Oil and Gas Prospects

EIA Energy Outlook

Gard Global Group

Discussion Agenda

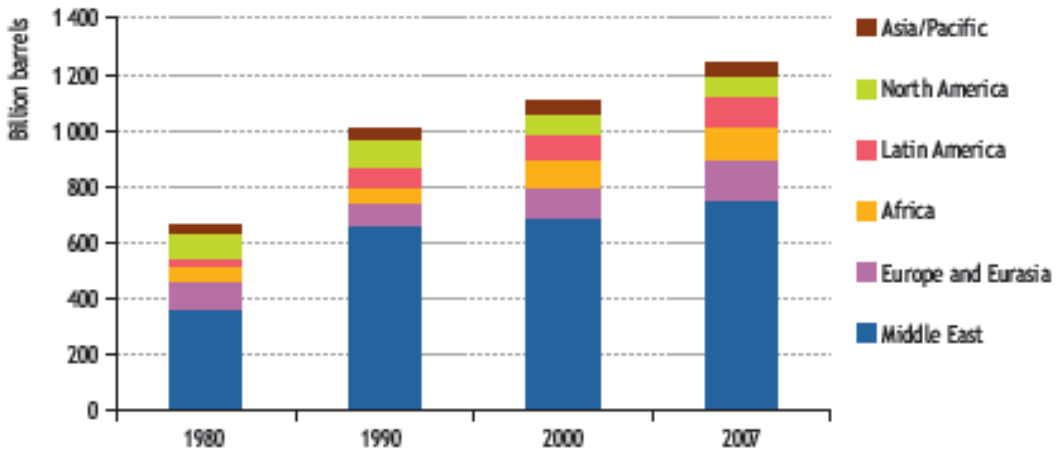
- How much oil is left?
- Is oilfield decline accelerating?
- In oil production are we running faster to stand still?
- Who will supply the world's demand for natural gas?
- Are we investing enough in the upstream industry?
- Between national and international oil companies, who will do what?
- Could Sub-Saharan oil and gas resources alleviate energy poverty?

How much Oil is Left?

- Reserves have doubled since 1980, largely from revisions of reserves already owned
- Volume discovered has fallen below volume produced in the last two decades
- Volume found since 2000 has exceeded the rate in the 1990s due to increased technologies and higher oil prices
- Recoverable conventional sources – (proven and probably reserves from discovered fields, reserves growth and economically discoverable oil yet to be found) amounts to 3.5 trillion barrels.
- Non conventional oil reserves are estimated at 6 trillion barrels of which 1 to 2 trillion is recoverable economically.

Proven oil reserves (90% probability of profitable recovery) have been growing

Figure 9.3 • Proven remaining oil reserves by region, 1980-2007 (end-year)



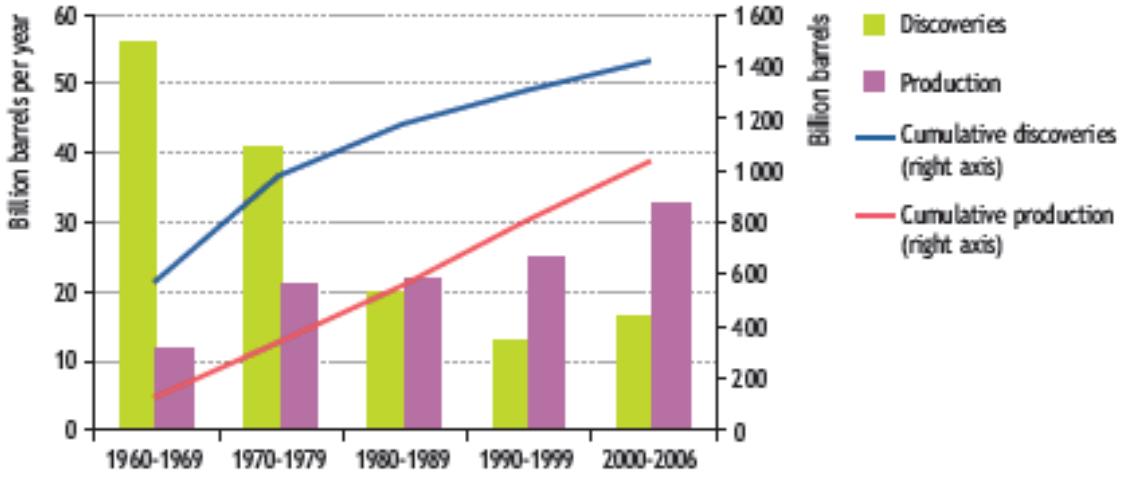
Source: BP (2008).

- The global reserves-to-production ratio (R/P), based on current levels of production, is in the range of 40 to 45 years, depending on the source and whether non-conventional resources are included.

- Overall, 71% of the total additions to reserves came from reserves growth and only 29% from discoveries. In all areas except for sub-Saharan Africa and Asia-Pacific, reserves growth outpaced discoveries.

Discoveries are well below production levels

Figure 9.4 • Oil discoveries* and production, 1960-2006

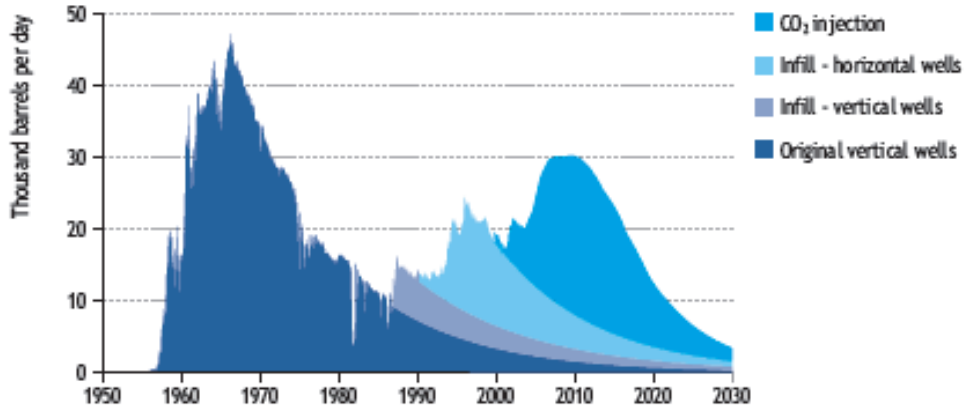


* Additions to proven reserves from new fields.
Sources: IHS and IEA databases.

- Fall in discoveries is largely in the Middle East and former USSR
- Discoveries are high in Africa, Latin America and Asia

Reserves growth is driven by technology, geology and definitional factors

Figure 9.8 • *A case study of oil reserves growth: the impact of technology on oil production from the Weyburn field in Canada*



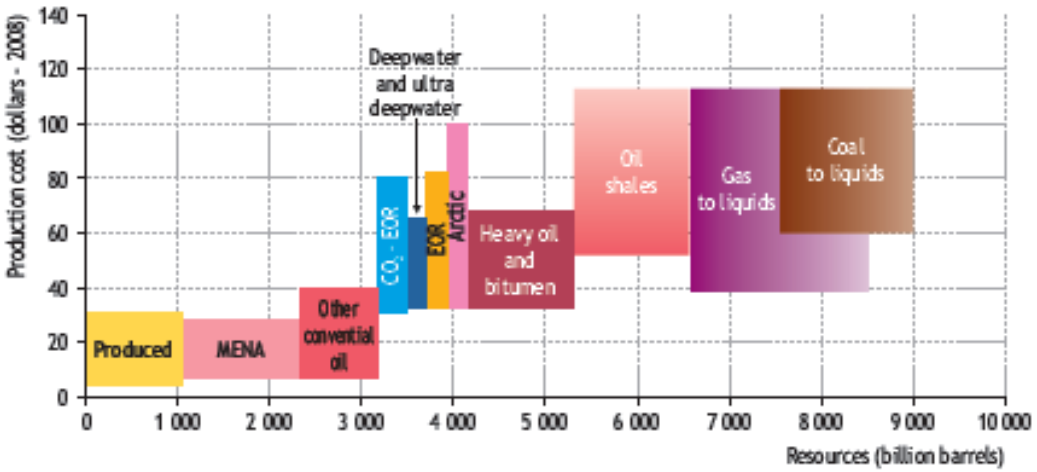
Source: PTRC Weyburn-Midale website (www.ptrc.ca).

- It will probably take much more than two decades for the average recovery factor worldwide to be raised from about 35% today to 50%.

- Achieving this would boost world reserves by about 1.2 trillion barrels — equal to the whole of today's proven reserves

Overall 9trillion barrels of oil is “available” at different costs of production

Figure 9.10 • Long-term oil-supply cost curve



- MENA – Middle East and North Africa

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Is the decline accelerating?

- The future rate of decline in output from producing oilfields as they mature is a critical determinant of the amount of new capacity and investment that will be needed globally to meet projected demand.

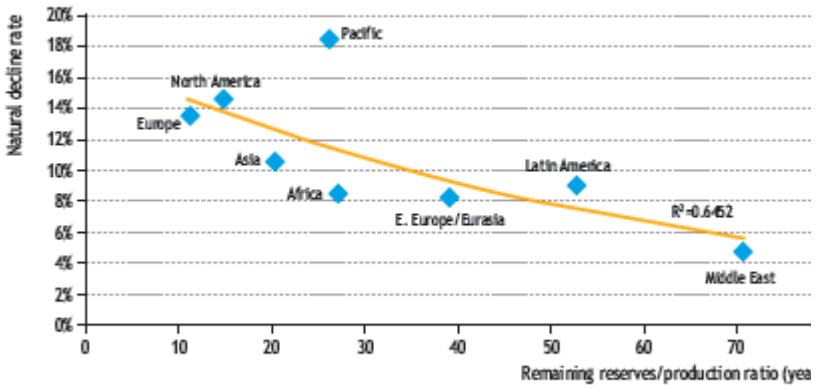
- The average rate of observed post-plateau decline, based on our data sub-set of 479 [of 800] fields, is 5.8%.

- The average annual *natural*, or underlying, decline rate for the world as a whole stripping out the effects of ongoing and periodic investment — is estimated at 9% for post-peak fields.

- Our Reference Scenario projections imply a one percentage-point increase in the global average natural decline rate to over 10% per year by 2030 as all regions experience a drop in average field size and most see a shift in production to offshore fields.

Natural decline rates are lower for larger reserves, and are expected to increase across board

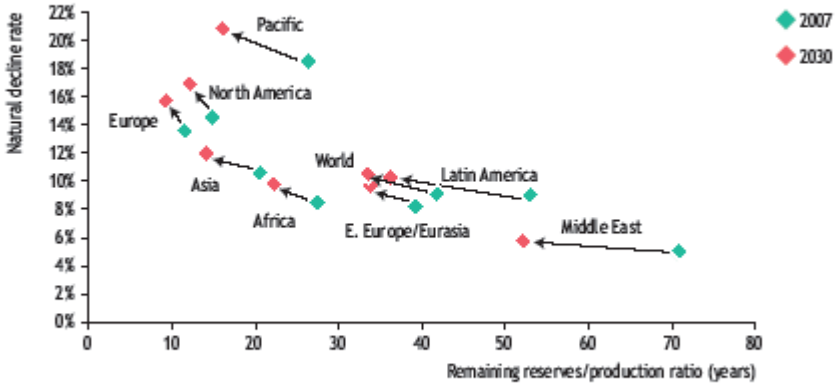
Figure 10.11 • Natural decline rates and reserves-to-production ratios by region, 2007



Note: Natural decline rates are production-weighted.

Sources: IHS databases; IEA databases and analysis.

Figure 10.12 • Projected change in natural decline rates and reserves-to-production ratios by region, 2007 to 2030



Note: Natural decline rates are production-weighted.

Sources: IHS databases; IEA databases and analysis.

- Future supply is far more sensitive to decline rates than to the rate of growth in oil demand.
- The field-by-field study involved building a large database containing the full production history and a range of technical parameters for around 800 of the largest individual oilfields in the world.

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In oil production are we running faster to stand still?

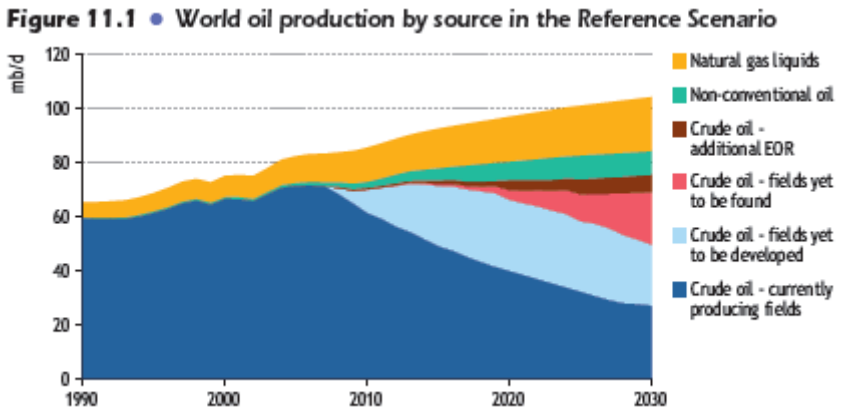
- In the Reference Scenario, world oil production (not including processing gains) rises by 26%, from 82.3 mb/d in 2007 to 103.8 mb/d in 2030. The share of OPEC countries in global output increases from 44% in 2007 to 51% in 2030. Saudi Arabia remains the world's largest producer throughout the projection period, its output climbing from 10.2 mb/d to 15.6 mb/d.

- Worldwide, conventional crude oil production increases only modestly between 2007 and 2030 — by 5 mb/d — as almost all the additional capacity from new oilfields is offset by the decline in output at existing fields. Output from known oilfields that are already being developed or are awaiting development expands through to 2020, but then begins to drop, as few such fields are left to be brought into production and many of them enter their decline phase. Fields that are yet to be found account for about a quarter of total crude oil production by 2030.

- The bulk of the net increase in total oil production comes from natural gas liquids (NGLs), driven by the relatively rapid expansion in gas supply, and from nonconventional resources and technologies. Enhanced oil recovery, predominately from CO2 injection, makes a growing contribution.

- Non-OPEC production of crude oil and NGLs declines from 44.8 mb/d in 2007 to 43.5 mb/d in 2015 and then falls further to 42.9 mb/d in 2030 in the Reference Scenario. Non-OPEC non-conventional oil production, in contrast, rises from 1.5 mb/d in 2007 to 7.9 mb/d in 2030.

Production from current reserves is going to decrease significantly



- Non-conventional oil production is bound to increase
- New reserves need to be found

EOR is bound to increase, and more production is going to come from oil sands

Figure 11.10 • Enhanced oil recovery by country in the Reference Scenario

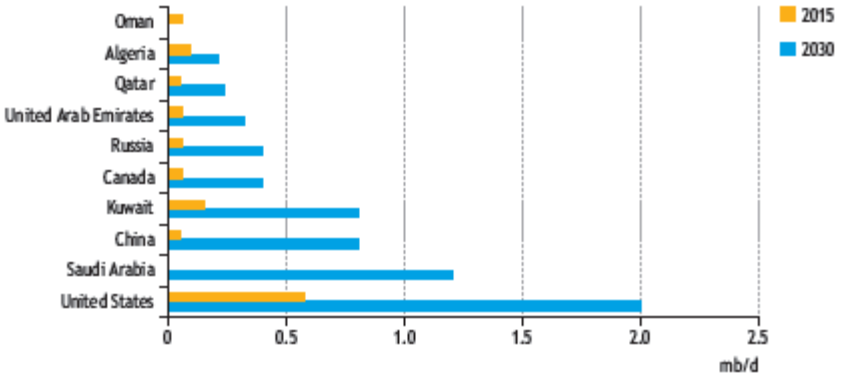
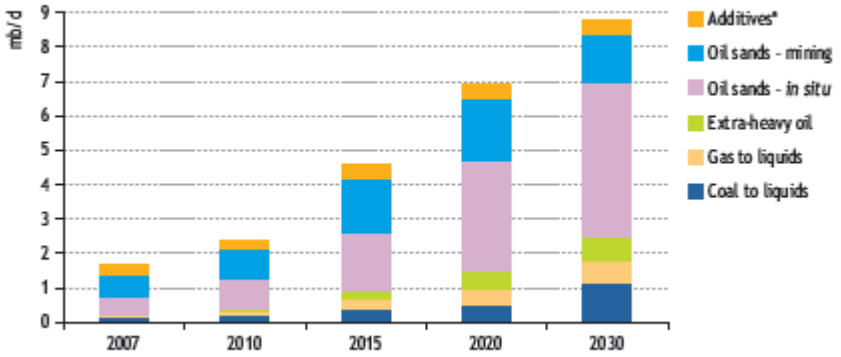


Figure 11.12 • World non-conventional oil production by type in the Reference Scenario



*Methyl tertiary butyl ether (MTBE) and other chemicals.

- *In situ* technologies are currently used for highly viscous oils: they include cyclic steam stimulation injection (CSS) and steam-assisted gravity drainage (SAGD). Technologies being developed include a vapour extraction process, which uses hydrocarbon solvents instead of steam to increase oil mobility, the use of downhole heaters and hybrid methods.

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Who will supply the world's growing demand for natural gas?

- Global proven reserves of natural gas at the end of 2007 stood at close to 180 trillion cubic metres — equal to around 60 years of current production. Like oil, gas resources are highly concentrated in a small number of countries and fields.

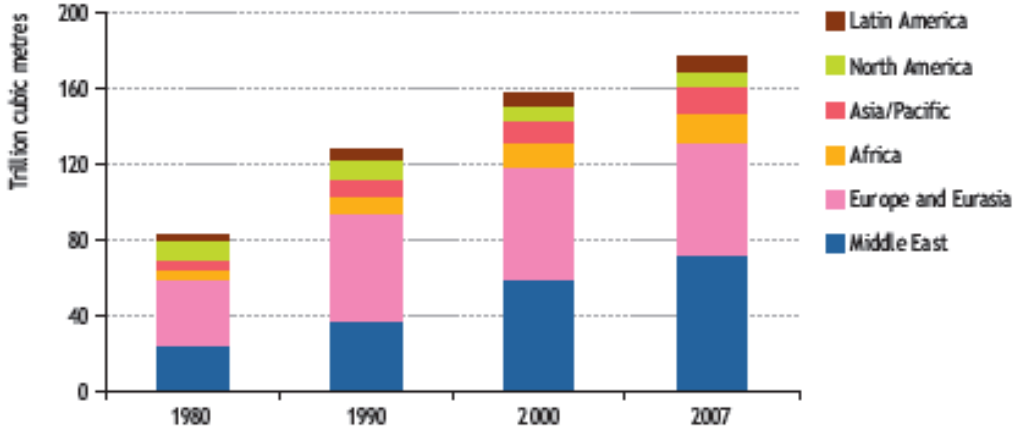
- These reserves have more than doubled since 1980, with the biggest increases coming from the Middle East. The bulk of the increase in reserves in recent years has come from upward revisions for fields that have been producing or have been undergoing appraisal and development work.

- Outlook for production by region depends largely on the proximity of reserves to markets, which primarily determines the cost of supply. Much of the world's gas resources is located far from the main markets, so that only a small proportion of the economic potential has yet been exploited.

- World natural gas production is projected to rise from just over 3 tcm in 2007 to 4.4 tcm in 2030. Production expands in all major regions, with the exception of OECD Europe, where production is already in decline, and in OECD North America, where output begins to dip in the second half of the *Outlook* period.

Conventional proven natural gas reserves are equivalent to 60 years of production

Figure 12.1 • Proven reserves of natural gas

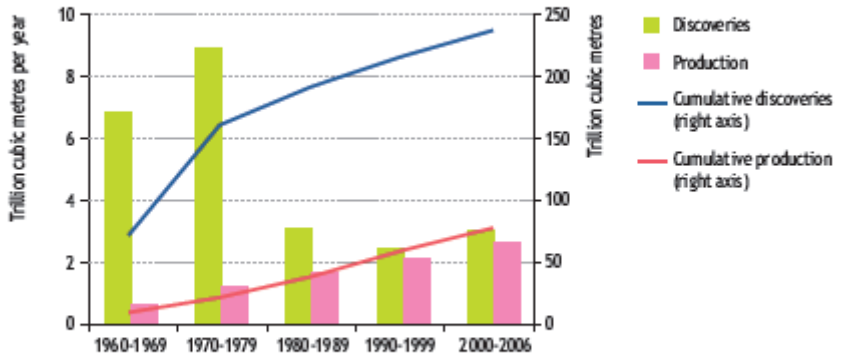


Source: BP (2008).

- Bulk of the increase comes from upward revision of current reserves
- The USGS estimates remaining ultimately recoverable resources of conventional natural gas, including proven reserves, reserves growth and undiscovered resources, at 436 tcm. Cumulative production to 2007 amounts to 13% of total initial resources
- Non-conventional gas resources — including coalbed methane, tight gas sands and gas shales — are much larger, amounting perhaps to over 900 tcm, with 25% in the United States and Canada combined.

Worldwide, natural gas discoveries still outweigh production

Figure 12.3 • Natural gas discoveries* and cumulative production, 1960-2006



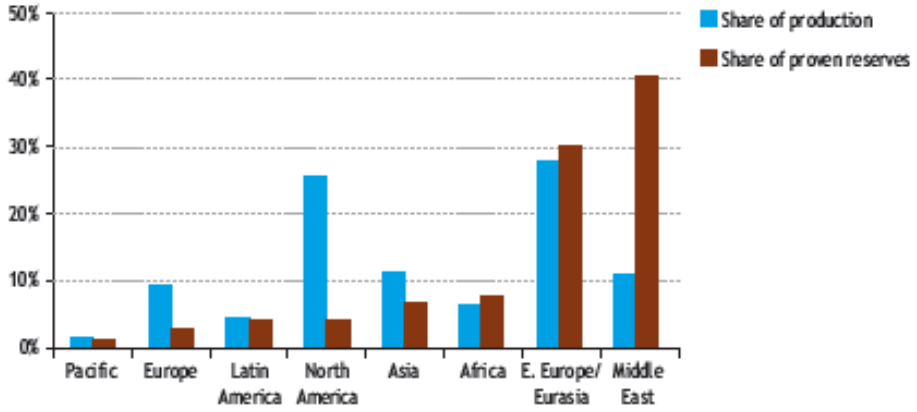
* Additions to proven reserves from new fields.

Sources: IHS and IEA databases.

- Recovery rates are much higher (30 to 100%) compared to oil (35 to 50%)

Due to proximity to market, the US proportionally produces more natural gas

Figure 12.2 • Regional share in natural gas production and proven reserves, 2007

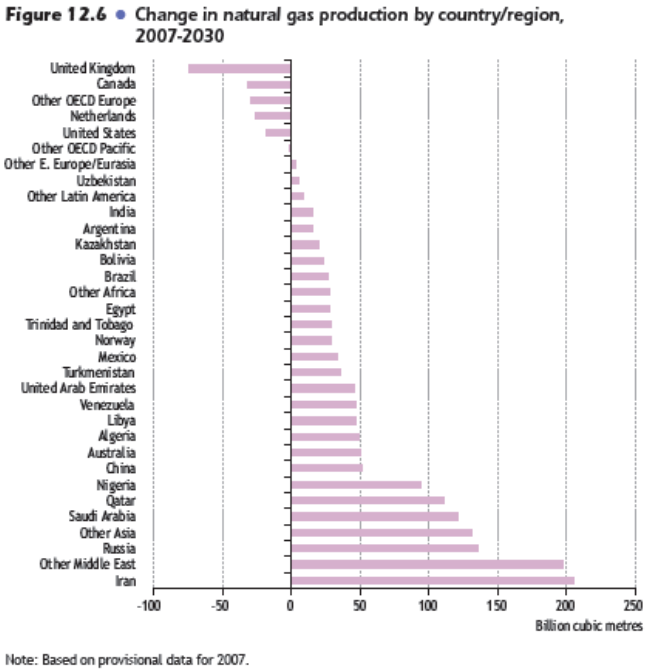


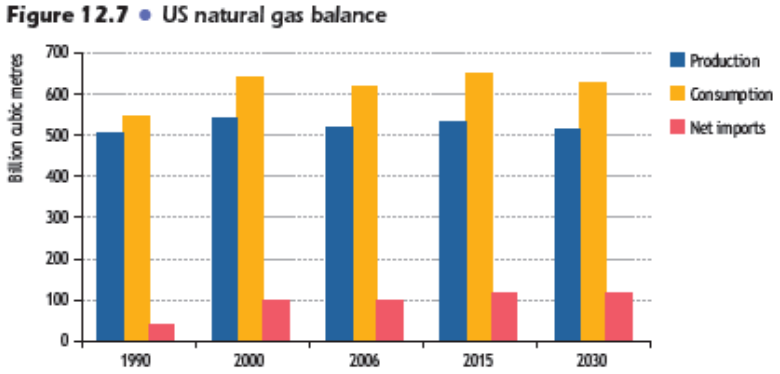
Note: 2007 data are provisional for the OECD and are estimates for the non-OECD countries.

Sources: Reserves - Cedigaz (2008); production - IEA databases.

- Transport is the largest cost component of natural gas
- US Energy Information Administration projects that the share of gas production from non-conventional resources in total domestic production will increase from 40% in 2004 to 50% in 2030, with this gas making up 28% of the US natural gas supply increase between 2004 and 2030

1P natural gas production is decreasing where it's most needed





- US reserves have been growing to 6tcm the last 10 years. Covers production for 11 years.
- Rising cost and dwindling output results in decrease in US production.
- The US is likely to import LNG from Mexico

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Are we investing enough in oil and gas exploration?

- Total upstream investment more than tripled between 2000 and 2007, from an estimated $120 billion to $390 billion. Most of this increase was due to higher unit costs: in cost-inflation adjusted terms, investment in 2007 was about 70% higher than in 2000.

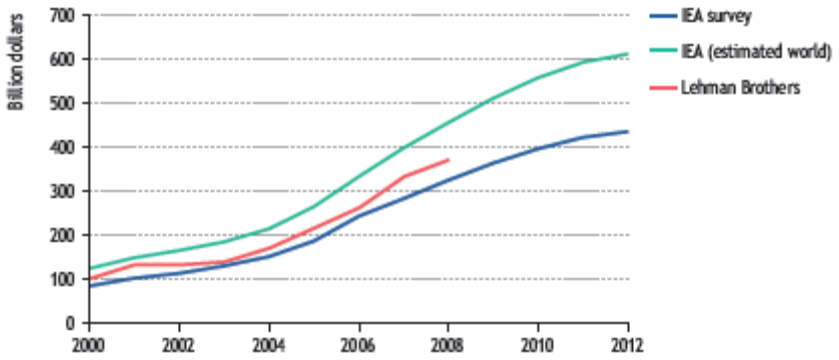
- The bulk of upstream investment will continue to be made by the international companies. Over the period 2000-2007, the five super-majors alone accounted for 29% of all the upstream investment made by the companies surveyed for this *Outlook* and other international and private upstream companies for a further 31%.

- Much of the increase in this upstream spending will go to meeting rising unit costs of developing dwindling resources in non-OPEC regions, where the bulk of their investment is directed.

- The Reference Scenario projections imply a need for cumulative investment in the upstream oil and gas sector of around $8.4 trillion (in year-2007 dollars) over 2007-2030, or $350 billion per year. That is significantly *less* than is currently being spent. But there is a major shift in where that investment is needed. Much more capital needs to go to the resource-rich regions, notably the Middle East, where unit costs are lowest.

Nominal investments are high, though real investments are not as high

Figure 13.1 • *World investment in oil and gas exploration and production*



Sources: IEA databases and analysis; Lehman Brothers (2007).

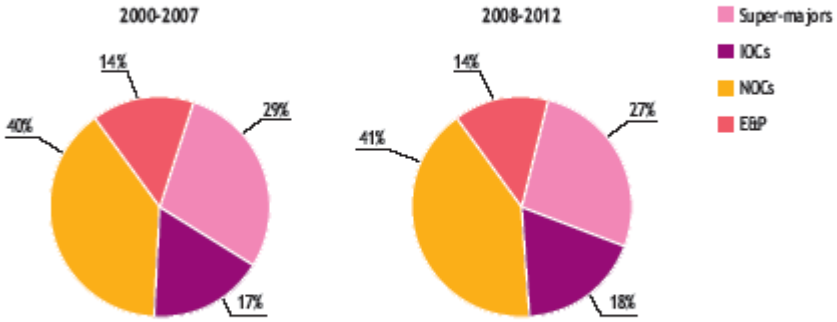
Figure 13.13 • *Year-on-year change in world upstream investment and dollar-cost inflation rate*

Source: IEA database and analysis.

- Although nominal upstream investment in dollar terms increased by about 220% between 2000 and 2007, we estimate that around two-thirds of this increase has been absorbed by cost inflation.
- The international price of steel has almost tripled since 2001, while the price of aluminum has doubled, driven by booming demand from China and other developing countries. The costs of hiring skilled personnel have also risen sharply.
- Costs will continue to swing in response to marginal imbalances in the supply of and demand for drilling services and equipment.

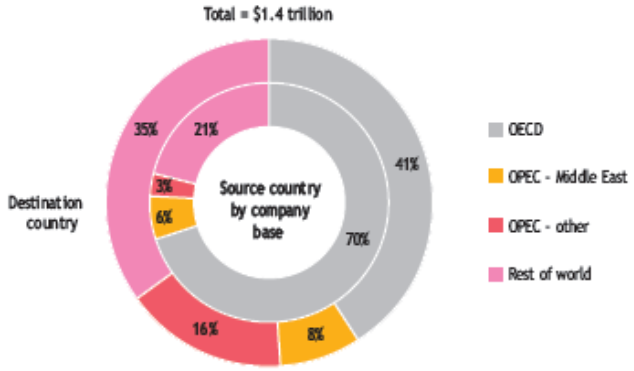
Investment are largely made by OECD private companies into OECD countries

Figure 13.2 • Upstream investment of surveyed companies by type of company



Note: For 50 surveyed companies. IOC = international oil company; NOC = national oil company. E&P = exploration and production; breakdown by type of company.
Source: IEA database and analysis.

Figure 13.5 • Investment in new upstream oil and gas projects, 2008-2015

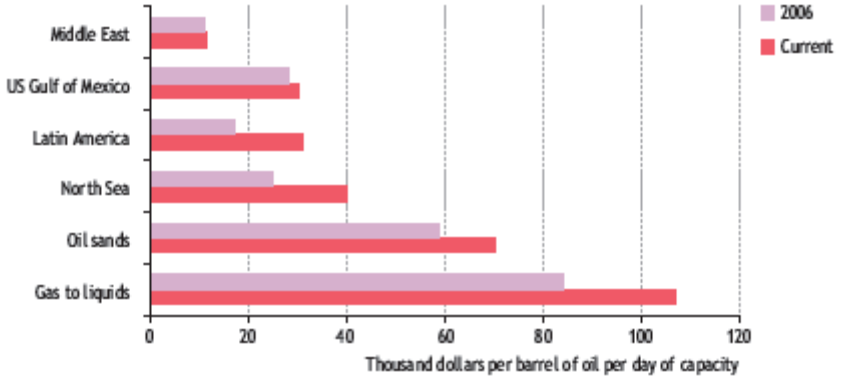


Note: Based on projects surveyed.
Source: IEA database and analysis.

- Private companies make most of the investments
- The share of total project investment made by the national oil companies of OPEC countries is very small, at only 9%, while those of Middle East OPEC countries account for 6%. This is because unit development costs in the Middle East are much lower than in most other regions.

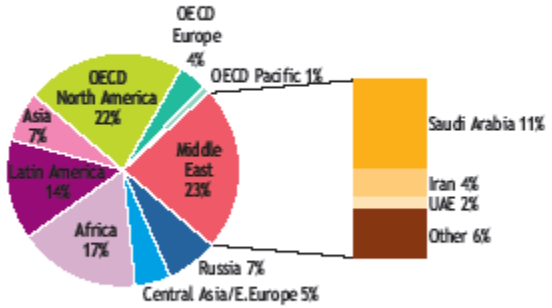
Upstream investment per produced barrel is much lower in the Middle East

Figure 13.10 • *Average capital cost of upstream projects under development*



Source: IEA database and analysis.

Figure 13.15 • *Gross peak-oil production capacity additions from current projects by region, 2008-2015*

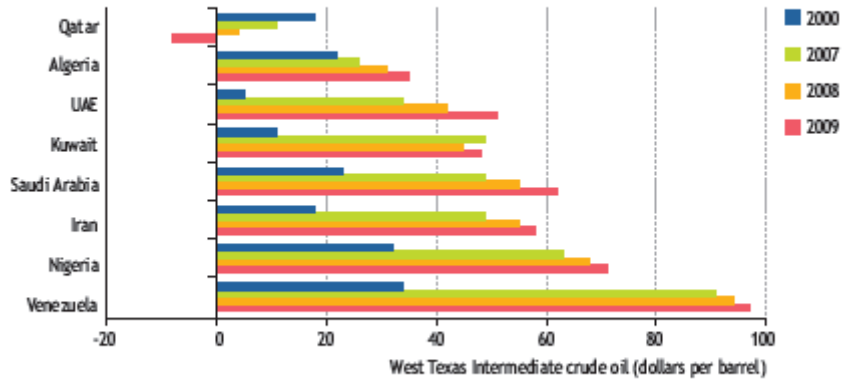


Source: IEA database and analysis.

- The increase in OECD/North America is largely to Canada oil sands, and US gulf of Mexico
- Even though spending by their national companies amounts to under 10% of the global total, the largest capacity additions come from Middle East countries, notably Saudi Arabia (3.10 mb/d), Iran (0.99 mb/d) and the UAE (0.43 mb/d).

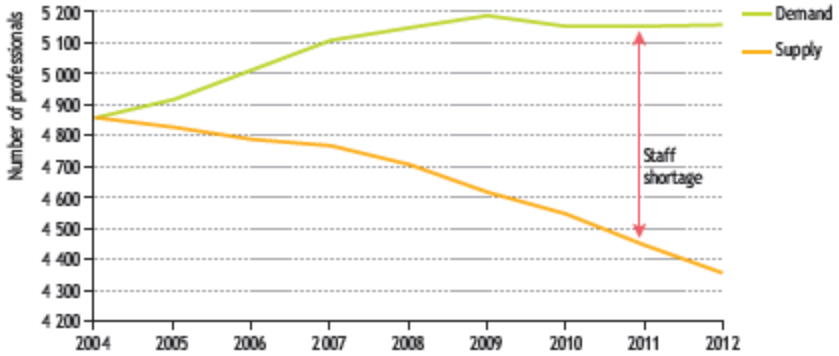
Some key barriers to more investment

Figure 13.18 • OPEC countries' external account price thresholds to balance the external account



Source: PFC (2008).

Figure 13.19 • Demand for and supply of mid-career petrotechnical professionals aged 30 to 39 in North America and Europe



Source: NPC (2007b).

- Political restriction on foreign companies participating in resource-rich countries in favor of national companies.
- Concern that over-investment in the upstream sector may lead to lower prices is also likely to temper capital spending.
- Availability of people

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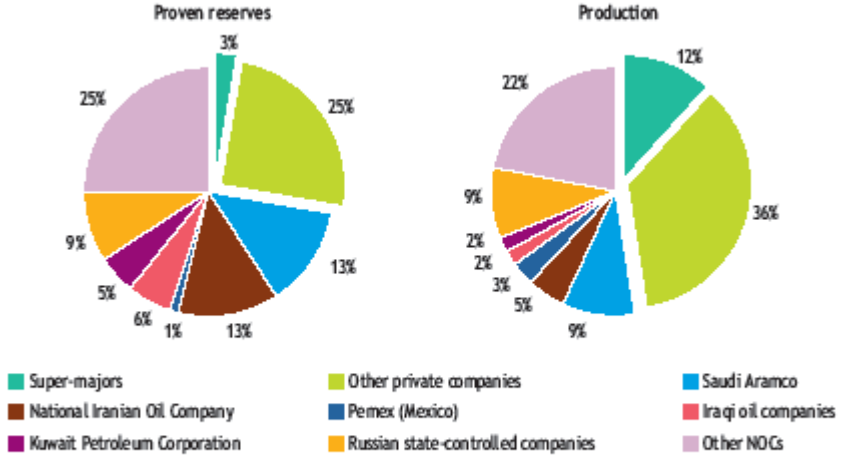
Who will do what?

- National oil companies control most reserves, but account for a much smaller share of current production.
- In most of the countries with the largest oil and gas reserves, national companies dominate the oil and gas industry; foreign companies are either not allowed to own and develop reserves, or are subject to restrictions.
- The international oil companies, which have traditionally dominated the global oil and gas industry, are increasingly being squeezed by the growing power of the national companies and by dwindling reserves and production in mature basins outside OPEC countries.
- The increasing dominance of national companies may make it less certain that the investment projected in this *Outlook* will actually be made. The long-term policies of the major resource-rich countries may favour slower depletion of their resources.
- Partnerships may help. The mutual benefits that could accrue are compelling: the national companies control most of the world's remaining reserves, but in some cases lack the technology, capital and/or skilled personnel to develop them efficiently; the international companies are opportunity-constrained, but have the finance and management skills, and technology to help national companies develop their reserves.

Super-major firms account for a disproportionate amount of oil and gas production

Figure 14.1 • World oil and gas reserves and production by company, 2007



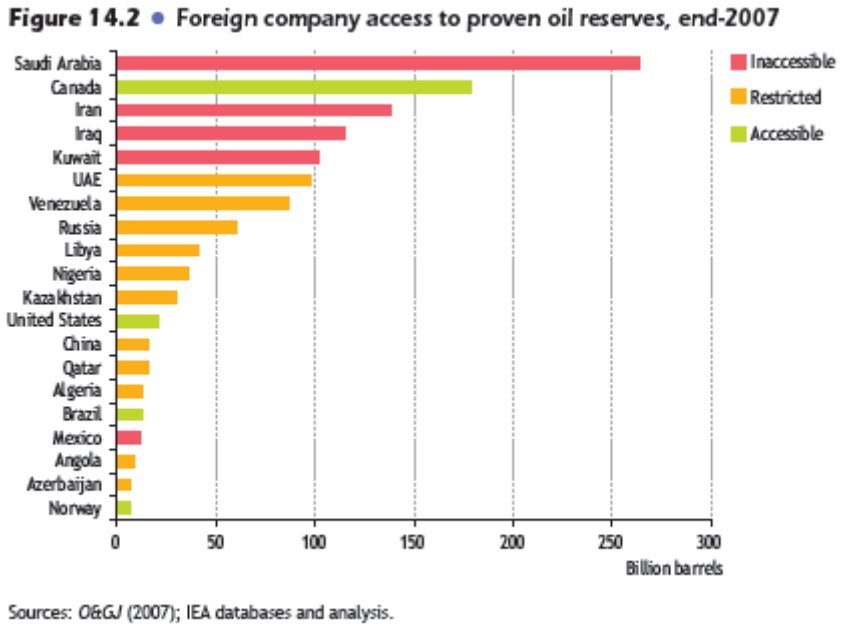
Note: Production shares are based on preliminary data for gas for 2007. The super-majors are ExxonMobil, Shell, BP, Total and Chevron.

Sources: *O&GJ* (2007); IEA databases and analysis.

- National oil companies currently account for 51% of world oil and gas production, the super-majors for 12%; other integrated international oil companies and wholly upstream companies account for the rest (Figure 14.1). The national companies' share of world proven reserves is much higher, at 71%.

- The national oil companies in the leading resource-holding countries are increasingly taking on the task of developing new fields themselves, often with the help of oilfield services companies.

Many countries impose restricted access on international companies



- In many countries, international oil companies only get access as subcontractors to national oil companies

Despite high profits, production has decreased at the five super-majors

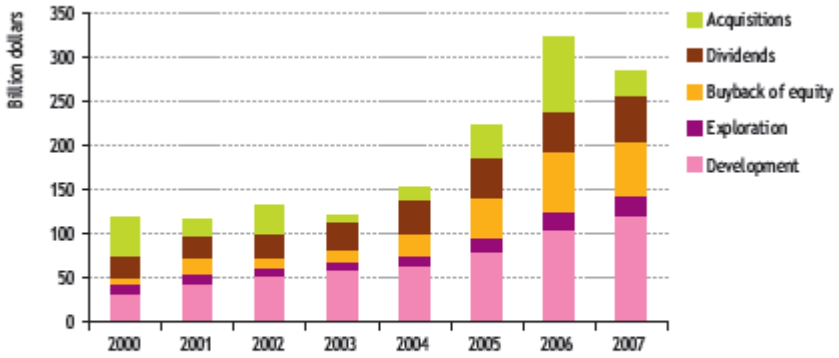
Figure 14.4 • Year-on-year increase in oil production of surveyed companies by type of company

Note: For 50 surveyed companies.
Sources: Company reports; IEA estimates.

- The five “super-majors” — ExxonMobil, Shell, BP, Total and Chevron — have seen a drop in their collective oil production in the last three years,

Proportionally less is spent on exploration due to short-term reporting & limited access to reserves

Figure 14.6 • International oil company outlays from operating cash-flow



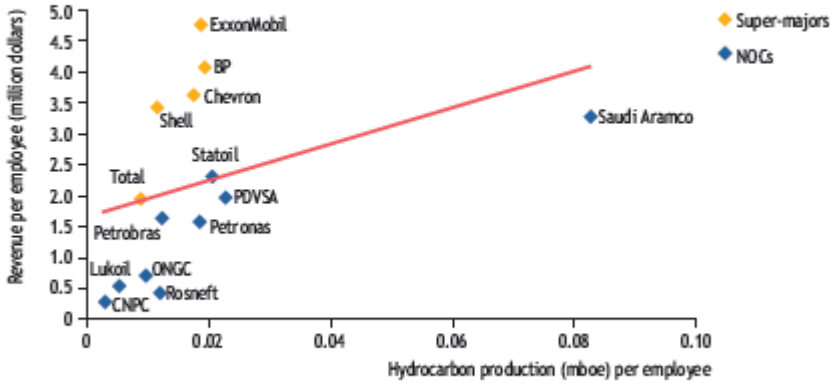
Note: Based on data for 20 companies, including the five super-majors plus Anadarko, Apache, BG, ConocoPhillips, CNR, Eni, Hess, Lukoil, Marathon, Nexen, Occidental, Petro-Canada, Repsol YPF, Talisman and Woodside.

Sources: Company reports.

- The lack of opportunities also results in low reserves replacement rates by international oil companies

Super majors tend to have more revenues and oil production per employee

Figure 14.10 ● Revenue and hydrocarbon production per employee by type of company, 2007



Sources: Company reports; IEA analysis.

- National Oil Companies are diverse. The most advanced, such as Norway's StatoilHydro, Brazil's Petrobras and Malaysia's Petronas, are comparable in size, efficiency, technological sophistication and management practices to the larger international companies.
- Saudi Aramco, which has invested heavily in training and research, is widely recognised as the most technically advanced of the Middle East national companies

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Could Sub-Saharan oil and gas resources alleviate energy poverty?

- Conventional oil production in the ten largest hydrocarbon-producing countries in sub-Saharan Africa reached 5.6 mb/d in 2007, of which 5.1 mb/d was exported. In the Reference Scenario, output grows to 7.4 mb/d in 2030 while exports climb to 6.4 mb/d in 2030

- The cumulative government take from oil and gas revenues is $4.1 trillion over 2006-2030. Nigeria and Angola remain the largest exporters, with combined cumulative revenues of about $3.5 trillion.

- In Sub-Saharan Africa, household access to modern energy services is very limited. Two thirds of households do not have access to electricity and three-quarters do not have access to clean fuels for cooking

- Tackling energy poverty is well within these countries' means. We estimate the capital cost of providing minimal energy services (electricity and liquefied petroleum gas stoves and cylinders) to these households over the *Outlook* period to be about $18 billion. This is roughly equivalent to only 0.4% of the governments' take from oil and gas exports over the *Outlook* period.

- An improvement in the efficiency of revenue allocation and the accountability of governments in the use of public funds would improve the likelihood of oil and gas revenues actually being used to alleviate poverty generally and energy poverty specifically.

Sub-Saharan African countries exported 5.1 mb/d (91% of total production) of oil in 2007

Table 15.1 • Production and reserves in assessed sub-Saharan African countries (ranked by oil reserves)

	Oil			Gas		
	Reserves (billion barrels)	Production (mb/d)	Exports (mb/d)	Reserves (bcm)	Production (bcm/yr)	Exports (bcm/yr)
Nigeria	36.2	2.35	2.03	5 207	29.3	18.9
Angola	9.0	1.70	1.64	270	0.8	-
Sudan	5.0	0.47	0.39	85	-	-
Gabon	2.0	0.23	0.22	28	0.1	-
Congo*	1.6	0.21	0.21	91	-	-
Chad	1.5	0.14	0.14	-	-	-
Equatorial Guinea	1.1	0.36	0.36	37	1.3	-**
Cameroon	0.2	0.09	0.06	135	-	-
Côte d'Ivoire	0.1	0.06	0.03	28	1.7	-
Mozambique	-	-	-	127	2.7	2.7
Total	56.8	5.61	5.09	6 008	35.9	21.6
% in world	*4.3%*	*7.0%*	*12.1%*	*3.4%*	*1.2%*	*5.2%*

* Also referred to as Congo-Brazzaville or the Republic of Congo.
** LNG exports commenced in 2007 from Equatorial Guinea.
Sources: Production and exports – IEA analysis; reserves – *O&GJ* (2007). For production, oil data is for 2007 and gas data is for 2006. All reserves data are for end-2007.

- Worldwide, these countries contribute 7% to global output of oil and 12% of oil trade. Gas exports from these countries represent about 5% of global gas trade. Exports of both oil and gas (in the form of liquefied natural gas, LNG) are set to grow rapidly.

Large chunks of the population do not have access to electricity

Table 15.2 • Number of people without access to electricity and relying on fuelwood and charcoal for cooking in assessed sub-Saharan African countries

	Total population, 2006 (million)	Number of people without electricity access* (million)	(%)	Number of people relying on fuelwood and charcoal for cooking* (million)	(%)
Angola	16.6	14.6	88	15.7	95
Cameroon	18.2	14.2	78	14.2	78
Chad	10.5	10.1	97	10.2	97
Congo	3.7	2.9	78	2.9	80
Côte d'Ivoire	18.9	11.6	61	14.7	78
Equatorial Guinea	0.5	0.4	73	0.3	59
Gabon	1.3	0.9	70	0.4	33
Mozambique	21	18.6	89	16.9	80
Nigeria	144.7	76.6	53	93.8	65
Sudan	37.7	26.9	71	35.2	93
Total	273.1	176.9	65	204	75

* Most recent estimates.

Sources: Population statistics are from UNPD (2007). The number of people without electricity access and relying on fuelwood and charcoal is from IEA analysis, based on national surveys and information provided from the World Bank, United Nations Development Programme and World Health Organisation.

- In the absence of new policy initiatives, the number of people living without electricity and exposed to the health risks associated with the burning of fuelwood and charcoal for cooking will actually rise over the *Outlook* period, as the population grows.

Oil and Gas exports are enough to cover costs of electrification in many countries

Figure 15.6 • Cumulative government oil and gas revenues in assessed sub-Saharan African countries, 2006-2030

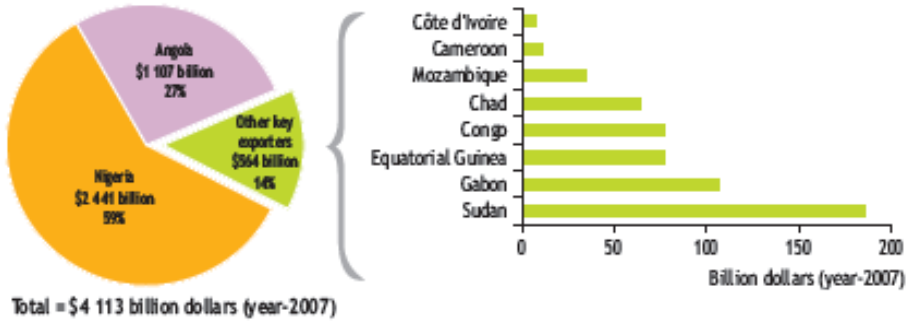
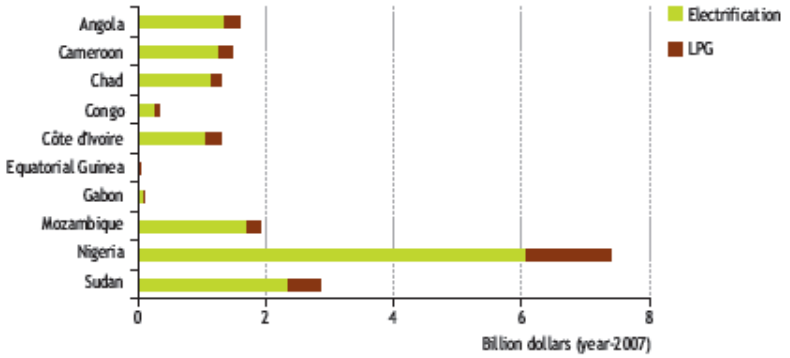


Figure 15.8 • Total additional cost* of universal access to electricity and clean cooking stoves in assessed sub-Saharan African countries



* From 2006 to 2030, over and above the Reference Scenario.
Source: IEA analysis.

- Per-capita oil and gas revenues vary widely among the assessed countries. Revenue per capita over the *Outlook* period averages some $515 in Nigeria but is close to $2 000 in Angola. In Gabon, average annual revenue per capita is some $2 700. It is over $5 000 in Equatorial Guinea
- A minimum consumption rate of 73 kWh per person per year is assumed, and central grid is the least expensive