Conventional Oil and Gas Technologies

HIGHLIGHTS

- **PROCESS AND TECHNOLOGY STATUS –** Oil and gas technologies include the exploration and development of oil and gas fields, and production processes. Over the past decades, dramatic improvements in all oil and gas technologies have led to important discoveries of new fields and a significant increase in the recovery factor, i.e. the percentage of hydrocarbons that is economically recoverable from a given reservoir. These developments have made meeting the growing global demand for hydrocarbons possible in spite of the unavoidable decline in new giant reservoirs. From 1970 to 2008 global oil production has increased by 70% and natural gas by 200%. In 2008, global oil production was about 82 million barrels per day (mb/d). The major producers were Saudi Arabia, Russia and the United States with 10.8, 9.9 and 6.7 mb/d, respectively. In the same year, global natural gas production was 3066 billion cubic meters (bm^3), with Russia, the United States and Canada being the major producers - 602, 583 and 175 bm^3. A number of oil and gas fields are currently under development or renewal. The three biggest development projects are Kashagan in Kazakhstan, and Sakhalin 2 and Shtokman in Russia. The estimated capacity of Kashagan is 0.82 mb/d.

- **PERFORMANCE AND COSTS –** The **recovery factor** is a key performance in oil and gas production. In oil fields it normally ranges from 30-50%, while in natural gas fields it is usually much higher, ranging from 70-80%. In 2005 the **energy consumption** per unit of production was between 0.8 to 2.3 GJ per toe, depending on location (about 2-5% of the output). The energy needed for oil and gas production is often obtained from locally produced gas, which is burned in gas turbines. In the production process, **energy losses** may occur because of gas flaring and venting. Gas flaring occurs when natural gas is associated to the oil production and there is neither a local market nor any infrastructure to sell/use natural gas. The World Bank Global Gas Flaring Reduction Initiative estimates that 150 bm^3 of gas were flared or vented in 2005. Carbon dioxide (CO_2) is the largest gaseous **emission** occurring either from flaring or fuel combustion in energy production. Methane (CH_4) is the second largest gaseous release, basically coming from venting and from incomplete combustion of hydrocarbons. Europe is the region with the lowest emissions per unit of production: 65 tCO_2/1000 toe, 0.2 tCH_4/1000 toe and 0.2 tNO_x/1000 toe. Africa has the highest CO_2 emissions (274 tCO_2/1000 toe), Australasia has the highest CH_4 emissions (1.9 tCH_4/1000 toe) and America has the highest NO_x emissions (0.5 tNO_x/1000 toe). In 2006, the highest **production cost** was recorded in Canada at US$ 8.3/boe and the lowest cost (US$3.2/boe) in the so-called *Other Western Hemisphere* area (Central and South America and the Caribbean). The production cost (in US $ per barrel of oil equivalent, $/boe) accounts for operating and maintaining wells and related equipment, after the hydrocarbons have been found and developed for production. The **exploration cost** is the cost of adding proved reserves of oil and natural gas through exploration and development activities. In the period 2004-2006, the US offshore explorations recorded the highest exploration cost ($63.7/boe) with the Middle East having the lowest one ($5.3/boe). The estimated development cost of the Kashagan field is US$ 54,000 million.

- **POTENTIAL AND BARRIERS –** Over the last few years, exploration costs have increased in all regions because of the general decline of new discoveries, and the growing cost of field development. Exploration and production costs tend to grow because of the increasingly remote locations and depth of the new discoveries, the rising costs of materials and equipment, and also for geo-political reasons. Key technology advances such as 3D seismic and horizontal drilling have led to important achievements in both exploration and production at more affordable costs. Further cost reduction, increasing recovery factors and production are expected from new technologies (e.g. low-cost wells, deepwater techniques, and enhanced recovery).

PROCESS AND TECHNOLOGY STATUS – Oil and gas technologies include exploration, development and production processes. National organisations of oil and gas producing countries (e.g. the Norwegian Petroleum Directorate [18]), and national oil companies provide oil and gas production data. Other sources provide production data using national and private sources (e.g. Oil and Gas Journal, British Petroleum (BP), Organisation of Petroleum Exporting Countries (OPEC)). Oil and natural gas production over the past decades are shown in tables 1 and 2. From 1970 to 2008, worldwide oil production has increased by 70% and natural gas production has increased by 200%. In 2008, global oil production was about 82 mb/d. Saudi Arabia was the first producing country (10.8 mb/d) followed by Russia (9.9 mb/d) and the United States (6.7 mb/d). The proven oil reserves were 1258 billion barrels [2] and the reserves to production (R/P) ratio was 43 years. In the same year, the global natural gas production totalled 3066 bm^3, with Russia, the United States and Canada being the largest producing countries (602 bm^3, 583 bm^3, and 175 bm^3, respectively). The proven natural gas reserves were 185 trillion m^3 [2] and the R/P ratio was 60 years. While the R/P ratio provides information on reserves availability, it is not the right parameter to use to discover how long the reserves will last because oil and gas production vary over time according to demand, and new resources are found by exploration. The recovery factor (i.e. the percentage of hydrocarbons in place that is economically recoverable from a given reservoir) also varies over time due to advancement in technology. Over the past decades, important technology advances such as 3D seismics and horizontal drilling has meant substantial improvements in exploration, development and production technologies. Further improvements in developing low-

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cost wells, deepwater production and enhanced recovery can reduce the development and production costs and make the exploitation of additional oil and gas resources economically affordable. ■ **Low-cost wells** – In general, drilling oil and gas wells is a costly process. Case drilling is among the innovative technologies that help reduce costs [1]. Usually a well is first drilled and then a diameter pipe is inserted into the drilled section and kept in place by cement (casing). Case drilling consists of using casing pipes instead of the traditional drilling pipes. The case is cemented to the rock at the end of the drilling process thereby saving several steps in the construction of the well. In addition, in conventional wells, the boring diameter is larger at the top and reduces with depth. The surface diameter can be a factor of 6 larger than the diameter at the production zone. Expandable casing ensures that a constant diameter is kept from top to bottom, saving significant energy consumption, waste production and drilling rig size compared to traditional drilling. The future development of expandable casing depends on further research on advanced materials. ■ **Deepwater Production** – The potential of deepwater fields is estimated to range between 150 and 200 billion barrels of oil equivalents (boe) [1]. In 2005, the world depth-record in deepwater production was about 3000-meters and it is estimated that some 70% of deepwater resources are located between 2000 and 4000 meters [0]. As the development and production of deepwater fields imply high costs, exploitation is only affordable at favourable sites and most productive fields. Technology development can make even smaller deepwater fields economically attractive. The economic impact of improving offshore deep-water technologies on the Norwegian North-Sea upstream sector is shown in Figure 1. Moving from fixed platforms to floating production has led to a considerable decrease in the investment costs. The recent development of subsea oil and gas production techniques can further decrease the production costs and make a considerable number of new fields economically profitable. New technologies for subsea separation and transportation to shore are currently being used in some new fields, such as the Snøhvit field in the Norwegian Barents Sea. ■ **Enhanced Oil Recovery** – The recovery factor varies widely as a function of the reservoir characteristics. Over the past decades, technology improvements have meant increasing recovery factors. Currently, a typical recovery factor for oil fields ranges from 30-50% while for natural gas it is typically higher, ranging from 70-80% [1]. However, extracting more than 40% of the oil in places may require enhanced oil recovery (EOR) techniques and additional costs, as well as in-depth analysis to ensure the economic affordability of the process [1]. Oil extraction from sedimentary reservoirs may be facilitated using fluids to replace oil. Replacing fluids may either be available in the reservoir or injected from the wells (e.g. water, gases, and complex materials). Examples of injected gases are CO_2, N_2 and CH_4 and an example of a complex material is the polymer Rhamnolipid. The advantage of using gaseous hydrocarbons and CO_2 is that

Table 1 – Oil Production by Region & Major Producers, [2]

Oil (1000 barrel/day)	1970	2000	2007	2008
US	11297	7733	6847	**6736**
Canada	1473	2721	3320	**3238**
Mexico	487	3450	3471	**3157**
Total North America	**13257**	**13904**	**13638**	**13131**
Brazil	167	1268	1833	**1899**
Venezuela	3754	3239	2613	**2566**
Total S. & Cent. America	**4829**	**6813**	**6636**	**6685**
Kazakhstan	n/a	744	1484	**1554**
Norway	-	3346	2556	**2455**
Russian Federation	n/a	6536	9978	**9886**
United Kingdom	4	2667	1638	**1544**
Total Europe & Eurasia	**7982**	**14950**	**17819**	**17591**
Iran	3848	3818	4322	**4325**
Iraq	1549	2614	2144	**2423**
Kuwait	3036	2206	2636	**2784**
Qatar	363	757	1197	**1378**
Saudi Arabia	3851	9491	10449	**10846**
United Arab Emirates	762	2626	2925	**2980**
Total Middle East	**13904**	**23516**	**25168**	**26200**
Algeria	1052	1578	2016	**1993**
Angola	103	746	1720	**1875**
Libya	3357	1475	1848	**1846**
Nigeria	1084	2155	2356	**2170**
Total Africa	**6112**	**7804**	**10320**	**10285**
China	615	3252	3743	**3795**
Indonesia	854	1456	969	**1004**
Total Asia Pacific	**1979**	**7874**	**7862**	**7928**
Total World	**48064**	**74861**	**81443**	**81820**
crude oil, shale oil, oil sands and natural gas liquids				

Table 2 – Nat. Gas by Region and Major Producers, [2]

Natural Gas (bcm)	1970	2000	2007	2008
US	595	543	541	**582**
Canada	57	182	184	**175**
Mexico	11	38	54	**55**
Total North America	**663**	**763**	**779**	**812**
Argentina	6	37	45	**44**
Total S. & Cent. America	**18**	**100**	**155**	**159**
Netherlands	27	58	61	**68**
Norway	-	50	90	**99**
Russian Federation	n/a	529	592	**602**
Turkmenistan	n/a	43	65	**66**
United Kingdom	10	108	72	**70**
Uzbekistan	n/a	51	59	**62**
Total Europe & Eurasia	**282**	**939**	**1053**	**1087**
Iran	13	60	112	**116**
Qatar	1	24	63	**77**
Saudi Arabia	2	50	74	**78**
United Arab Emirates	1	38	50	**50**
Total Middle East	**20**	**208**	**358**	**381**
Algeria	3	84	85	**87**
Egypt	0	21	56	**59**
Total Africa	**3**	**130**	**204**	**215**
China	3	27	69	**76**
Indonesia	1	65	68	**70**
Malaysia	-	45	61	**63**
Total Asia Pacific	**16**	**272**	**396**	**411**
Total World	**1001**	**2412**	**2945**	**3066**
* Excluding gas flared or recyled.				

these gases are miscible with oil, depending on the reservoir pressure and temperature [15, 16, 17]. Research on rock-to-fluid interface can lead to cost reductions of enhanced recovery processes, but EOR profitability is highly sensitive to oil prices. The recovery rates of Norwegian fields are shown in Table 3. All fields have experienced an increase of the expected recovery from 1986 to 2001; the Statfjord field has increased from 49% to 68%. A number of new fields are under development or being renewed worldwide. Table 4 shows capacities and costs of new upstream projects for the period 2008-2015. The three biggest projects under development are Kashagan in Kazakhstan, Sakhalin 2 and Shtokman in Russia.

PERFORMANCE AND COSTS [1] **– ■ Energy Use –** In the oil and gas production processes, energy input is needed for: a) driving pumps and compressors for producing hydrocarbons and associated water, if any, as well as for re-injecting water and gases into wells, and moving oil and gas through pipelines; b) heating oil for separation processes; c) producing steam for enhanced oil recovery, if any; d) driving turbines to generate electricity for equipment, facilities and living quarters. The energy is often obtained from locally produced natural gas burned in gas turbines (e.g. offshore platforms) or delivered by external suppliers. Table 5 shows the energy consumption per unit of production in various world regions. In 2006, North America recorded the highest energy consumption (i.e. 2.36 GJ per ton oil equivalent, toe) and Africa was the smallest one (0.93 GJ/ toe [8)]. ■ **Energy Losses –** Energy losses in primary oil and gas production are mainly due to gas flaring and venting. Flaring occurs when natural gas is produced in association with oil and there is no market or infrastructure to sell or/and use it. Venting and flaring of natural gas also occur during start-up, shut-down and off- design operations of primary production facilities. The World Bank Global Gas Flaring Reduction Initiative estimates that 150 bm^3 of gas were flared or vented in 2005 [10]. Table 6 summarises statistical data for natural gas flaring. The OPEC Annual Statistical Bulletin provides data for the OPEC countries while the United Nations database is used for non-OPEC countries. Statistics combine vented and flared gas. The ratio between flared and vented gas depends on field characteristics and on the operation regime. In Nigeria, the country with the largest amount of flared and vented gas, flaring and venting have been reduced from 27 bm^3 in 1993 to 22 bm^3 in 2007, while natural gas production

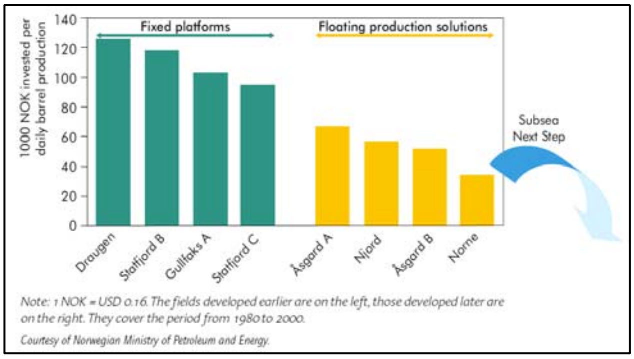

Fig. 1 – Impact of new offshore technology on oil production investment costs in the Norwegian North Sea, [3]

Table 3 – Recovery rate for selected Norwegian fields, [3]

Recovery rate (%)	1986	1993	1996	2001
Statfjord	49	59	61	68
Gullfaks	47	46	49	62
Heidrun	-	27	31	48

Table 4 – New oil and gas projects 2008 - 2015, [14]

Project	Country	Start	Oil 10^3b/d	Gas $10^6m^3/y$	Cost US\$B
Kashagan1	Kazakhstan	2014	370		29
Kashagan2	Kazakhstan	2015	450		25
Sakhalin2 expl.	Russia	2008	220		20
Khurais expl.	S. Arabia	2009	1200	4341	11
Tengiz3 expl.	Kazakhstan	2013	260		9.5
Shtokman2	Russia	2015	0	50000	25
Shtokman1	Russia	2014	0	22490	15
Natuna D	Indonesia	2015	0	10306	15
D1&D3Block	India	2008	0	14470	8.84
MA1 Field	India	2008	40	3617	8.84

Table 5 – Energy input per unit of production (GJ/toe), [8]

	AFR	Austrasia	EU	FSU	ME	N.AM	S.AM	Tot
2006	0.9	1.9	1.1	1.2	1.3	2.4	1.7	1.5
2005	0.8	1.5	1.0	1.2	1.3	2.3	1.7	1.4
2004	0.8	1.6	1.0	0.8	1.3	2.1	1.6	1.4

Table 6 – Flared and vented natural gas (10^6 m^3) [10,11,12]

	1995	2005	2007		1995	2005	2007
Algeria	8099	2996	4675	India	1756	901	
Lybia	1700	2504	2909	Indonesia	5000	3657	2765
Nigeria	26986	23000	22000	US	8258	3463	
Iran	1106	15695	11700	Canada	24242	1939	
Iraq		6621	50	Brazil	1241	2567	
Kuwait		250	500	Mexico	1991	1733	
Oman		1900	369	Venezuela	3570	7077	7184
Qatar		4200		Russia		14700	
S. Arabia		200	240	Kazakhstan		2700	5300
UAE		970	360	Norway	8858	474	
Total (2005) 150,000 10^6 m^3							

[1] Performance, emissions and costs for primary oil and gas production facilities are given in annual reports of the oil companies. These reports often include all the activities of the oil companies and do not separate data by field, type of facility or by country. Production data by region, are provided by the International Association for Oil and Gas Producers (OGP) [8] and the Financial Reporting System (FRS, [4]) of the US Energy Information Administration (EIA). The OGP Association consists of 31 member companies working in 60 countries worldwide. OGP members publish their emissions data in the annual report on *Environmental Performance in the E&P Industry*. In 2006, the report included data relevant to about 33% of global oil and natural gas production. The regional coverage is uneven, ranging from 100% of the production in Europe to 17% of known production in the Middle East and 5% in the Former Soviet Union. Global averages are calculated using data from all regions, including those from the FSU and the Middle East. The FRS by the US EIA was established in 1977 with the goal of implementing a financial and operating data reporting program on major energy-producing companies. The FRS basically includes US owned companies. However, major non-US companies like BP and Shell also report to FRS. In 2005, some 29 companies provided data to the FRS. Information, data and analysis are aggregated to a regional level and published annually in the *Performance Profiles of Major Energy Producers* report.

has increased from 5 bm^3 to 35 bm^3. Policy and research efforts are being made worldwide to reduce flaring of natural gas (for example, the Algerian Government has announced banning natural gas flaring after 2010) [9]. Figure 2 shows the percentage of vented gas over the total vented and flared gas in the United Kingdom from 1980 to 2004 for offshore and onshore production facilities. ■ **Emissions** – Emissions from primary oil and gas production facilities are provided annually by the International Association of Oil & Gas Producers (OGP) in the report *Environmental Performance in the E&P industry*. **CO_2 emissions** are the largest gaseous emissions from the oil and gas industry. They come from the flaring and combustion process and depend on the fuel used to supply energy to the production process. Around 96% of the total CO_2 emissions comes from treatment processes and activities while drilling accounts for only some 3% of total CO_2 [8]. Table 7 shows CO_2, CH_4 and NO_x emissions per unit of production from 2004 to 2006 for several world regions. After CO_2, **CH_4 emissions** are the largest gaseous release in oil and gas production. They come mainly from venting and from incomplete combustion of hydrocarbons. CH_4 has approximately 20 times higher global warming potential compared to CO_2. The largest portion of methane emissions (98%) is from treatment processes, including flaring and venting. Terminal and drilling activities are only responsible for the remaining 2% of total CH_4 emissions. **NO_x Emissions** are mainly nitric oxide and nitrogen dioxide, both referred to as NO_x - occurring from combustion of hydrocarbons. The emission of NO_x depends on the combustion temperature, on operation regime and combustion devices. Around 76% of the NO_x emissions come from treatments and processes (incl. flaring and venting). Drilling accounts for 23% of the NO_x emissions [8].

■ **Costs** – Wells and surface facilities account for the largest cost share in oil and gas production. The Financial Reporting System (FRS) Companies provide production (lifting) and exploration (finding) costs by region. Oil and natural gas are often produced together and single production cost is not necessarily made available. Therefore, costs are usually given per barrel of oil equivalent (boe, equal to about 6.1 GJ). The cost definitions are provided by [4]. **Production (lifting) cost** is the cost of operating and maintaining wells and related equipment and facilities per boe of oil and gas produced, after the hydrocarbons have been found, acquired and developed for production. **Exploration (finding) cost** is the cost of adding proved reserves of oil and natural gas through exploration and development activities and purchase of properties that might contain reserves. Ideally, finding costs would include all costs incurred in finding any particular proved reserves excluding the purchase of already discovered reserves. In practice, finding costs are actually measured as the ratio of exploration and development expenditure to proved reserve additions over

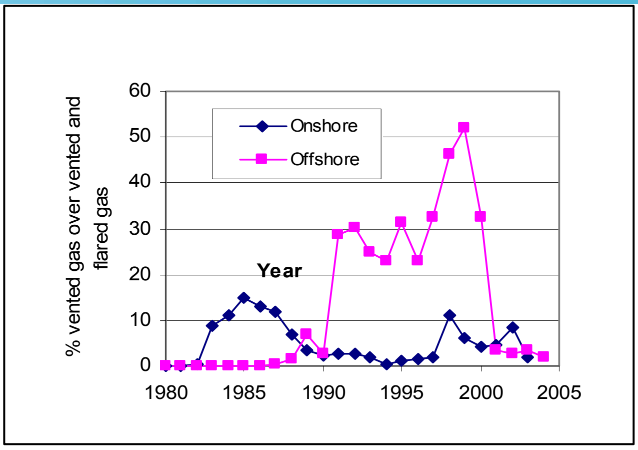

Fig. 2 – Vented natural gas (%) over vented & flared total in the UK from 1980-2004, off-/onshore, [13]

Table 7 – Emissions per unit of output (t/1000 t), [8]

	Afr	Aus/ Asia	EU	FSU	ME	N. Am	S. Am	Tot
2004								
CO_2	313	133	65	141	95	127	118	138
CH_4	1.9	2.2	0.2	0.8	0.5	1.1	1.6	1.1
NOx	0.4	0.3	0.2	0.3	0.2	0.5	0.7	0.4
2005								
CO_2	274	134	65	139	97	113	109	132
CH_4	1.7	1.9	0.2	1.0	0.5	1.1	1.7	1.1
NOx	0.4	0.3	0.2	0.3	0.2	0.5	0.5	0.3
2006								
CO_2	262	153	70	132	83	150	134	142
CH_4	1.5	1.4	0.3	0.8	0.4	1.5	1.4	1.0
NOx	0.4	0.4	0.2	0.3	0.2	0.6	0.7	0.4

Table 8 – Lifting cost by region (2006 US$/boe)

Region	2005	2006	Change,%
US	5.56	6.83	22.8
Canada	7.2	8.29	15.1
Europe	5.89	6.34	7.6
FSU	5.38	4.09	-24
Africa	4.22	4.1	-2.7
MEt	4.96	4.59	-7.5
OEH	3.86	4.32	11.8
OWH	3.27	3.21	-1.9
Total	**5.29**	**5.96**	**12.6**

1000 cubic feet of nat. gas = 0.178 oil barrels.

Table 9 – Exploration costs by region, 2005-2006, [4]

Region	2003-2005	2004-2006	% Change
US			
• Onshore	7.05	11.34	60.9
• Offshore	45.76	63.71	39.2
Canada	17.43	19.39	11.2
Europe	10.26	22.79	122.1
FSU	13.74	NM	NM
Africa	16.19	25.66	58.5
ME	4.95	5.26	6.3
OEH	9.5	12.59	32.6
OWH	26.56	42.59	60.4
Total	**11.38**	**17.23**	**51.3**

Notes: NM = Not meaningful.
OEH, Other Eastern Hemisphere: primarily Asia Pacific region
OWH, Other Western Hemisphere: Central and S. America, Caribbean

a specified period of time (excl. net purchases of proved reserves). ■ **Production (Lifting) Costs** – Table 8 shows the lifting costs by region for the FRS companies in 2005 and 2006. The lifting cost does not include production taxes, but the FRS does also give an overview of the production taxes in its regions. The United States shows the highest increase in lifting costs from 2005 to 2006 while Canada has the highest level of production costs at US$

8.3/boe in 2006. Three regions, i.e. the Former Soviet Union, the Middle East and Africa, have declining lifting costs resulting from an increase in production and economy of scale. Figure 3 shows the lifting cost from 1981 to 2006 for FRS companies, in US companies (domestic) and foreign companies (foreign). From 2000 to 2006 the lifting costs in the Unites States increased by 92% while in the rest of the world they increased by 42%.

■ **Exploration (Finding) Costs** – Table 9 shows the finding costs for the FRS companies in 2003-2005 and in 2004-2006. Finding costs are often calculated as a weighted average over three years. All regions show increasing finding costs from 2003-2005 and 2004-2006. The regions with the largest increase are Europe, the US onshore, Other Western Hemisphere (OWH) and Africa. In the period 2004-2006, only the Middle East had a finding cost below US$ 10/boe (i.e. US$ 5.3/boe). The largest finding cost is found in the United States (offshore) at US$ 63.7/boe. Figure 4 shows the average finding costs and the proven oil reserves in selected countries in the Middle East and North Africa. The low cost in Iraq reflects the potential for rehabilitating existing fields and the costs of the development of new fields are closer to the costs of Iran [4]. Finding costs have increased in all regions in the current decade. Figure 5 shows the finding cost for the FRS companies by region in 1999-2001 and in 2004-2006. The OWH region has the largest proportional increase from 1999-2001 and 2004-2005, the main influencing factor being a fall in reserve additions from natural gas field extensions and new discoveries [4]. In Africa and Europe, the main reason for the cost increase is the increasing development expenditures [4].

■ **Decommissioning Cost (Offshore Facilities)** – Offshore oil production accounts for 30% of the total oil production and 50% of the total natural gas production worldwide [5]. The lifetime of an oil rig is about 20 years [6]. At the end of its life, unless it is re-used or re-developed, the rig must be decommissioned. A challenge for decommissioning is that there is no standard method because of the wide variety of oil and gas offshore structures and equipment. The United Kingdom has 470 offshore installations. Some 10% of them are floating, 30% are sub-sea, 50% are small steel or concrete structures and 10% are large structures. It is estimated that the cost of 90% decommissioning of the UK structures will range between 10 and 20 billion pounds [6]. Fernandez et. al have compared three decommissioning alternatives for California Outer Continental Shelf (OCS) oil and gas platforms [7]. The first alternative would be to leave the platform in place. This implies that all the equipment related to the oil extraction is removed while the other parts of the platform remain. The second alternative would be to completely remove the platform and materials from the ocean. The third option would be to partially remove the oil platform, with material disposal either offshore or onshore. Table 10 shows the costs for the three decommissioning alternatives for the California OCS platforms.

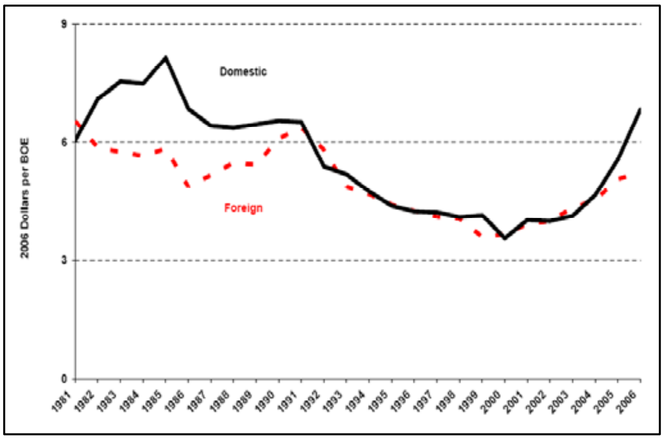

Fig. 3 - Lifting cost for FRS companies 1981- 2006, [4]-
(Domestic = US; Foreign = Rest of the World,)

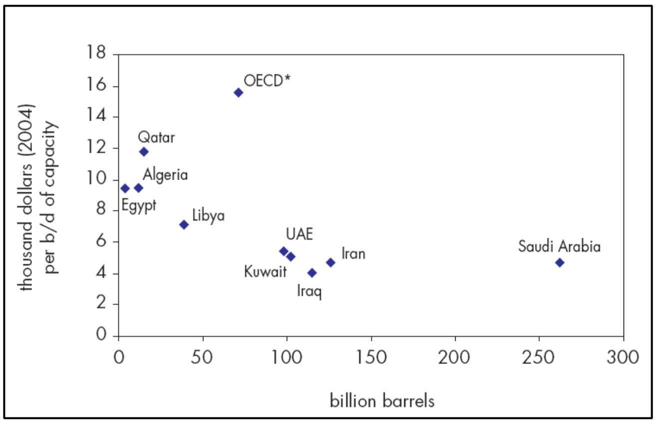

Fig. 4 – Av. exploration and proven oil reserves, [4]

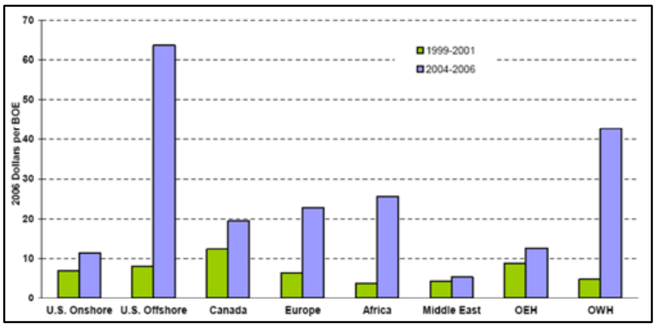

Fig. 5 – Exploration cost by region, 1991–2001 & 2004-2005, [4]

Table 10 - Decommissioning Costs, [7]

Decommissioning options	Cost (2001 US$, million)
Leave in place	2.1 – 18.6
Complete Removal	8.5 – 106.4
Partial Removal	5.9 - 90.4

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Table 11 – Summary Table: Key Data and Figures for Conventional Oil & Gas Production Technologies

Technical Performance		
Energy Consumption	**Oil**	**Natural Gas**
Energy input	Local produced natural gas or other external supplies (electricity, nat. gas, oil ...)	
Output		
Energy consumption (GJ per toe), 2005	From 0.8 (Africa) to 2.3 (North America); 1.4 global average	
Losses (billion m^3 nat. gas)		
Flared and vented natural gas, 2005	150 worldwide; 23 Nigeria, 16 Iran, 15 Russia	
Per produced billion barrel of oil, 2005	Min. 0.4 (Norway); Max: 24.4 (Nigeria); 5.1 global average	
Recovery factor (%)		
Typical	30 – 50 (enhanced recovery for values > 40)	70 – 80
Life time, oil and natural gas rig	20 years	
Platform type	50 % offshore and 50 % onshore	30 % offshore and 70 % onshore
Min. production capacity, 2005	81 mb/d	2763 billion m^3,
Emissions (ton per 1000 toe)		
CO_2 emissions, 2005	From 64.9 (Europe) to 273.57 (Africa); 132.3 global average	
CH_4 emissions, 2005	From 0.2 (Europe) to 1.9 (Australasia); 1.1 global average	
NO_x emissions, 2005	From 0.16 (Middle East) to 0.46 (North America); 0.32 global average	
Costs (US$2005)		
Production costs, 2005 (per boe)	From 3.3 (OWH) to 7.2 (Canada); 5.3 global average	
Production costs, 2006 (per boe)	From 3.2 (OWH) to 8.3 (Canada); 6.0 global average	
Exp. & develop. cost, 2005 (per boe)	From 5.3 (Middle East) to 63.7 (US offshore); 17.2 global average	
Decommissioning cost	Dependent on type of installation and decommissioning	
Decommissioning cost, OCS offshore	From 2 mill. (leave in place) to 106 mill. (complete removal)	

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