Total Energy Supply and Emissions in BAU Scenario

Energy supply covers the production and transformation most fuels. This includes primary fuels such as coal, oil, gas and peat, and transformation of those fuels through petroleum refining and electricity generation. It also includes nuclear power, hydropower, wind, solar, biomass, including waste, tidal energy, waves and ocean thermal gradients used for electrical power generation, and geothermal energy used for electrical power and heating. Carbon dioxide capture and storage (CCS), which is an important mitigation strategy for fossil fuel electric power generation and some industrial processes, will be covered in a special section.

The Reference scenario is the Reference scenario of the IEA's 2006 World Energy Outlook (IEA 2006). It projects energy supply and demand by type to 2030 for 17 regions. It also projects the related greenhouse gas emissions and the associated investment. The investment has been converted from a cumulative figure to annual flows. The mitigation scenario is the Beyond Alternative Policies scenario of the IEA's 2006 World Energy Outlook. This scenario has been disaggregated into the same regions as the Reference scenario. Energy supply and demand by type, related emissions and annual investment by region are also available for the mitigation scenario.

Current Sources of Financing

Components of energy supply are divided among three economic sectors:

- Oil, gas and coal production are part of mining and quarrying together with other mining activities
- Electricity generation, transmission and distribution and gas distribution are part of electricity, gas distribution and water supply
- Petroleum refining is part of the industrial sector

Since most of the investment is for electricity generation, transmission and distribution and gas distribution, the sources of investment for electricity, gas distribution and water supply are shown in Table X

Table Y gross fixed capital formation for electricity, gas distribution and water supply, 2000. Millions USD

Region	Total Electricity gas distribution water	Domestic	Foreign Direct Invest	Foreign Debt	ODA Total	ODA Bilateral	ODA Multilateral
World	228,236	67.8%	12.2%	16.4%	3.6%	1.9%	1.7%
Africa	2,561	71.7%			28.3%	14.9%	13.4%

Most of the investment is domestic. Foreign equity and debt are important in developed countries, ODA is important in developing countries.

The sources of financing vary with mostly private financing in the United States and the UK, a mix of government and private financing in much of Europe, and mostly government funding in EIT and most developing countries. Much developing country financing, other than in China, comes through a combination of ODA and loans from the World Bank and regional development banks.

Different sources provide somewhat inconsistent estimates of annual investment for different components of energy supply. This is shown in Table Y.

Table Y Alternative estimates of investment in energy supply

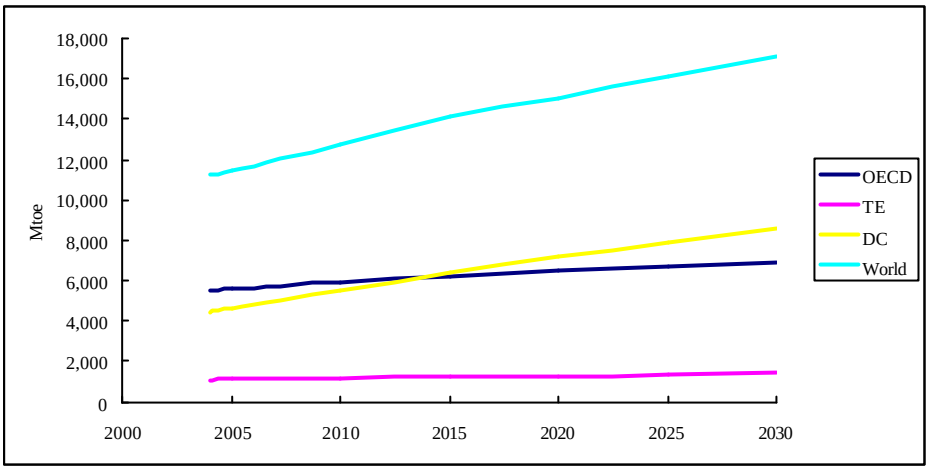
	Table X 2000 Million 2000 USD	OECD 2005 Million 2001 USD	IEA 2005 Million 2005 USD	New Energy Finance 2005 Million 2005 USD
Fossil-fired generation			$107,000	
Large hydro and nuclear generation			$44,100	
Renewables including small hydro			$35,500	$28,900 Asset investments
Transmission and distribution			$225,700	
Total electricity	$176,057[a]	$134,020	$412,300	
Gas distribution	$15,156[a]	$11,537		
Water supply	$37,023[a]	$28,183		
Electricity, gas distribution and water supply	$228,236	$173,740		
Oil supply			$84,500	
Gas supply			$134,000	
Coal supply			$20,000	
Petroleum refining			$29,500	
Notes; a estimated assuming the same shares as the OECD data				

The investment for electricity supply estimated by the IEA, USD 412 billion in 2005, looks high relative to the other data sources -- $135 to $175 billion for 2000 and 2005 respectively. The explanation of the discrepancy probably lies in the estimated investment in transmission and distribution, the largest component of the IEA estimate. Other studies do not include these costs and hence underestimate the total costs of the electrical system.

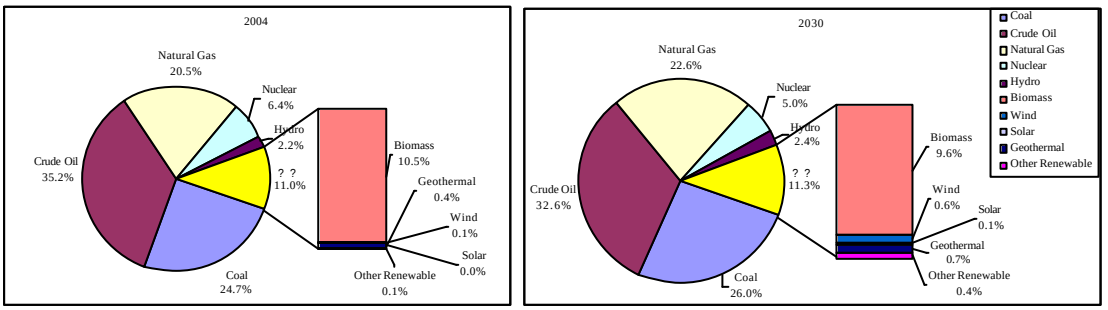
Reference Scenario Energy Supply and Emissions

Global primary energy demand in the Reference Scenario is projected to increase by 1.6% per

year between 2004 and 2030, reaching 17.1 billion tonnes of oil equivalent (toe), 53% (6 billion toe) more than in 2004. The pace of demand growth slackens progressively over the projection period, from 2.1% per year for 2004-2015 to 1.3% for 2015-2030. Energy demand in developing countries grows faster than the global average -- 2.6% per year from 2004 to 2030.



Fossil fuels are projected to remain the dominant sources of primary energy globally. Their share of world demand edges up from 80% in 2004 to 81% in 2030. Oil remains the single largest fuel in the primary fuel mix in 2030, though its share drops, from 35% to 32%. Coal sees the biggest increase in demand in volume terms, with its share increasing one percentage point to 26%. Gas demand grows faster than coal, but does not overtake it before 2030. The share of nuclear power is expected to fall; few new reactors are built and several existing reactors are retired before 2030. Hydropower's share of primary energy is projected to rise slightly. The share of traditional biomass falls, as developing countries increasingly switch to modern commercial energy. Other renewable energy technologies, including wind, solar, geothermal, wave and tidal energy, see the fastest increase in demand, but their share of total energy use still projected to reach only 1.7% in 2030 – up from 0.5% today.



Over 70% of the increase in world primary energy demand between 2004 and 2030 comes from the developing countries. The increase in demand by developing countries results from their rapid economic and population growth. Industrialisation and urbanisation boost demand for commercial fuels.

Global energy-related carbon-dioxide (CO_2) emissions increase by 1.7 % per year over 2004-2030 in the Reference Scenario. They reach 40,400 $MtCO_2$ in 2030, an increase of 14,300 $MtCO_2$, or 55% from 2004. Developing countries account for over three-quarters of the increase in global CO_2 emissions. This increase is greater than the growth of their energy demand, because their incremental energy use is carbon-intensive. They use more coal and less gas than developed countries. Developing countries overtake the OECD as the biggest emitter by around 2012 and are the source of 52% of global emissions by 2030.

Power generation is projected to contribute a little less than half the increase in global emissions from 2004 to 2030. By 2030, the power sector accounts for 44% of total emissions, up from 40% today. Continuing improvements in the thermal efficiency of power stations are largely outweighed by the strong growth in demand for electricity. Transport remains the second-largest sector for emissions worldwide, with its share of total emissions stable at 20 to 25 % throughout the projection period.

CO_2 Emissions by Sectors (million tonnes)

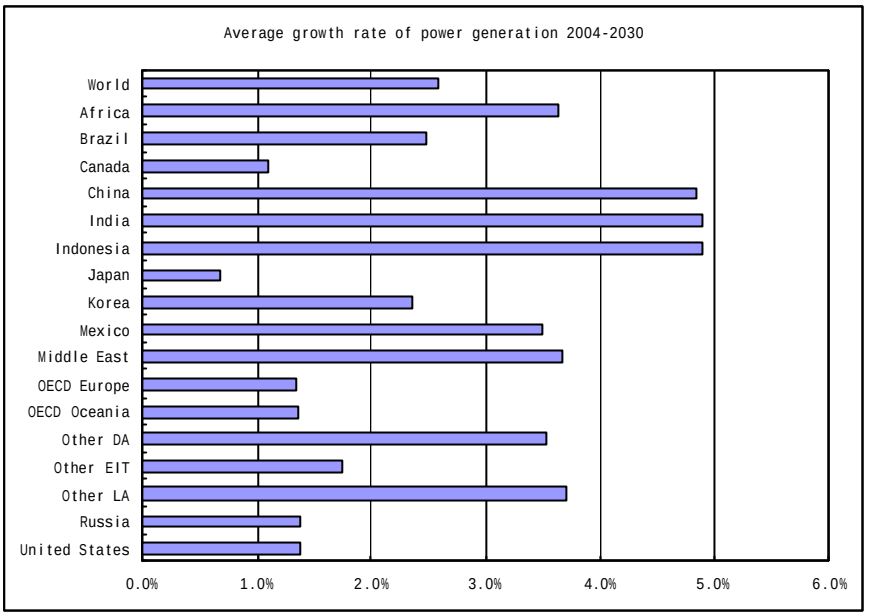
	2004	2010	2015	2020	2025	2030
Power Generation	10,421	12,311	13,993	15,182	16,345	17,477
Industry	5,362	6,252	6,964	7,346	7,716	8,075
Transport	6,345	7,092	7,709	8,334	8,957	9,577
Building and Agriculture	3,330	3,630	3,871	4,051	4,223	4,387
Other	685	771	838	891	942	992
Total	26,143	30,055	33,375	35,803	38,183	40,508

Coal recently overtook oil as the leading contributor to energy-related CO_2 emissions and its share of emissions increases from 38% today to 41% in 2030. The share of natural gas also increases, from 19% to 20%, while that of oil falls, from 43% to 39%.

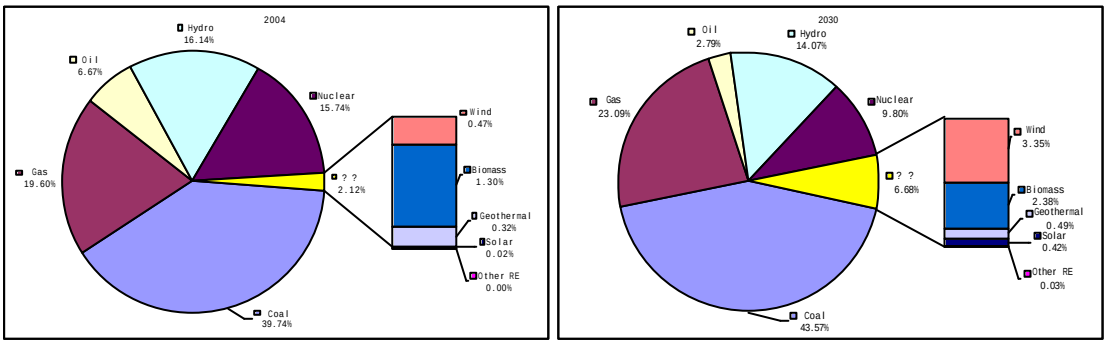
Total Generation, Energy Consumption and Emissions in Power Sector

2.2.1 Total Generation and Generation Mix

World electricity demand is projected to increase from 17 408 TWh in 2004 to 33 750 TWh in 2030 in the Reference Scenario, growing at 2.6% per year on average; less than GDP growth rate of 3.4% and more than total primary energy supply of 1.6%. Electricity demand is projected to grow at an annual rate of almost 5% in China, India and Indonesia.



Though world electricity generation almost doubles by 2030, the generation mix remains relatively stable. The share of coal-fired generation increases from 40% now to 44% in 2030, while the share of gas-fired generation grows from 20% to 23%. Non-hydro renewable energy sources – biomass, wind, solar, geothermal, wave and tidal energy – continue to increase their share, to almost 7% in 2030 from 2% now. Oil use in power generation continues to shrink to 3% by 2030. Hydropower accounts for a smaller share in 2030 than now. Nuclear power suffers the largest fall in market share, dropping from 16% in 2004 to 10% in 2030.



2.2.2 Capacity additions

A total of 5 087 GW of generating capacity is projected to be built worldwide in the Reference Scenario. More than half of this capacity is located in developing countries. Developing countries need to build some 2 700 GW of capacity, of which two-thirds will be in developing Asia. China alone builds around 1 100 GW, sustaining the recent pace of adding 50 GW to 70 GW of new capacity every year. OECD countries need over 2 000 GW to replace retirements of old coal-fired and nuclear plants. Most of these retirements are in

OECD Europe, where environmental restrictions will force old and inefficient coal-fired units to close and where present policies require 27 GW of nuclear power plants to be retired prematurely.

Installed Capacity and Capacity Additions by 2030

Generation Capacity GW	2004	2030	Cumulative capacity additions
World	4054	7877	5033
OECD	2360	3546	1997
OECD North America	1180	1740	915
USA	995	1429	740
Canada	131	184	81
Mexico	54	126	94
OECD Pacific	386	519	197
Japan	261	305	91
Korea	64	120	65
OECD Oceania	61	94	41
OECD Europe	794	1287	885
TE	405	556	327
Russia	220	286	163
Other TE	185	269	165
Developing Countries	1289	3776	2708
Developing Asia	789	2513	1839
China	442	1496	1105
India	131	436	325
Indonesia	34	111	85
Other Developing Asia	181	469	324
Latin America	206	504	336
Brazil	87	173	98
Other LA	119	332	238
Africa	112	294	203
Middle East	182	464	331

Coal accounts for 34% of the capacity additions, 1723 GW by 2030. Two-thirds of the new coal capacity will be built in developing countries, of which 96% will be in developing Asia. Driven by deployment of clean coal technology, the world average generation efficiency of coal power plants increases from 31% in 2004 to 39% in 2030, although in developing countries efficiency, at 38.7%, still lags 2.5% behind that of OECD countries.

The 1689 GW of new natural gas generation capacity is distributed more evenly, but China and India only build 3.3% and 1.8% respectively due to resource limitations. 180 GW of nuclear power will be built worldwide, with 75 GW in China, India, Japan and Korea. 78% of total new hydropower capacity will be built in developing counties. The largest addition, 187 GW, occurs in China followed by 121 GW in Latin America. Non-hydro renewables

especially wind, solar and biomass grow significantly by 2030 and reach a comparable scale to conventional options.

In the Reference Scenario, world CO_2 emissions from power plants increase from 9,600 $MtCO_2$ to 16,400 $MtCO_2$, a rate of 2% per year, since coal retains the biggest share in generation mix. Emissions from electricity generation increase from 41% to 44% of global energy-related CO_2 emissions. CO_2 emissions from electricity generation grow in all regions but most rapidly, by far, in developing countries.

2.3 Investment Needed for Energy Supply in BAU Scenario

Cumulative investment in energy-supply infrastructure in the Reference Scenario is projected to be just over 2005 USD 20 trillion over 2005-2030. The power sector requires more than $11 trillion, 56% of the total. Capital expenditure in the oil industry – oil production, pipelines and other forms of transportation, and refineries, amounts to $4.3 trillion, just over one-fifth of the total. Gas investment – gas production, pipelines, LNG and other transportation -- is $3.9 trillion, or 19% of the total. Investment in coal supply is about $563 billion, or 3% of total energy investment.

More than half of all the energy investment needed worldwide is projected to be in developing countries, where demand and production increase most quickly. China alone needs to invest about $3.7 trillion – 18% of the world total. About $7.5 trillion (37%) is needed for OECD countries to replace and expand the existing facilities.

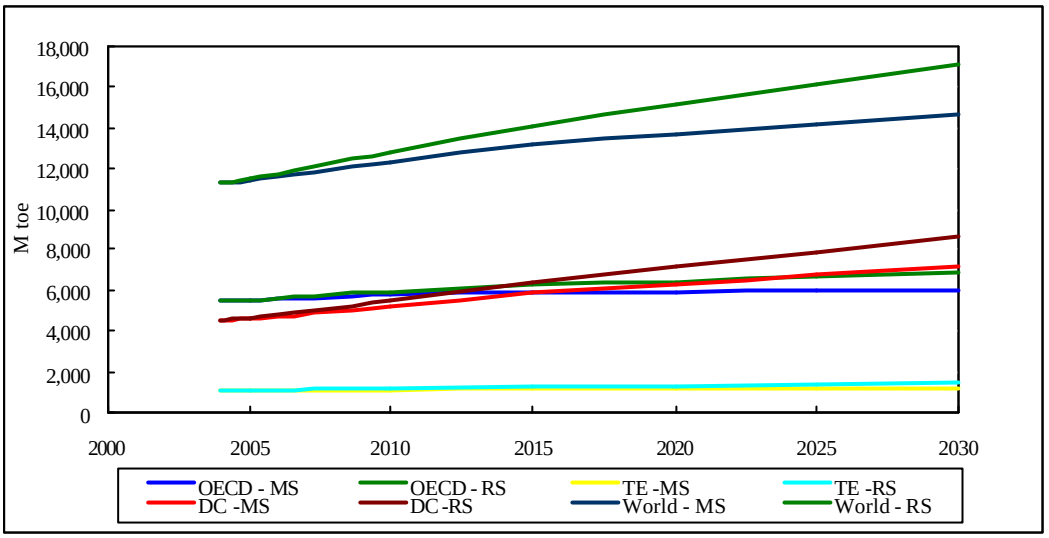
Upstream (production) investment accounts for 73% of the total in the oil industry, 56% of the total in the gas industry, and 100% in the case of coal. Most of the oil industry investment occurs in Russia and the Middle East. Natural gas investment is concentrated in OECD North America, where demand increases strongly and where construction costs are high. Almost half of the coal investment occurs in China and one fourth each in North America and Australia.

	Transmission and Distribution	Power Generation	Coal, Oil and Gas Supply	Total
World	6077	5218	8378	19673
OECD	1991	2236	3049	7276
OECD North America	1025	950	2125	4100
United States	792	796		1588
Canada	88	89		176
Mexico	145	65		210
OECD Pacific	300	270	227	797
Japan	99	127		226
Korea	145	87		232
Australia and New Zealand	56	55		111
OECD Europe	665	1017	697	2379
Transition Economies	303	294	1261	1858
Russia	113	153	932	1198
Other EIT	191	141		331
Developing Countries	3783	2688	4069	10540
Developing Asia	2873	1968	1417	6257
China	1838	1172	713	3723
India	559	408	141	1108
Indonesia	103	85	148	336
Other Developing Asia	373	303	414	1090
Latin America	399	330	655	1384
Brazil	125	126	186	437
Other Latin America	274	204		478
Africa	281	204	918	1403
Middle East	231	186	1079	1496

3 Total Energy Supply and Emissions in the Mitigation Scenario

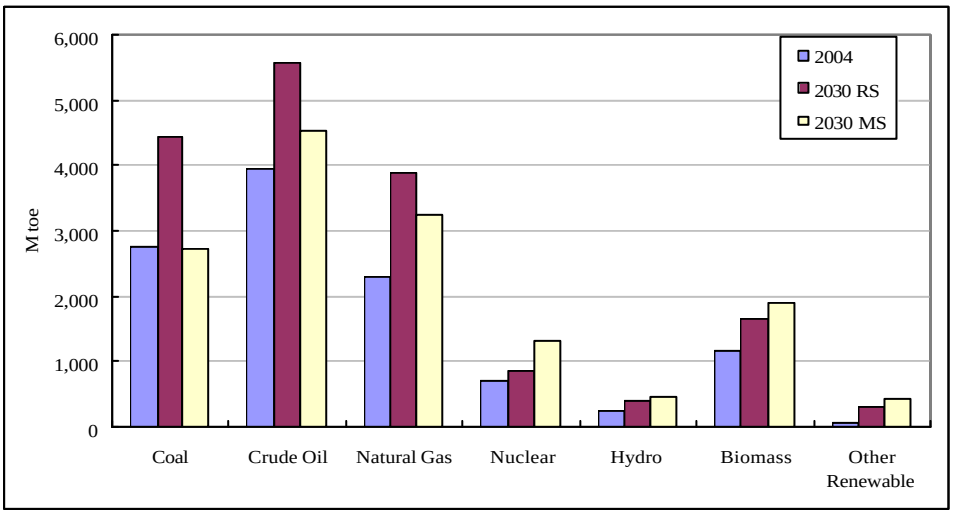
3.1 Total Energy Supply and Emissions

In the Mitigation Scenario global primary energy demand rises from 11.1 billion toe in 2004 to 14.6 billion toe in 2030, 2.5 billion toe lower than in the Reference Scenario. Energy demand still grows fastest in developing countries, but the growth in their demand is moderated to 2.7 billion toe compared with 4.2 billion toe in the Reference Scenario.

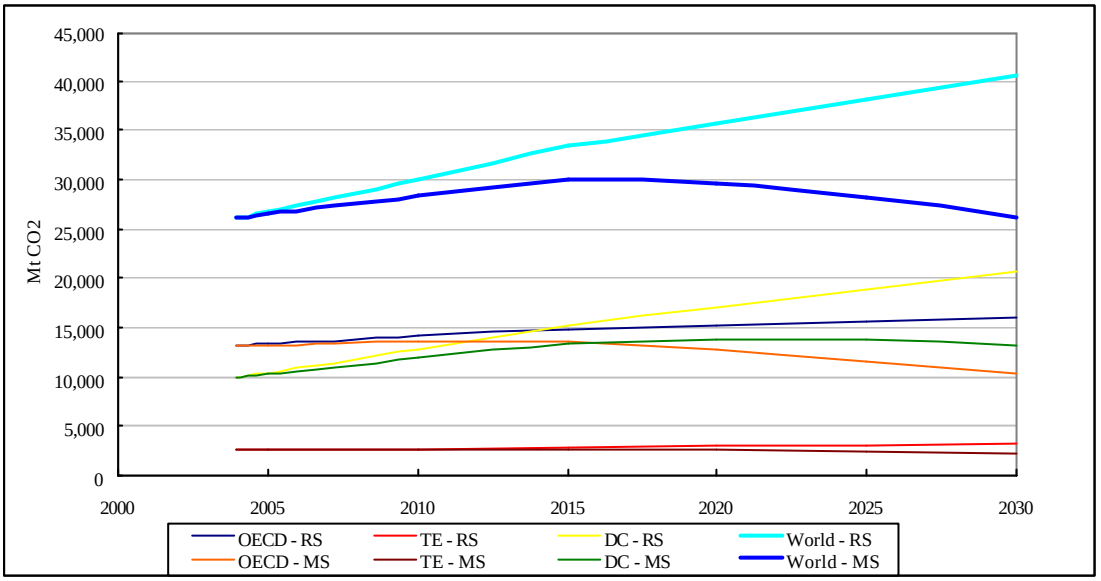


Fossil fuels still play the dominant roles in primary energy supply. Their share decreases to 72% in 2030 from 81% in the Reference Scenario and 80% in 2004. Oil remains the source of primary energy, although its share of total primary energy drops to 31% in 2030. Consumption of coal declines slightly from the current volume, so its share drops to 19% of the total in 2030. Gas remains the fastest growing fossil fuel, overtaking coal by 2030.

Nuclear power increases by 87% in the Mitigation Scenario, much more than the 21% increase in the Reference Scenario, with most of the additional capacity built in the USA and EU. Hydropower also experiences rapid growth especially in developing countries. The share of traditional biomass falls, while the share of total biomass increases due to strong growth of modern biomass technologies such as bio-fuel and biomass power generation. Other renewable energy technologies, including wind, solar, geothermal, wave and tidal energy, increase even faster than in the Reference Scenario due to strong renewable energy promotion policies.

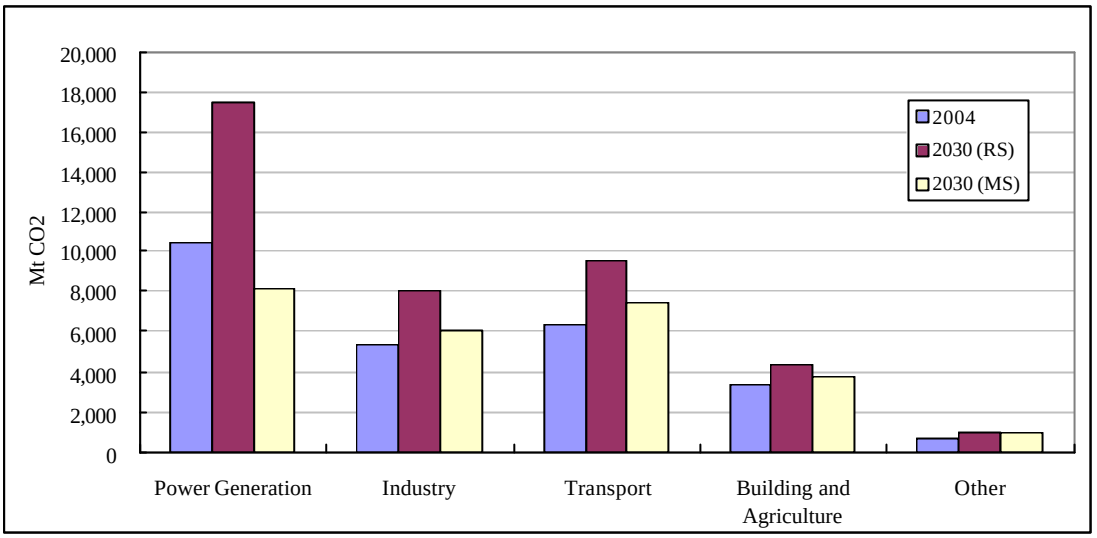


Global energy-related carbon-dioxide (CO_2) emissions peak at 30 Gt CO_2 by 2020 and decrease to the current level by 2030. Emissions of OCED countries remain stable from 2004 to 2015 and then decrease to 10 Gt CO_2 by 2030, 7% below their 1990 emissions. Developing country emissions increase by 3.3 Gt CO_2 then start to decline by 2030. The emissions trend in Transition Economies is slightly decreasing rather than slightly increasing in the Reference Scenario.



Due to projected large scale deployment of CCS, strong expansion of zero emission power generation, and improved efficiency of generation technologies CO_2 emissions from power generation decease to 78% of the current level. Although power generation is still the biggest source of energy related CO_2 emissions, it makes the largest contribution to reducing emissions from the Reference scenario. Transport remains the second-largest source of global CO_2 emissions. Vehicle efficiency improvement, large-scale deployment of hybrid vehicles, and promotion of biofuel decrease transportation emissions by 2.1 Gt CO_2 from the Reference scenario in 2030. Like the transport sector, the emissions of all the other demand sectors increase, but by much less than in the Reference scenario.

CO_2 Emissions by Sectors (million tonnes)

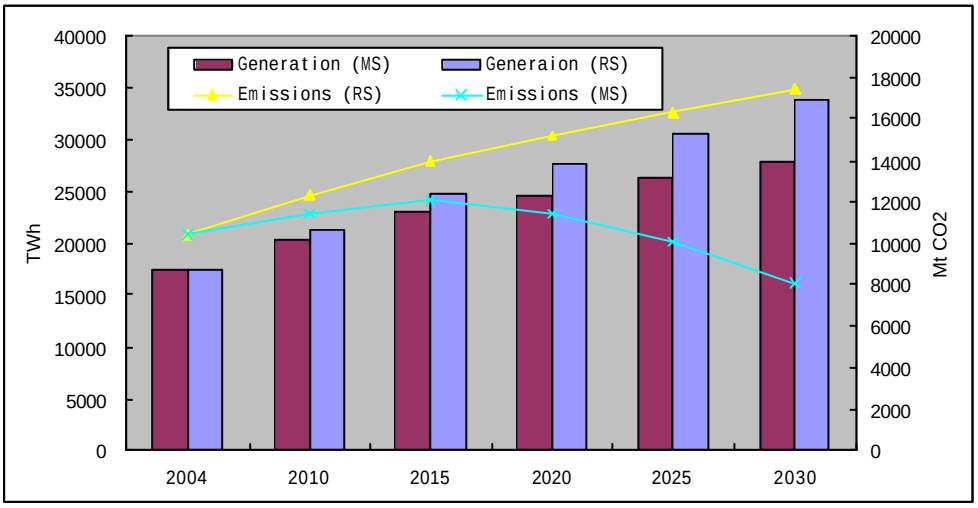


Oil retains its position as the leading contributor to energy-related CO_2 emissions; its share of emissions increases from 43% today to 48% in 2030. The share of natural gas also increases -- from 19% to 25% -- while the share of coal declines.

3.2 Total Generation, Energy Consumption and Emissions in Power Sector

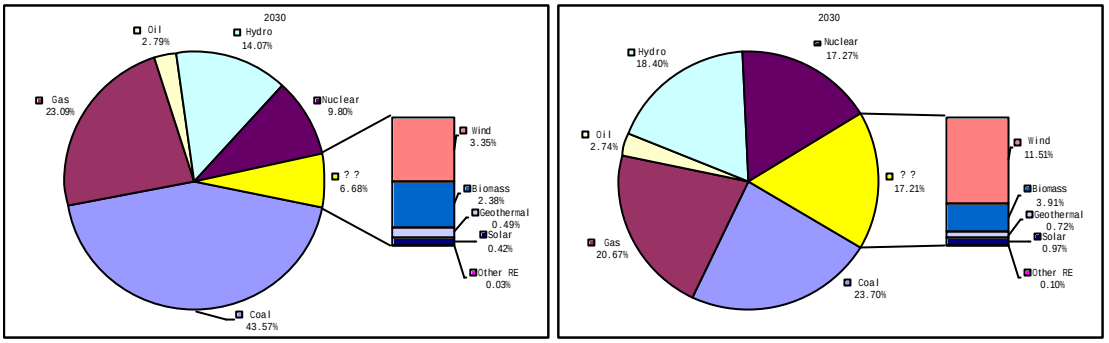
3.2.1 Total Generation and Generation Mix

World electricity demand in the Mitigation Scenario is projected to increase from 17 408 TWh in 2004 to 27 983 TWh in 2030, growing more slowly than in the Reference Scenario. The share of OECD countries in total generation drops from 58% in 2004 to 43% in 2030 while that of developing countries increases from 33% to 50%.



The Mitigation scenario presumes a substantial shift in the world's electricity generation mix by 2030. Coal is projected to remain the largest source of electricity and generation capacity increases by 200 GW but its share shrinks from 40% in 2004 to 26% in 2030, and is no larger

in absolute terms than it was in 2004. Al though coal retains the largest share of the generation mix, total new coal capacity is less than natural gas and hydro additions. Gas-fired generation grows rapidly and becomes the second largest source at 21% in 2030. Nuclear, hydro and renewables generation capacity expands significantly, each representing about 17% of the total in 2030.



3.2.2 Capacity additions

Total installed capacity is projected to be 7 128 GW worldwide in Mitigation scenario, 749 GW less than in Reference scenario. As in the Reference Scenario, more than half of new capacity is in developing countries. Developing countries need to build some 2 330 GW of capacity, of which two-thirds will be in developing Asia. OECD countries need almost 2 000 GW of new capacity.

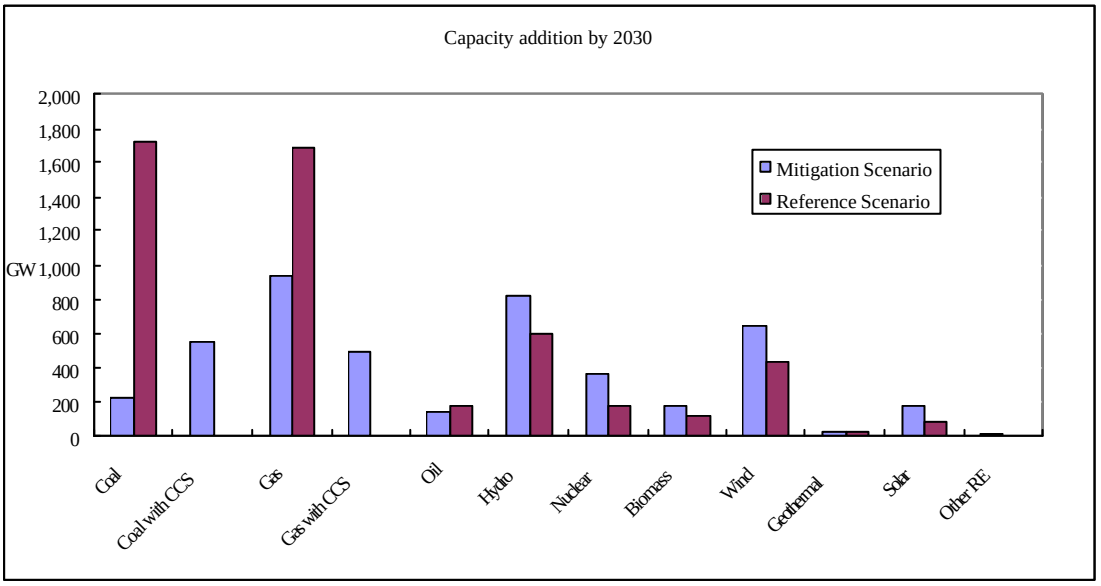
Installed capacity and Capacity Addition by 2030

Generation Capacity GW	2004	2030	Cumulative capacity addition
World	4054	7128	4561
OECD	2360	3306	1969
OECD North America	1180	1690	1005
USA	995	1430	868
Canada	131	146	57
Mexico	54	113	81
OECD Pacific	386	481	217
Japan	261	272	93
Korea	64	110	62
OECD Oceania	61	99	62
OECD Europe	794	1135	747
TE	405	464	262
Russia	220	254	142
Other TE	185	209	121
Developing Countries	1289	3358	2330
Developing Asia	789	2292	1626
China	442	1415	1024

India	131	422	311
Indonesia	34	98	72
Other Developing Asia	181	356	220
Latin America	206	396	238
Brazil	87	138	73
Other LA	119	258	166
Africa	112	274	198
Middle East	182	396	268

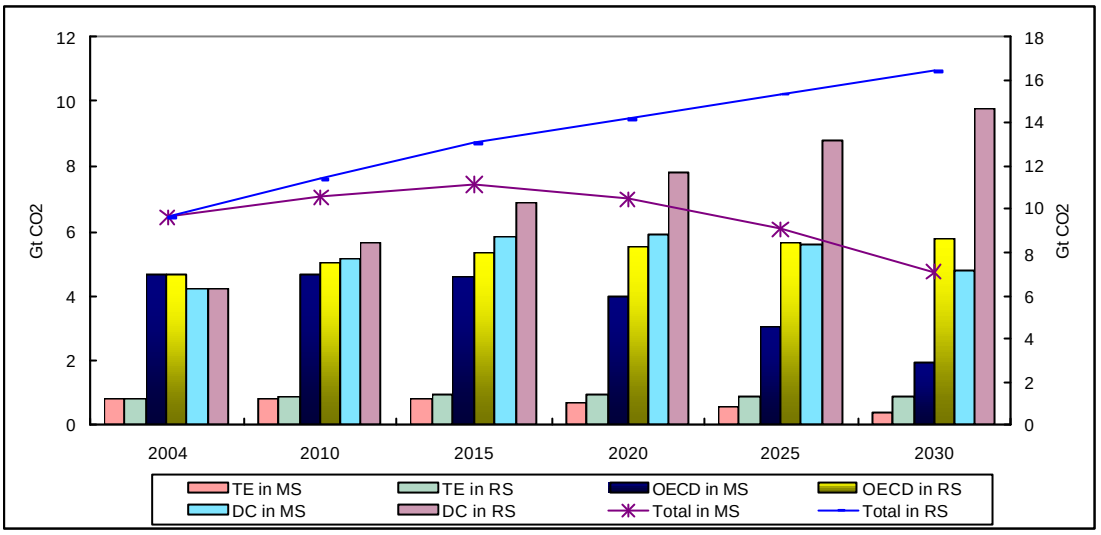
The Mitigation scenario assumes a significant amount of CO_2 capture and storage for power plants and industry. Carbon dioxide can be captured from the emissions of large sources and pumped into geologic formations for long-term storage. Many variations on this basic theme have been proposed; for example, pre-combustion vs. post-combustion capture, production of hydrogen from fossil fuels, and the use of different chemical approaches and potential storage reservoirs. While the basic technology exists, several legal, environmental and safety issues still need to be addressed, and few demonstration facilities have been constructed to date. Adoption of CO_2 capture and storage therefore is not assumed to begin until 2015.

By 2030 CO_2 capture and storage is projected for 70% of the new coal capacity (545 GW) and 35% of new gas capacity (494 GW). As a result, world average generation efficiency of coal power plants drops from 39% in the Reference Scenario to 34% in the Mitigation Scenario. The efficiency of gas plants drops from XX% in the Reference Scenario to XX% in the Mitigation Scenario. These efficiency losses mean that the generation capacity in the Mitigation scenario is XX % higher than it would be with no CO_2 capture and storage.



In the Mitigation scenario global CO_2 emissions from power plants change dramatically. In all regions, the CO_2 emissions peak and begin to decline by 2030. Emissions peak in 2015 at 11 Gt CO_2 and drop to 7 Gt CO_2 by 2030, 10.5 Gt CO_2 lower than in the Reference

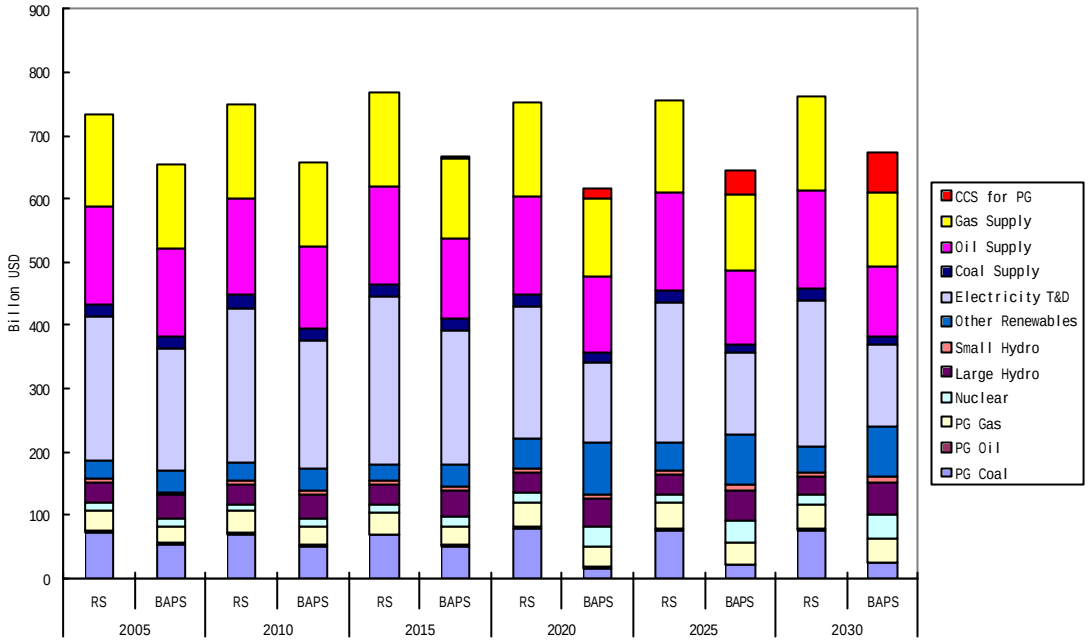
scenario. Of the 10.5 Gt CO_2 reduction, 2 Gt CO_2 is achieved due to deployment of CCS in coal and gas fired power plants, 2 Gt CO_2 is due to demand reduction, and the remaining is due to increased use of nuclear and renewables.



3.3 Investment Needed for Energy Supply in Mitigation Scenario

Due to large reduction in total energy supply, the cumulative investment in energy-supply infrastructure in the Mitigation Scenario is projected to be reduced accordingly, around $ 16.8 trillion (in year-2005 dollars) over 2005-2030, $2.9 trillion less than Reference Scenario. The power sector requires more than $10 trillion of investment, which accounts for 60% of total, 4 points higher comparing with 56% in Reference Scenario. Capital expenditure in the oil industry – oil production, pipelines and other forms of transportation, and refineries, amounts to $3.2 trillion. Gas investment – gas production, pipelines, LNG and other transportation is $3.2 trillion, in the same level of oil. Investment in coal supply is about $389 billion, or 2.3% of total energy investment.

	Transmission and Distribution	Change %	Power Generation	Change %	Coal, Oil and Gas Supply	Change %	Total	Change %
World	4221	-30.5%	5907	13.2%	6800	-18.8%	16928	-14.0%
OECD	998	-49.9%	2664	19.1%	2792	-8.4%	6453	-11.3%
OECD North America	539	-47.4%	1292	36.0%	1967	-7.5%	3798	-7.4%
United States	389	-50.9%	1138	42.9%	-	0.0%	1527	-3.8%
Canada	29	-66.3%	81	-9.2%	-	0.0%	110	-37.6%
Mexico	121	-16.8%	73	12.2%	-	0.0%	194	-7.8%
OECD Pacific	187	-37.6%	368	36.6%	203	-10.6%	758	-4.8%
Japan	37	-62.4%	171	34.7%	-	0.0%	209	-7.8%
Korea	118	-18.5%	100	14.5%	-	0.0%	218	-6.1%
Australia and New Zealand	32	-43.2%	97	75.8%	-	0.0%	129	15.7%
OECD Europe	271	-59.3%	1004	-1.2%	622	-10.7%	1897	-20.2%
Transition Economies	202	-33.5%	350	19.3%	827	-34.4%	1379	-25.7%
Russia	87	-22.8%	194	26.7%	827	-11.3%	1108	-7.5%
Other EIT	115	-39.7%	156	11.2%	-	0.0%	271	-18.1%
Developing Countries	3021	-20.1%	2892	7.6%	3181	-21.8%	9095	-13.7%
Developing Asia	2336	-18.7%	2126	8.0%	1277	-9.9%	5738	-8.3%
China	1573	-14.4%	1316	12.3%	663	-7.1%	3552	-4.6%
India	465	-16.9%	444	8.8%	131	-7.4%	1040	-6.2%
Indonesia	85	-17.5%	86	1.4%	136	-7.9%	307	-8.5%
Other Developing Asia	213	-42.9%	280	-7.8%	347	-16.1%	840	-23.0%
Latin America	283	-29.0%	298	-9.6%	147	-77.6%	728	-47.4%
Brazil	73	-41.3%	97	-23.1%	147	-21.3%	317	-27.5%
Other Latin America	210	-23.5%	201	-1.3%	-	0.0%	411	-14.0%
Africa	226	-19.5%	267	31.1%	811	-11.7%	1304	-7.1%



Investment in conventional generation, transmission and distribution and production of fossil fuels is lower in the Mitigation scenario than in the Reference scenario. Investment in nuclear, large hydro, renewables and CO_2 capture and storage is higher than in the reference scenario. As shown in Table Y most of the additional investment occurs in developing countries.

Table Y Additional investment by technology for electricity supply, gas distribution and water supply, 2030. Millions USD (BAPS –Reference scenario in 2030)

Country/Regions	CCS	Nuclear	Large Hydro	Wind	Other Renewable	Total
World	31.1%	18.5%	16.0%	9.9%	31.1%	1888
OECD	17.8%	6.3%	2.4%	5.2%	17.8%	818
OECD North America	12.8%	4.0%	1.1%	2.3%	12.8%	437
United States	12.2%	3.9%	0.5%	1.6%	12.2%	388
Canada	0.1%	0.1%	0.5%	0.6%	0.1%	27
Mexico	0.6%	0.0%	0.1%	0.1%	0.6%	23
OECD Pacific	1.4%	1.9%	0.4%	0.7%	1.4%	137
Japan	0.3%	0.6%	0.0%	0.3%	0.3%	61
Korea	0.5%	1.4%	0.0%	0.0%	0.5%	35
Australia and New Zealand	0.6%	0.0%	0.4%	0.4%	0.6%	41
OECD Europe	3.7%	0.4%	0.9%	2.2%	3.7%	244
Transition Economies	1.3%	3.6%	1.2%	0.3%	1.3%	133

Russia	0.9%	1.9%	0.6%	0.1%	0.9%	71
Other EIT	0.4%	1.7%	0.6%	0.2%	0.4%	61
Developing Countries	11.9%	8.6%	12.4%	4.4%	11.9%	938
Developing Asia	9.7%	8.2%	8.6%	3.9%	9.7%	732
China	7.4%	4.8%	3.9%	2.3%	7.4%	431
India	1.4%	3.0%	2.8%	0.8%	1.4%	179
Indonesia	0.6%	0.0%	0.1%	0.1%	0.6%	22
Other Developing Asia excluding China, India and Indonesia	0.3%	0.4%	1.8%	0.7%	0.3%	100
Latin America	0.3%	0.1%	0.2%	0.2%	0.3%	33
Brazil	0.1%	0.1%	-1.6%	0.1%	0.1%	-26
Other Latin America	0.3%	0.0%	1.8%	0.1%	0.3%	60
Africa	0.4%	0.2%	3.4%	0.2%	0.4%	121
Middle East	1.5%	0.0%	0.1%	0.1%	1.5%	51

Historically nuclear plants have been financed by the utilities that also build fossil-fired generation and transmission systems. These utilities probably would be expected to finance the cost of CO_2 capture and storage (CCS) at coal and gas plants. The added investment for nuclear and CCS is less than the reduced investment for fossil-fired generation. Governments generally fund large hydro facilities, and since some of these sites are remote, there are large transmission costs to be financed as well. Thus the financing challenge faced by electric utilities in less severe under the Mitigation scenario than under the Reference scenario, although some private utilities may be reluctant to invest in nuclear plants.

Financing for CCS will require resolution of long-term liability issues. The expectation is that the CO_2 will remain in the reservoir for thousands of years. The entity operating a CCS reservoir cannot be held responsible for such periods of time. Its responsibility must be transferred to the government at some reasonable period after the reservoir is sealed even though there is no record of a government lasting for these time frames either. The legal responsibility of entities operating CCS reservoirs must be clearly defined if they are to be able to attract the required investment. This is why it is important to leave open the possibility of photosynthetic capture of CO_2, which does not require long storage as it produces biofuels that can be reused in the power plant.

Investment in various types of renewables would grow rapidly under the Mitigation scenario. Private investment is – and is likely to remain - the main source of financing for renewable energy and energy efficiency. Consequently, renewable energy has flourished in countries with developed financial markets, active private investors and supportive government policy.

The range of financing options available to renewable energy projects and companies has expanded significantly as technologies have matured and moved into the mainstream.

New Energy Finance estimates that it should be possible to finance the increased investment in renewables, including expansion of the supply chain. More challenging, though, will be ensuring that investment flows to the countries / regions that need it most. Between now and 2030, OECD countries' share of global investment will fall, with developing countries requiring significantly higher levels of investment than they are currently receiving. Countries with the lowest levels of investment (Africa, the Middle East) have the biggest gap to close in percentage terms, even though their required investment in dollar terms is relatively modest.

There are several factors that might alter the scenarios depicted here. The first is that a major effort to reduce wasted opportunities could allow increased power production without increased emissions. For example, it has been estimated that an amount of electricity equal to 19% of current US production could be generated simply by utilizing currently waste heat and pressure losses to generate electrical power, and an additional 1 % of total US energy could be obtained from presently flared solvents. In addition, by increasing the use of distributed power sources utilizing combined heat, power and cooling, not only would emissions be reduced directly, but there would also be a major reduction in transmission and distribution costs. Finally, the assumption that CCS will be a major source of emissions reduction may not happen as envisioned if the loss of efficiency is as large as envisioned, if the costs increase, and if it is decided that the long-term storage management issues are insurmountable. In any case, alternatives that avoid these problems like photosynthetic capture of CO_2 may prove preferable as it can also be retrofitted to existing power plants.

The Clean Development Mechanism is already helping to finance renewable energy and energy efficiency projects in developing countries. Currently CDM projects are concentrated in a relatively small number of countries. Expansion of this source of investment depends on future commitments, the distribution of projects, and a reduction in transaction costs.

It may well be necessary to utilize all of the policy options available to address the climate problem including the trade regime. Finally, the use of bilateral and multilateral ODA, and international agency funding in loans can be turned so as to avoid financing high GHG emitting projects. Focusing on sustainable energy projects can transform the climate issue from a pollution reduction problem into the centerpiece of sustainable development.