegian oil and gas innovation system

Government organisations involved in funding research:

- **Ministry of Oil and Energy (MOE)**
 - Effectuates industrial policy in petroleum production
 - Administers legal/regulative framework of industrial development
- **Norwegian Petroleum Directorate (NPD)**
 - Resource management, ensuring that industry operators act in accordance with MOE guidelines
- **Norwegian Research Council (NRC)**
 - Manages government sponsored R&D programmes partly funded by MOE, NPD
 - RUTH (1991-1996)
 - FORCE (1997 →)
 - DEMO2000 (1999 →)
 - OFFSHORE 2010 (1999 →)
 - Initiates strategic research initiatives such as Centres of Excellence



NRC financing of petroleum-related research 1995-2002 (Million NOK, nominal)

Year	Strategic R&D	Applied R&D	Technology demonstration programmes	TOTAL
1995	63,7	88,2		151,9
1996	71,0	71,3		142,3
1997	64,7	67,0		131,7
1998	69,5	62,0		131,5
1999	67,7	49,2	100	216,9
2000	76,5	47,6	80	204,1
2001	75,2	43,1	20	138,3
2002	86,1	34,6	20	140,7

Source: Karlsen ed. (2002)

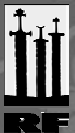


Characteristics of the Norwegian oil and gas innovation system: R&D financing

Current expenditures on R&D in the offshore technology sector 1999 and 2001. Million NOK

<u>R&D performing sector</u>	<u>1999</u>	<u>2001</u>
Industry	1185	1390
Institute sector	465	450
<u>Higher education sector</u>	<u>110</u>	<u>80</u>
TOTAL	1760	1920

Source: NIFU/Statistics Norway 2003



Characteristics of the Norwegian oil and gas innovation system: R&D financing

R&D spending in oil companies from production license activities 1997-2000. Million NOK, nominal.

Of which spent extramurally

<u>Year</u>	<u>Total</u>	<u>(suppliers, R&D institutes, HEIs)</u>
1997	1295	580
1998	1297	552
1999	1194	456
2000	1138	517

Source: NRC 2003

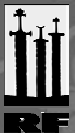


The production of knowledge relevant to oil and gas innovations

- The number of petroleum research scientists at Norw. public R&D institutes 2000

– Christian Michelsen Research	26
– IE (Institute for Energy Technology)	75
– RF (Rogaland Research)	85
– SINTEF Petroleum	60
– <u>SINTEF, other oil&gas</u>	<u>191</u>
TOTAL	437

Source: Lunde (2001)



The production of knowledge relevant to oil and gas innovations

Graduates in petroleum technological fields at Norwegian HEIs 1997-2001 (MSc and PhDs)

University of Oslo	58
University of Bergen	68
Norw. University of Technology	494
<u>Stavanger University College</u>	<u>490</u>
TOTAL	1110

Source: Karlsen ed. (2002)



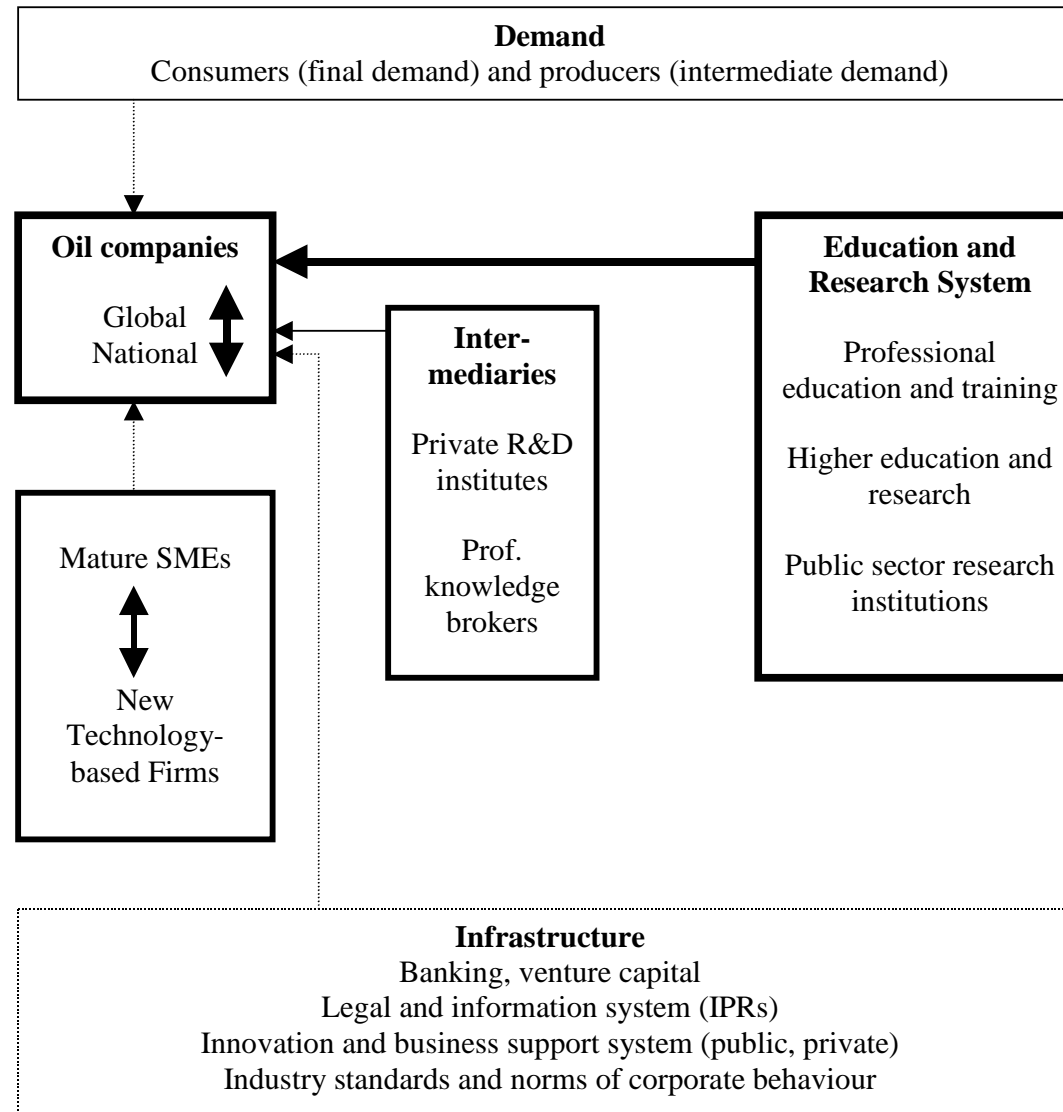
Patterns of collaborative R&D in the oil&gas industry : integrators in the sectoral innovation system

- INFOIL/SESAME database on R&D projects within North Sea offshore oil and gas
 - Typology of R&D partnerships including terms 'joint research, joint industry project, collaborative research'
 - 73 projects, 146 organisations
 - Network analysis reveals nexus agents, thematic R&D mediators
 - Projects grouped in eight thematic areas (HSE, equipment and materials testing, data acquisition and processing, reservoir flow and dynamics etc.)
- *Oil operators nexus agents for R&D cooperation together with – but to a lesser extent – governmental agencies and public research institutions. Service companies relative specialists operating within thematic subsets*

Source: Acha & Cusmano (2001)



The diffusion of knowledge relevant to innovations in oil and gas



Measures used to protect IPRs 1999-2001 in upstream oil and gas

Industry	No. of innovative companies	Filing for patent protection	Strategic secrecy	Strategically complex systems design	Time advantages
Upstream oil&gas	36	67%	62%	27%	29%
Total private sector	3416	18%	31%	19%	25%

Source: Statistics Norway Innovation Survey 2001 (rev. July 2003)



Evidence from bibliometric analyses of three technological fields in upstream oil and gas

- **3D/4D visualisation of geological data**

Search terms: graphical computing, computer graphics, visual computing, visualisation, volume data, stereo display, active stereo, passive stereo, visual interpretation, integrated visualisation, visual modelling, voxels, HPV, HPC

- **Horizontal drilling**

Search terms: horizontal drilling, advanced wells, extended reach drilling (ERD), sidetrack drilling

- **Underwater production**

Search terms: underwater production, deep water drilling, petroleum production, oil exploration, subsea production, offshore oil production



Bibliometric sources:

- ISI Web of Science
- ISI Proceedings
- INSPEC
- ETDE World Energy Base of the International Energy Agency
- ISI's NCR – National Citation Report for Norway
- ISI's JPD – Journal Performance Indicators on Diskette



Bibliometric indicators calculated include:

- Number of published papers (P)
- Numbers of citations received by those papers (C)
- Average number of citations per paper (CPP)
- Expected citation rate for papers chosen (XCR)
- Share of non-cited papers (%Pnc)

- Main Norwegian institutions publishing in the three chosen technological sub-fields
- Share of internationally co-authored papers
- Main co-authoring countries
- Main co-authoring foreign R&D institutions



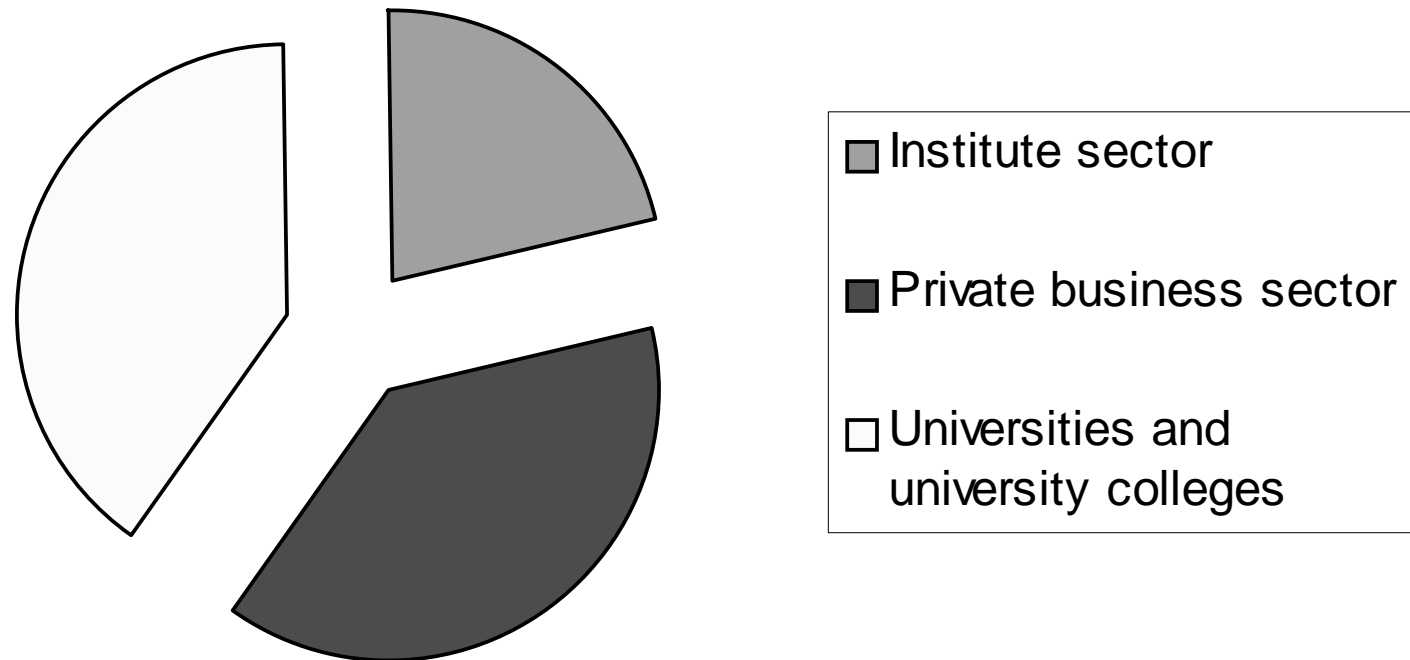
Publication output and impact

Indicator	Oil&Gas (1991- 2002)	Biotech (1993- 2000)	Marine science (1993- 2000)	Economics (1993- 2000)
Number of published papers (P)	205	1962	3358	320
Numbers of citations received by those papers (C)	761	19960	18213	663
Average number of citations per paper (CPP)	3,71	10,17	5,42	2,07
Expected citation rate for papers chosen (XCR)	3,40	9,20	4,63	1,99
Share of non-cited papers (%Pnc)	44,88	21,92	30,02	55,00

Sources: Hinze (2001), Rapmund (2003)

Share of publications by sector:

Norwegian publications. 1991-2002 (N=205)



Main R&D institutions by publications 1991-2002:

- HEIs and public petroleum research institutes
 - University of Bergen
 - NTNU – Norwegian University of Science and Technology
 - University of Oslo
 - SINTEF Group
 - Rogaland Research
- National oil companies
 - Statoil
 - Norsk Hydro
 - (Saga Petroleum)



... a closing digression on applications of 3D/4D visualisation in oil and gas

- Data: interviews with practitioners, key informants in Norwegian oil companies and specialised ICT service companies
- Introduced to oil&gas in Houston as a knowledge spillover from Houston health technology cluster
- Negligible knowledge spillovers oil&gas → health/medical imaging in Norway
- At the organisational level: new disciplinary collaborations in interpreting geological data
- From enhancing oil and gas recovery rates (economic motive) to accelerating organisational learning (process innovation motive)

