CSIS

Center for Strategic and International Studies
1800 K Street N.W.
Washington, DC 20006
(202) 775-3270

The Changing Geopolitics of Energy – Part I

Key Global Trends in Supply and Demand: 1990-2020

Anthony H. Cordesman
With the Assistance of Sarin Hacatoryan

Strategic Energy Initiative
Center for Strategic and International Studies

August 12, 1998

Table of Contents

Key Short Term Geopolitical Issues

- **Asian economic crisis**
- **OPEC and other oil producer uncertainties regarding prices and investment margin**
- **Lack of clear data on Caspian and Central Asian reserves and export options**
- **Sanctions and Embargoes affecting Iran, Iraq, Libya**
- **Instability in Indonesia**
- **Nuclear power versus nuclear proliferation**
- **El Nino vs. El Nina**

Key Mid-to-Long Term Geopolitical Issues

- **Growth of Demand to Feed the Global Economy**
- **Continued Global Dependence on Oil & Gas Exports**
- **Role of the Middle East and North Africa**
- **Problems with Rogue Suppliers: Iran, Iraq, Libya**
- **Need for Expanded Exports from the Gulf States**
- **The Uncertain of Russia and the Former FSU**
- **The Emergence of Asia and the Impact of Asian Economic Growth**
- **China and the impact of the "Gigastate"**
- **The Impact of India**
- **Sub-Saharan Africa's Role in Oil and Gas Exports**
- **The Impact of the North Sea and Atlantic Basin Oil and Gas**
- **The Impact of Mexico and Venezuela**
- **The Changing Nature of "Near Real-Time Inventory" and Global Energy Distribution**
- **The Regional Impact of Technology Growth**

Key Technology Issues

- **Impact of EOR and tertiary recovery**
- **The changing role of gas, gas liquids**
- **New transportation needs and infrastructure: Tankers, pipelines, ports, refineries**
- **Using coal safely**
- **Using nuclear energy safely**
- **Nuclear power versus nuclear proliferation**
- **True nature of environmental impacts: Water, waste disposal, Hydrocarbon emissions: Acid rain, global warming.**
- **Impact of conservation, economic restructuring: Net energy gain.**
- **Renewables**
- **New technologies**

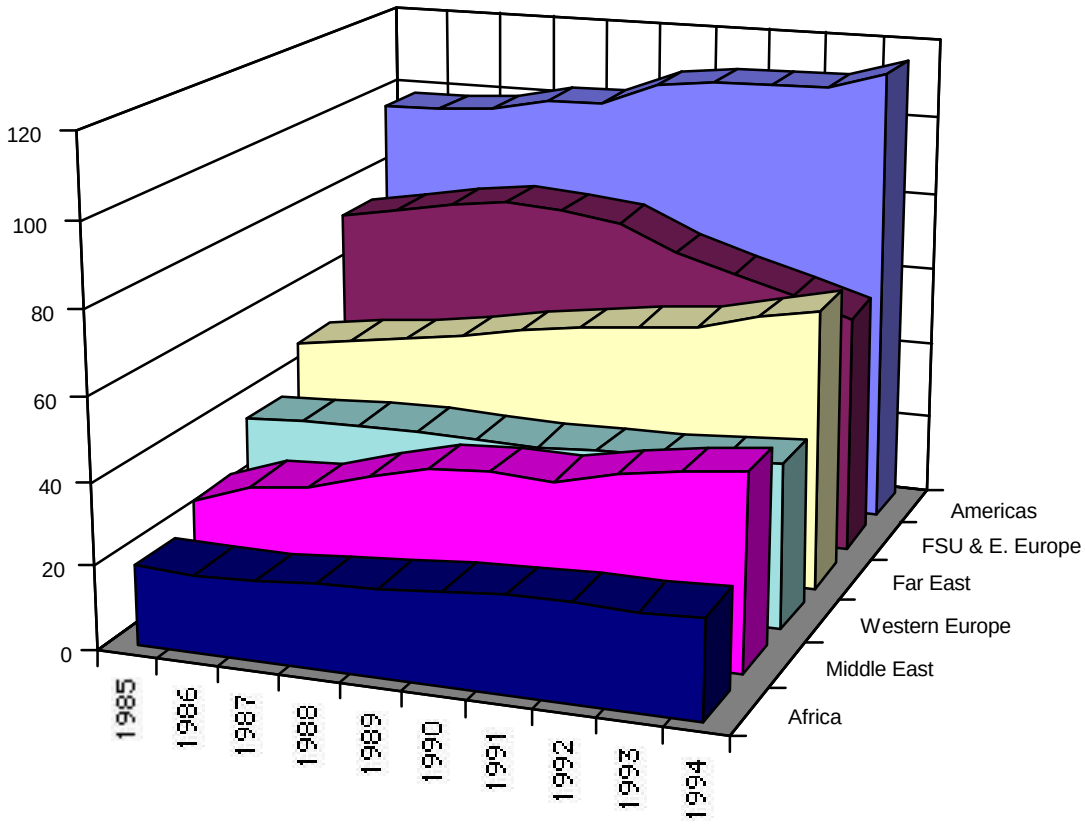
Growing Demand for the World Economy

Key Demand Issues

- **Demand is driven by development and developing nations.**
- **Industrialized states also increase demand, but at far lower rates.**
- **US increase in energy demand is a small part of the emerging geopolitics of energy.**
- **Current ("pre-bust") estimates indicate that Asian demand shapes the future energy balance.**
    - **Asia increase in demand exceeds that of all other developing regions.**
    - **China, India, and Pacific Rim states dominate increase in demand.**
    - **Asian demand alone will require massive increases in tankers, pipelines, ports, refineries.**
- **Demand growth estimates already assume a very high level of technology gain, particularly in oil and gas.**
- **Conservation and industrial restructuring are poorly modeled.**
- **Changes in transportation sector demand are highly uncertain.**

Setting the Stage: Rising World Energy Use By Region Over the Last Decade: 1985-1994

(in Quadrillions of BTU)

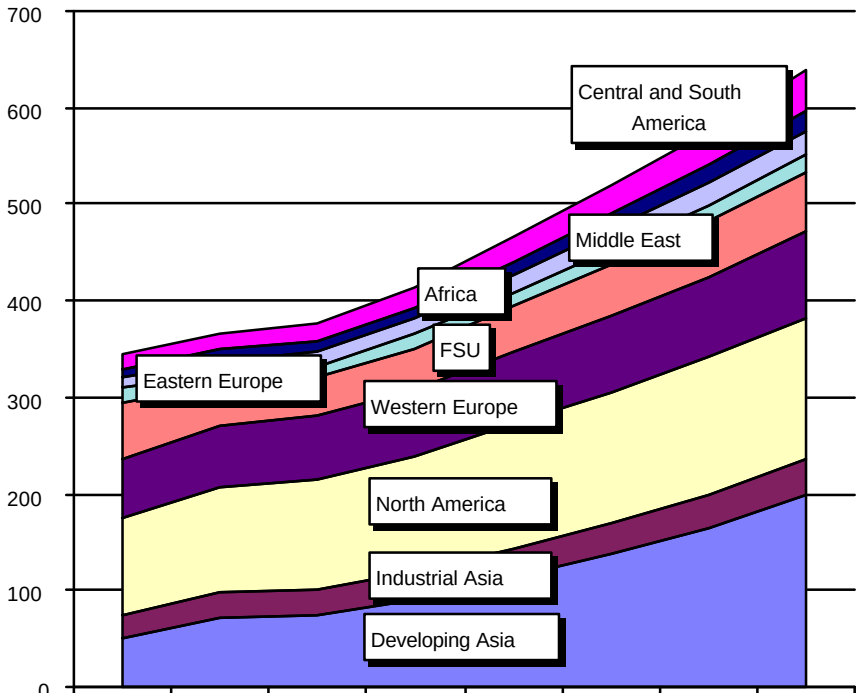


	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Africa	19.29	19.08	19.45	20.57	21.41	22.42	23.41	23.5	23.46	24.05
Middle East	25.77	30.75	32.21	36.12	39.72	41.04	40.33	43.59	45.8	47.39
Western Europe	37.3	38.11	38.54	38.75	38.4	38.14	38.54	38.8	39.42	40.27
Far East	48.69	50.79	52.62	54.37	57.17	59.45	61.11	62.39	66.19	68.98
FSU & E. Europe	74.96	77.63	79.67	82.02	80.83	78.93	72.53	68.25	64.15	59.67
Americas	98.15	97.85	99.21	102.2	102.8	108.7	110.1	110.6	110.9	115.1

Source: Adapted by Anthony H. Cordesman from EIA, Annual Energy Review, 1995, p. 289.

Future World Energy Use: 1990-2020: The Developing World -- Particularly Asia -- Dominates Demand Growth

(in Quadrillions of BTU)

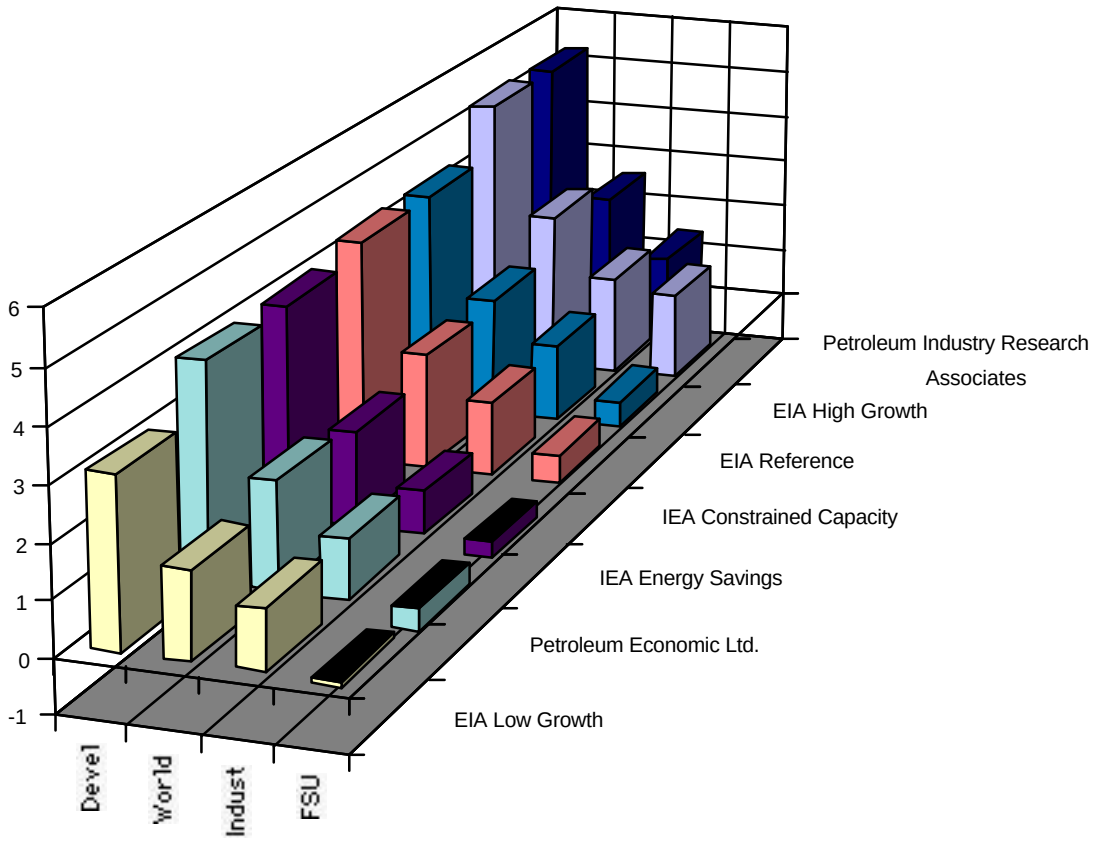


	1990	1995	1996	2000	2005	2010	2015	2020
Central and South America	13.7	16.8	17.7	20.3	25	30	35.8	42.7
Africa	9.2	10.7	11.1	12.2	13.9	15.7	17.7	19.8
Middle East	11.1	13.9	14.6	15.5	17.6	19.9	22.6	25.5
Eastern Europe	15.2	12.4	12.6	13.7	15.1	16.5	18	19.5
FSU	58.5	40.8	39.8	42.6	47.5	52.4	56.5	60.8
Western Europe	61.9	64.8	66.7	69.7	74.5	79	83.4	88.1
North America	99.7	108	112.2	119.8	128.1	136.5	142.1	147.1
Industrial Asia	23	26.3	26.9	28.4	30.1	32.1	34.1	36.3
Developing Asia	51.4	71.8	74.5	90.8	113.8	137.4	165.4	199.4

Source: Adapted by Anthony H. Cordesman from the "reference case" EIA, International Energy Outlook , 1998 DOE/EIA-0484(97), p. 133.

Different Sources Indicate that The Developing World Averages Two to Four Times the Demand Growth of Industrialized States

(Comparative Estimated Near-Term Average Annual Increase in the Demand for Energy: Average Annual Percent of Growth: 1990-2020)

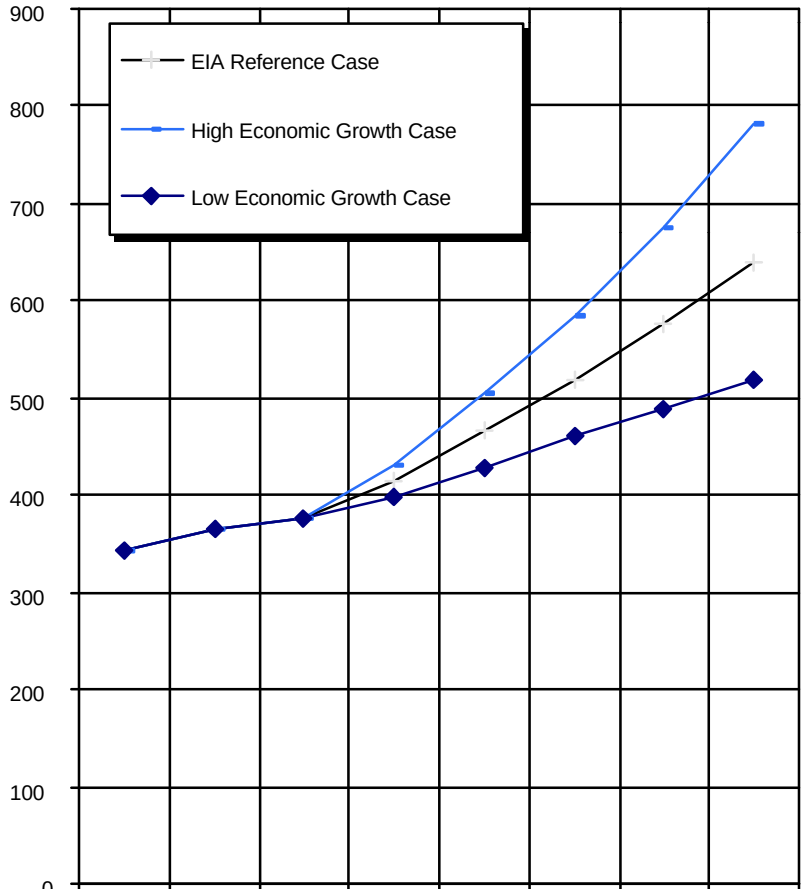


	Devel	World	Indust	FSU
EIA Low Growth	3.1	1.6	1.1	-0.1
Petroleum Economic Ltd.	4	2	1.1	-0.4
IEA Energy Savings	4	1.8	0.8	-0.3
IEA Constrained Capacity	4.3	2.2	1.4	0.5
EIA Reference	4.3	2.3	1.5	0.5
EIA High Growth	5.3	3.1	1.9	1.7
Petroleum Industry Research Associates	5.3	2.6	1.4	-

Source: Adapted by Anthony H. Cordesman from the "reference case" EIA, International Energy Outlook, 1998 DOE/EIA-0484(97), p. 21.

But, Much is Dependent on Global Economic Growth

(Consumption from all sources of energy in Quadrillions of BTU)



	1990	1995	1996	2000	2005	2010	2015	2020
EIA Reference Case	343.8	365.6	376.1	413	465.7	519.6	575.6	639.4
High Economic Growth Case	343.8	365.6	376.1	430.2	505.1	585.5	674.7	781.1
Low Economic Growth Case	343.8	365.6	376.1	396.6	428.8	460	488.4	518.8

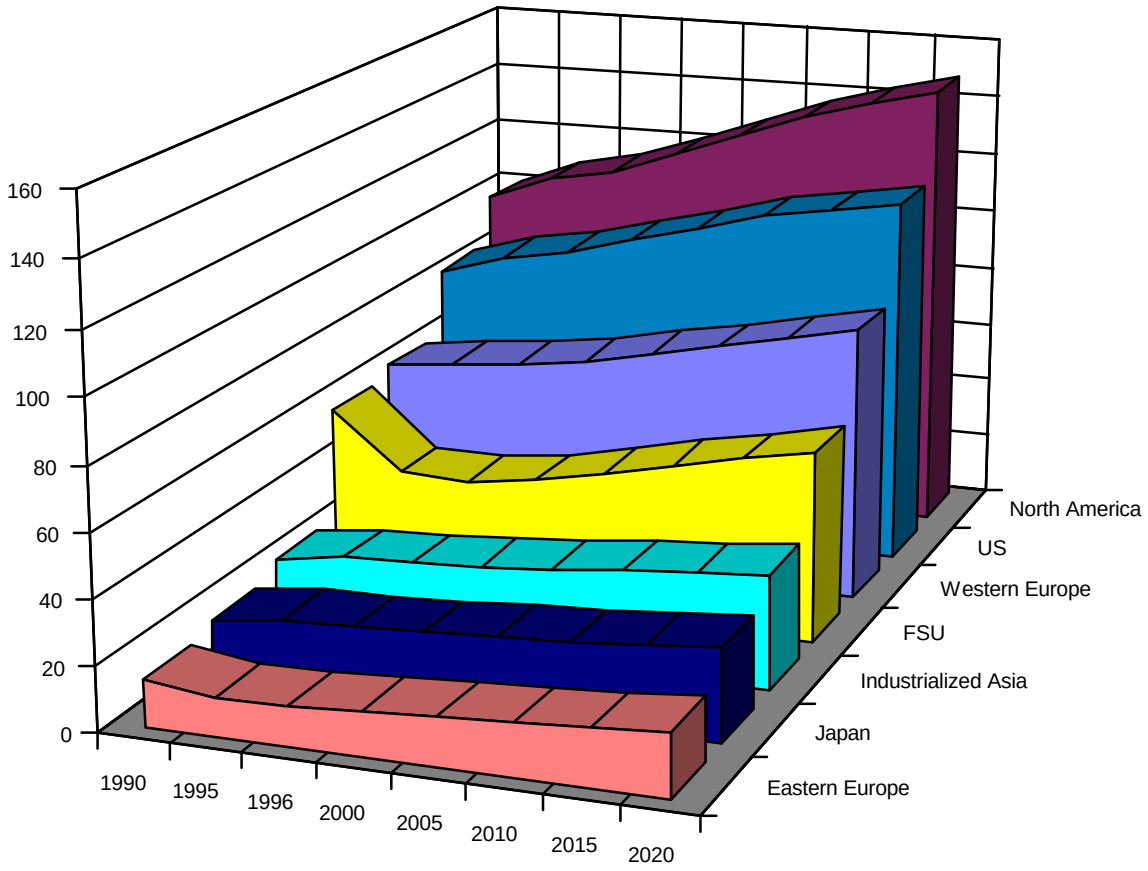
Source: Adapted by Anthony H. Cordesman from the "reference case" EIA, International Energy Outlook, 1998, DOE/EIA-0484(97), pp. 133, 147, 161.

The Impact of Energy Supply to the Industrialized States is Changing Radically

- **Industrialized states increase demand at relatively low rates.**
    - **Average of 1.3% annual rise for North America from 1997 to 2015, with 1.3% rise in oil, 1.9% in natural gas, 1.0 in coal, -1.8% in nuclear, and 2.2% rise in other sources.**
    - **Average of 1.3% annual rise for Western Europe from 1997 to 2015, with 0.5% rise in oil, 3.9% in natural gas, no change in coal, -0.4% in nuclear, and 2.2% rise in other sources.**
    - **Average of 1.5% annual rise for Industrialized Asia (Japan & Australasia) from 1997 to 2015, with 1.6% rise in oil, 2.6% in natural gas, -0.5% rise in coal, 1.0% rise in nuclear, and 2.2% rise in other sources..**
- **Former Soviet Union and Eastern Europe are not classed as Industrialized States, and data are distorted by the fact their economic implosion cut energy use from 73.6 billion quads in 1990 to 52.1 in 1995.**
    - **Project a 1.8% annual rise for from 1997 to 2015, with 2.6% rise in oil, 2.7% in natural gas, -0.3% drop c in coal, -0.6% drop in nuclear, and 1.4% rise in other sources..**
    - **Eastern European demand recovers slightly more quickly than that in FSU, averaging 2.0% annual versus 1.8%.**
    - **Assumes only moderate economic recovery and growth. Successful capitalism would sharply reduce export surplus.**

Most Industrialized Regions Show Relatively Slow Growth in Total Energy Demand

(in Quadrillions of BTU)

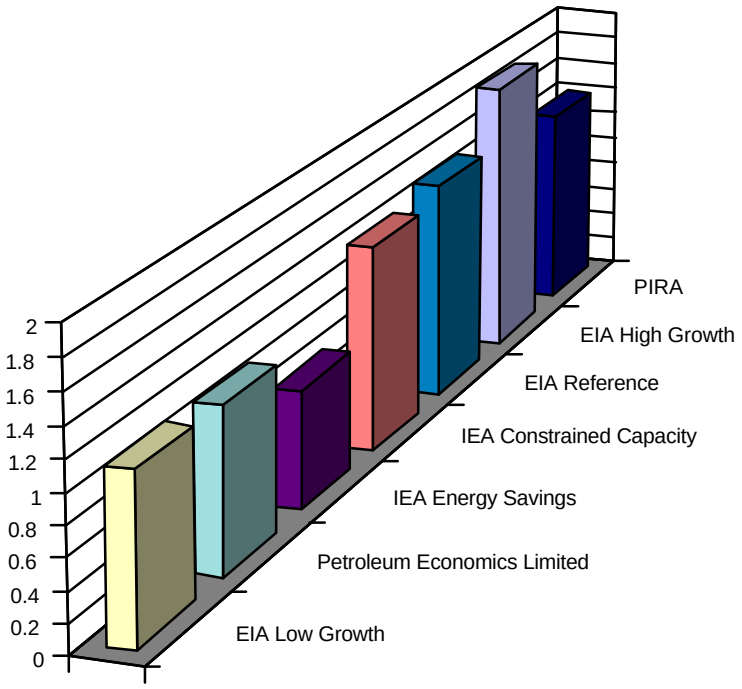


	1990	1995	1996	2000	2005	2010	2015	2020
Eastern Europe	15.2	12.4	12.6	13.7	15.1	16.5	18	19.5
Japan	18.1	20.8	21.4	22.3	23.5	25.1	26.7	28.5
Industrialized Asia	23	26.3	26.9	28.4	30.1	32.1	34.1	36.3
FSU	58.5	40.8	39.8	42.6	47.5	52.4	56.5	60.8
Western Europe	61.9	64.8	66.7	69.7	74.5	79	83.4	88.1
US	83.9	90.4	94	99.8	105.8	112.2	115.7	118.6
North America	99.7	108	112.2	119.8	128.1	136.5	142.1	147.1

Source: Adapted by Anthony H. Cordesman from the "reference case" EIA, International Energy Outlook, 1998, DOE/EIA-0484(97), p. 133.

Radically Different Sources Agree on Low Demand Growth in the Industrialized States

(Comparative Estimated Near-Term Average Annual Percent of Increase in the Demand for Energy: 1990-2010)

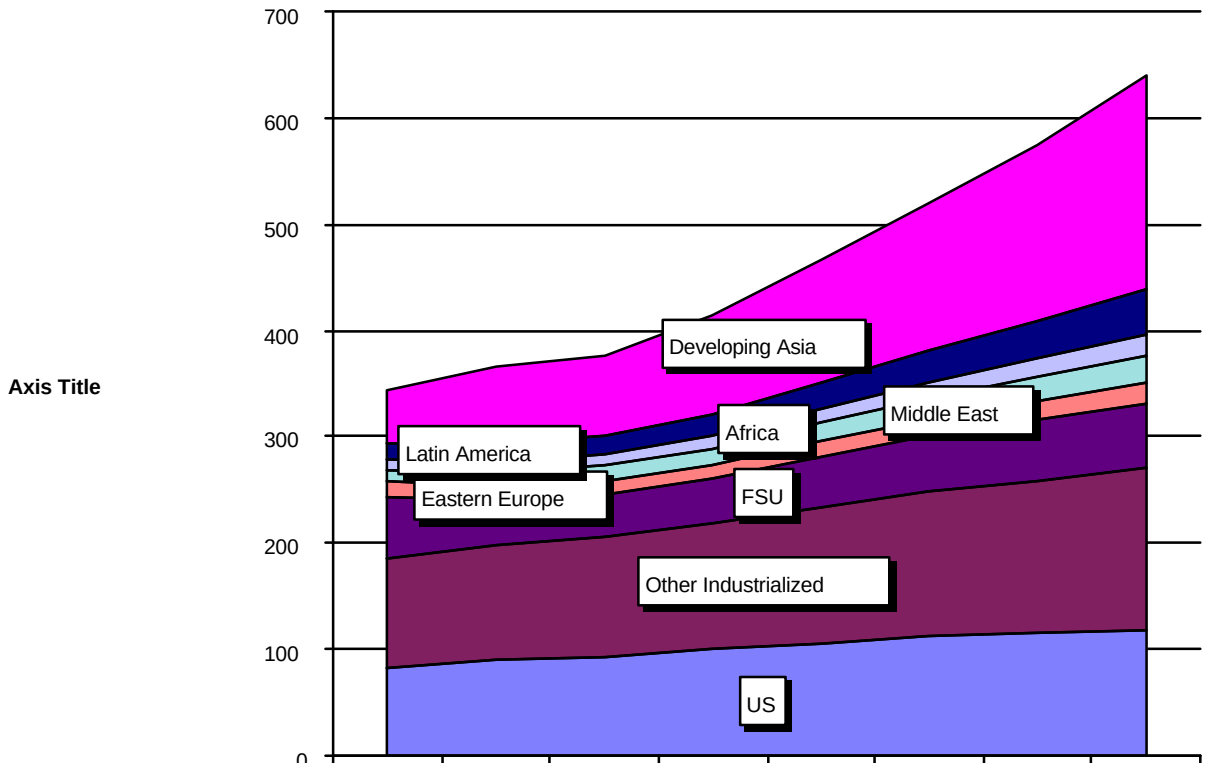


EIA Low Growth	1.1
Petroleum Economics Limited	1.1
IEA Energy Savings	0.8
IEA Constrained Capacity	1.4
EIA Reference	1.5
EIA High Growth	1.9
PIRA	1.4

Source: Adapted by Anthony H. Cordesman from the "reference case" EIA, International Energy Outlook, 1998 DOE/EIA-0484(97), p. 21.

US versus World Energy Use: 1990-2020: The Vast Majority of Future Demand Growth is Foreign

(in Quadrillions of BTU)



	1990	1995	1996	2000	2005	2010	2015	2020
Developing Asia	51.4	71.8	74.5	90.8	113.8	137.4	165.4	199.4
Latin America	13.7	16.8	17.7	20.3	25	30	35.8	42.7
Africa	9.2	10.7	11.1	12.2	13.9	15.7	17.7	19.8
Middle East	11.1	13.9	14.6	15.5	17.6	19.9	22.6	25.5
Eastern Europe	15.2	12.4	12.6	13.7	15.1	16.5	18	19.5
FSU	58.5	40.8	39.8	42.6	47.5	52.4	56.5	60.8
Other Industrialized	100.8	108.7	111.8	118.1	127	135.4	143.9	152.9
US	83.9	90.4	94	99.8	105.8	112.2	115.7	118.6

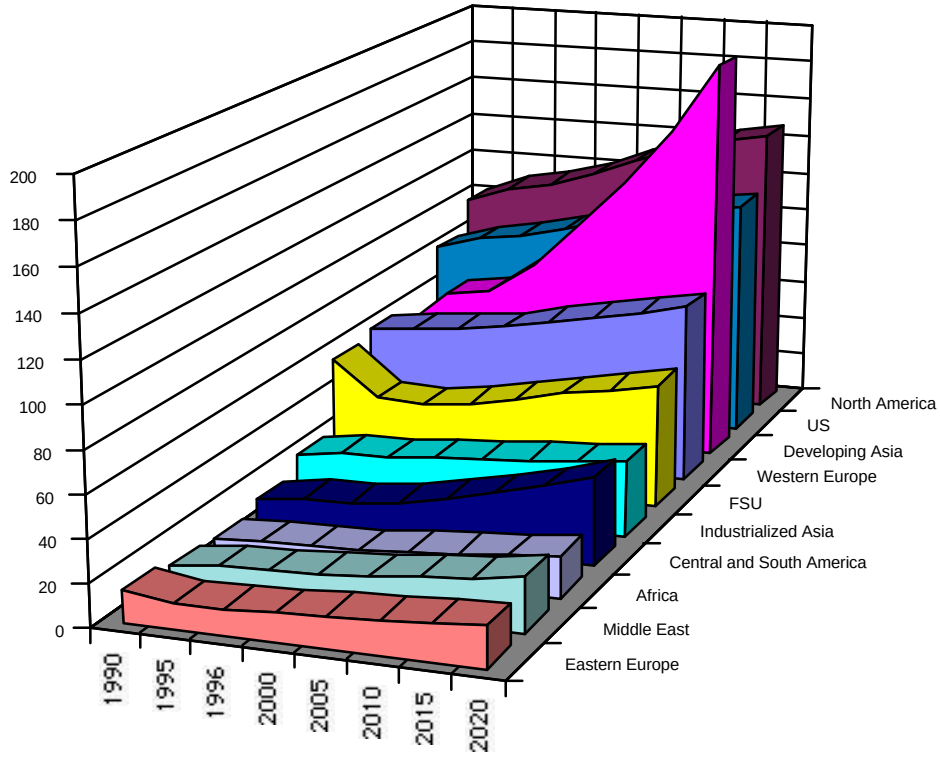
Source: Adapted by Anthony H. Cordesman from the "reference case" EIA, International Energy Outlook, 1998, DOE/EIA-0484(97), p. 133.

Energy Supply to the Developing States Must Rise Sharply Under Current Economic Assumptions

- **Developing states increase demand at relatively high rates.**
    - **Average of 4.2% annual rise for Developing Asia from 1997 to 2015, with 4.1% rise in oil, 7.9% in natural gas, 3.5 in coal, 5.1% in nuclear, and 4.5 rise in other sources.**
    - **Average of 3.0% annual rise for Latin and Central America from 1997 to 2015, with 3.3% rise in oil, 5.3% in natural gas, 2.6% rise in coal, 2.6% in nuclear, and 0.4% rise in other sources.**
    - **Average of 1.5% annual rise for Middle East from 1997 to 2015, with 1.9% rise in oil, 0.7% in natural gas, 0.6% rise in coal, 0.0% rise in nuclear, and 4.1% rise in other sources.**
    - **Average of 1.9% annual rise for Sub-Saharan Africa from 1997 to 2015, with 3.2% rise in oil, 2.5% in natural gas, 0.3% rise in coal, -0.9%% drop in nuclear, and 2.1% rise in other sources.**

Developing Asian Nations, Latin America, and the Recovery of the FSU and Eastern Europe Dominate the Growth of World Energy Demand

(in Quadrillions of BTU)

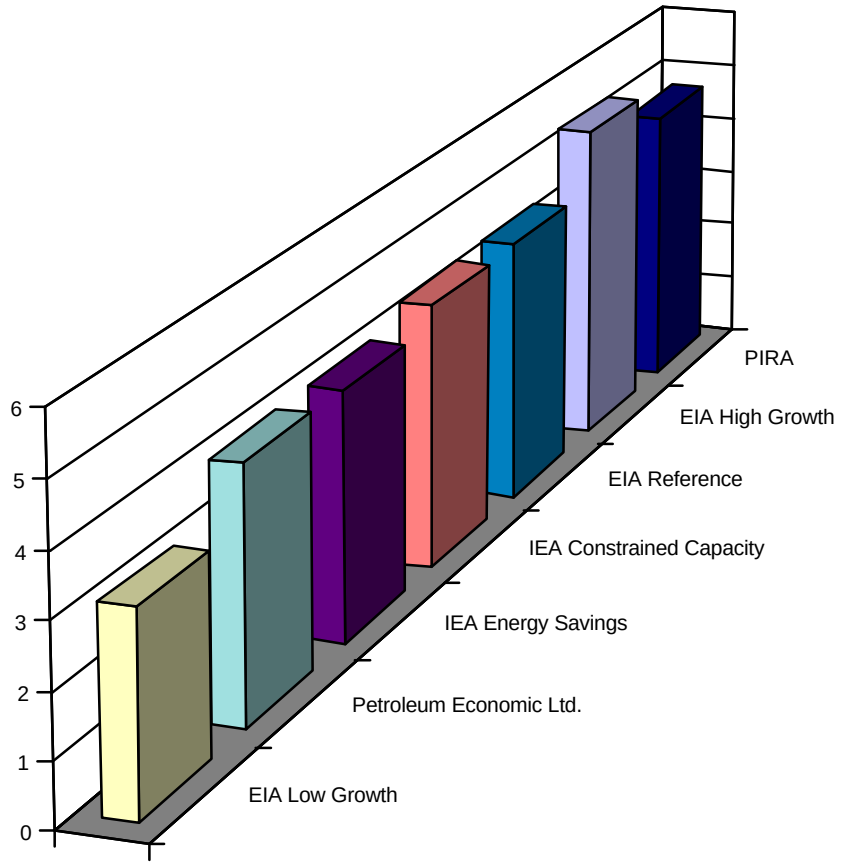


	1990	1995	1996	2000	2005	2010	2015	2020
Eastern Europe	15.2	12.4	12.6	13.7	15.1	16.5	18	19.5
Middle East	11.1	13.9	14.6	15.5	17.6	19.9	22.6	25.5
Africa	9.2	10.7	11.1	12.2	13.9	15.7	17.7	19.8
Central and South America	13.7	16.8	17.7	20.3	25	30	35.8	42.7
Industrialized Asia	23	26.3	26.9	28.4	30.1	32.1	34.1	36.3
FSU	58.5	40.8	39.8	42.6	47.5	52.4	56.5	60.8
Western Europe	61.9	64.8	66.7	69.7	74.5	79	83.4	88.1
Developing Asia	51.4	71.8	74.5	90.8	113.8	137.4	165.4	199.4
US	83.9	90.4	94	99.8	105.8	112.2	115.7	118.6
North America	99.7	108	112.2	119.8	128.1	136.5	142.1	147.1

Source: Adapted by Anthony H. Cordesman from the "reference case" EIA, International Energy Outlook, 1998, DOE/EIA-0484(97), p. 133.

All Major Sources Agreed on Extremely High Demand Growth in the Developing World Before the Crisis in Asia:

(Comparative Estimates of Near-Term Average Annual Increase in the Demand for Energy: Average Annual Percent of Growth: 1993-2010)

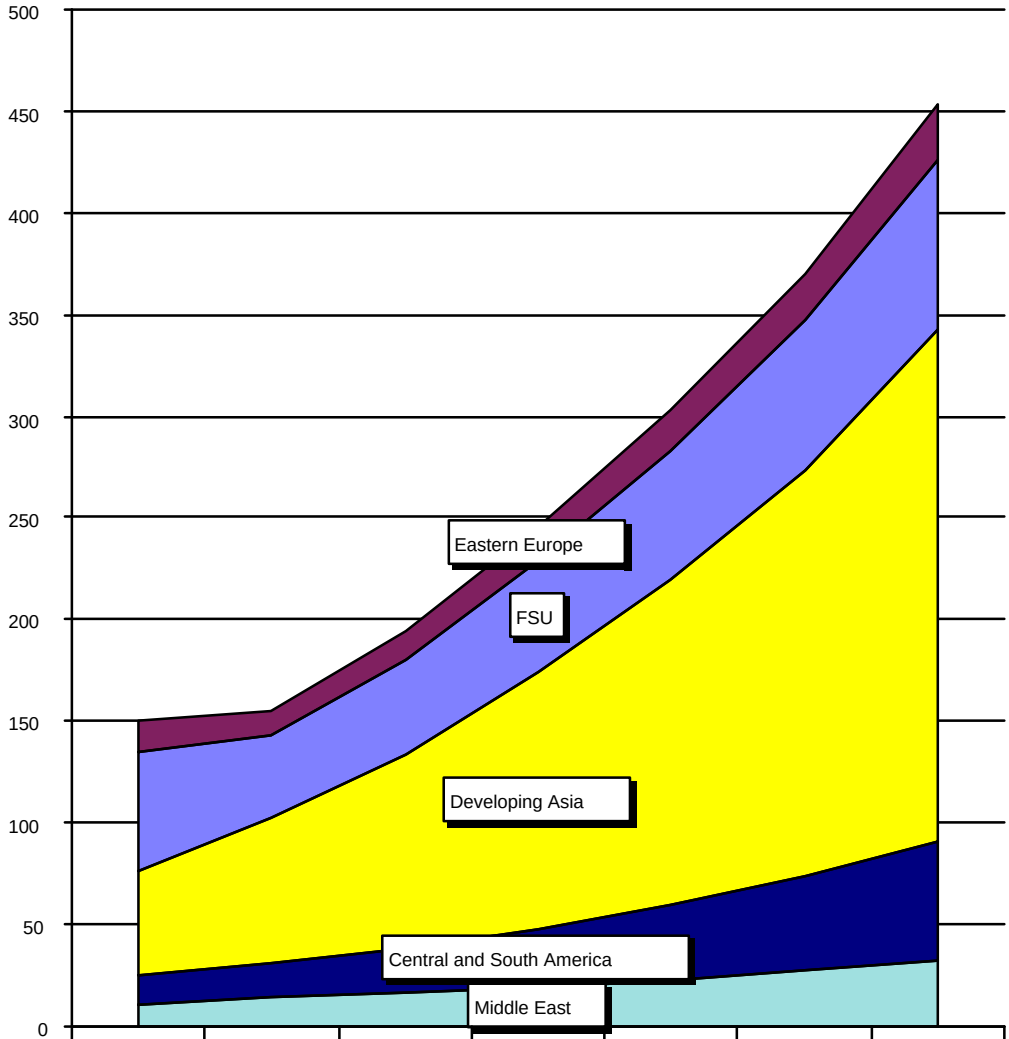


EIA Low Growth	3.1
Petroleum Economic Ltd.	4
IEA Energy Savings	4
IEA Constrained Capacity	4.3
EIA Reference	4.3
EIA High Growth	5.3
PIRA	4.7

Source: Adapted by Anthony H. Cordesman from the "reference case" EIA, International Energy Outlook, 1998, DOE/EIA-0484(97), p. 21.

Impact of the "High Growth" Regions on World Energy Demand

(in Quadrillions of BTU)

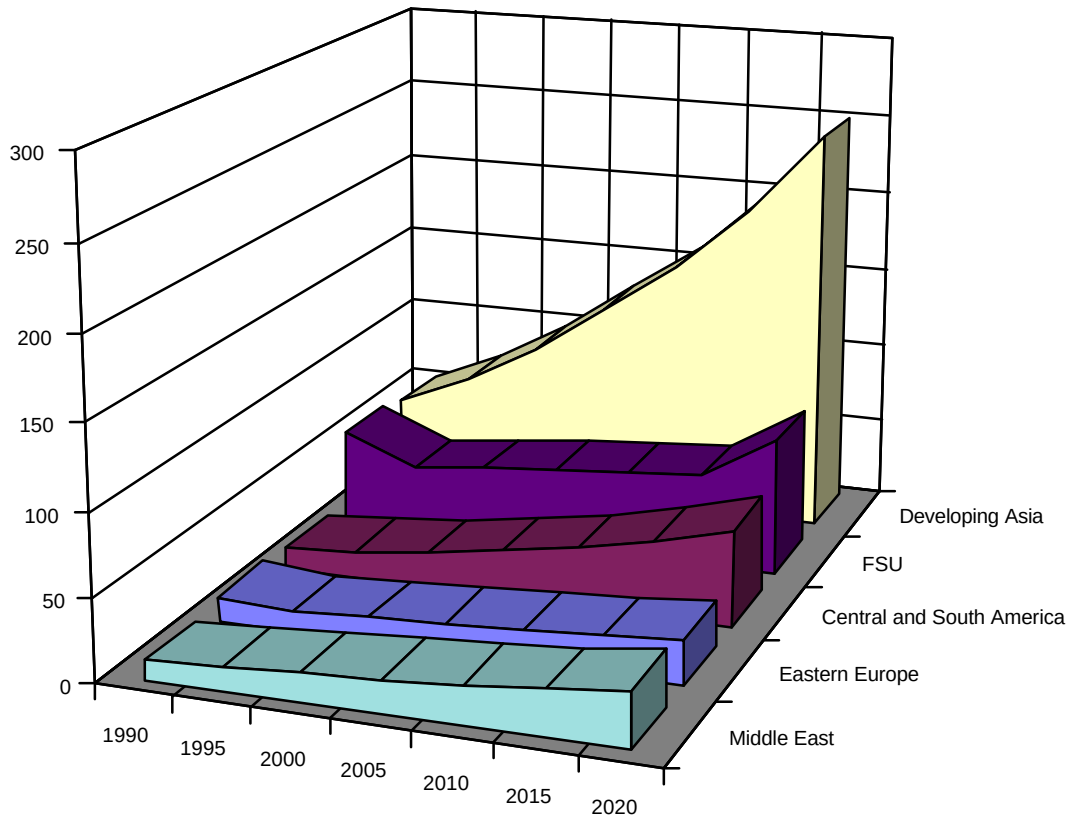


	1990	1995	2000	2005	2010	2015	2020
Eastern Europe	15.2	12.4	14.8	17.4	20.2	23.2	26.6
FSU	58.5	40.8	45.7	54.3	64	73.6	84.5
Developing Asia	51.4	71.8	96.1	126.7	159.5	200	251
Central and South America	13.7	16.8	21.7	28.5	36.4	46.2	58.7
Middle East	11.1	13.9	16.3	19.5	23.1	27.4	32.4

Source: Adapted by Anthony H. Cordesman from the "reference case" EIA, International Energy Outlook, 1998, DOE/EIA-0484(97), p. 147.

Comparative Growth of Energy Demand in High Growth Regions

(in Quadrillions of BTU)

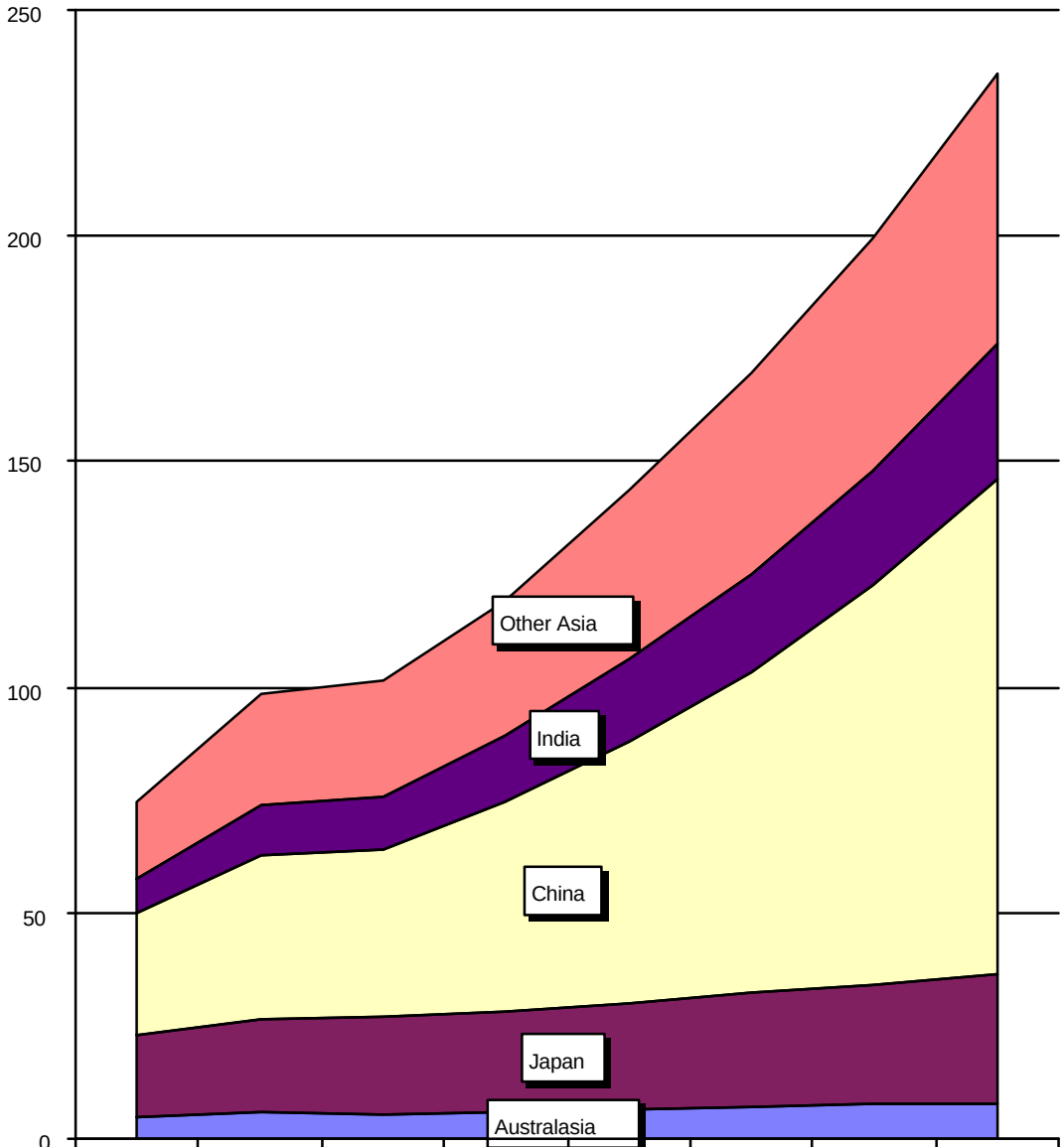


	1990	1995	2000	2005	2010	2015	2020
Middle East	11.1	13.9	16.3	19.5	23.1	27.4	32.4
Eastern Europe	15.2	12.4	14.8	17.4	20.2	23.2	26.6
Central and South America	13.7	16.8	21.7	28.5	36.4	46.2	58.7
FSU	58.5	40	45.3	49.4	53.8	56.8	84.5
Developing Asia	51.4	71.8	96.1	126.7	159.5	200	251

Source: Adapted by Anthony H. Cordesman from the "reference case" EIA, International Energy Outlook, 1998, DOE/EIA-0484(97), p. 147.

Future Asian Energy Use: 1990-2020

(in Quadrillions of BTU)

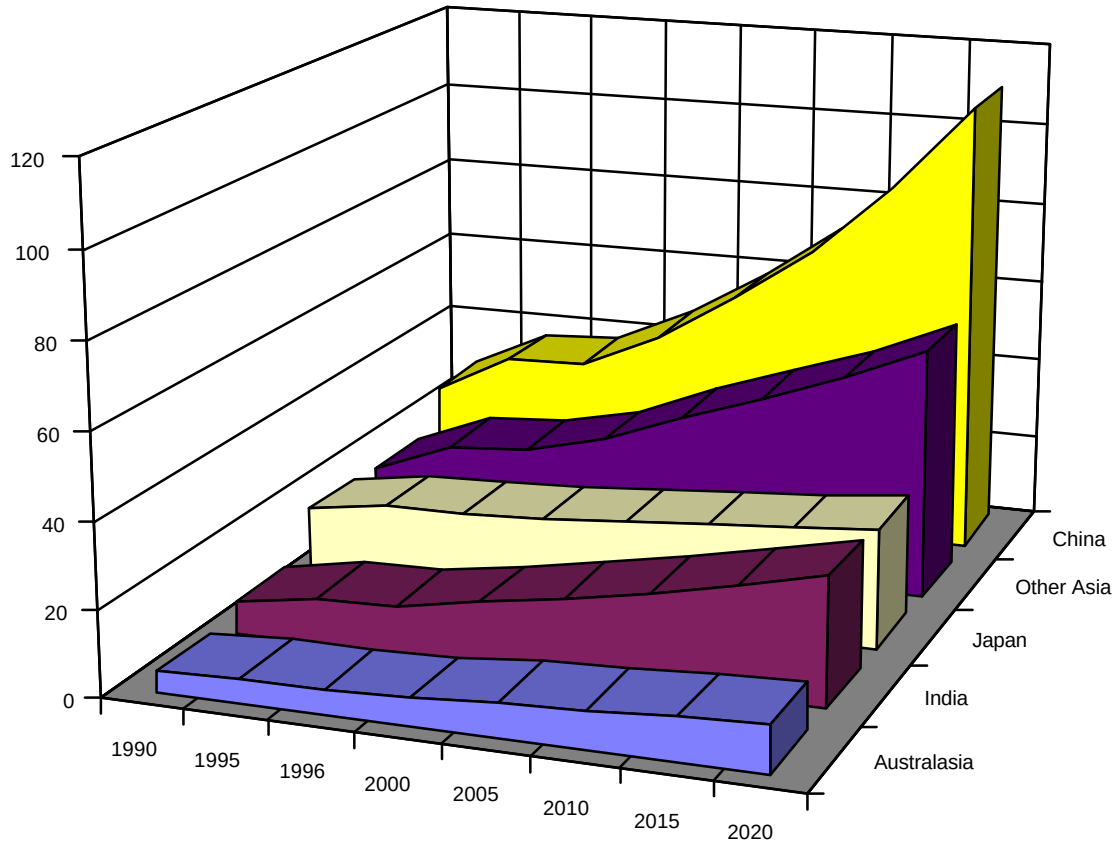


	1990	1995	1996	2000	2005	2010	2015	2020
Other Asia	16.7	24.4	25.9	30.1	37.8	44.4	51.4	59.6
India	7.7	11.1	11.5	14.7	18.1	21.7	25.6	30.2
China	27	36.4	37.1	46	58	71.3	88.4	109.7
Japan	18.1	20.8	21.4	22.3	23.5	25.1	26.7	28.5
Australasia	4.9	5.6	5.5	6.1	6.6	7	7.4	7.8

Source: Adapted by Anthony H. Cordesman from the "reference case" EIA, International Energy Outlook, 1998, DOE/EIA-0484(97), p. 133.

China, Pacific Rim, and India Are the Source of Virtually All Growth in Asian Demand

(In Quadrillions of BTUs, EIA Reference Case)

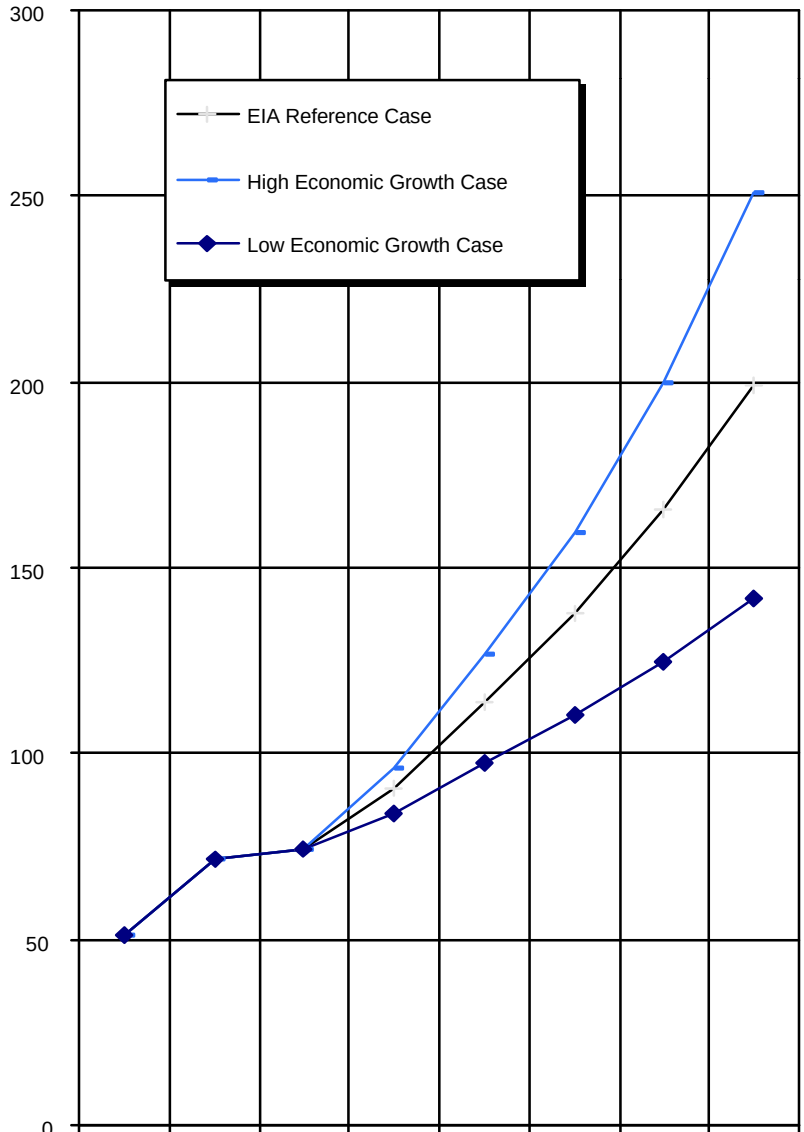


	1990	1995	1996	2000	2005	2010	2015	2020
Australasia	4.9	5.5	5.6	6.6	8	9	10	11
India	7.7	11.1	11.5	14.7	18.1	21.7	25.6	30.2
Japan	18.1	20.8	21.4	22.3	23.5	25.1	26.7	28.5
Other Asia	16.7	24.4	25.9	30.1	37.8	44.4	51.4	59.6
China	27	36.4	37.1	46	58	71.3	88.4	109.7

Source: Adapted by Anthony H. Cordesman from EIA, International Energy Outlook, 1998, p. 133.

But, Asian Economic Crisis Could Change All of the Geopolitical Trends

(Consumption from all sources of energy in Quadrillions of BTU)



	1990	1995	1996	2000	2005	2010	2015	2020
EIA Reference Case	51.4	71.8	74.5	90.8	113.8	137.4	165.4	199.4
High Economic Growth Case	51.4	71.8	74.5	96.1	126.7	159.5	200	251
Low Economic Growth Case	51.4	71.8	74.5	83.9	97.8	110.7	125.1	141.5

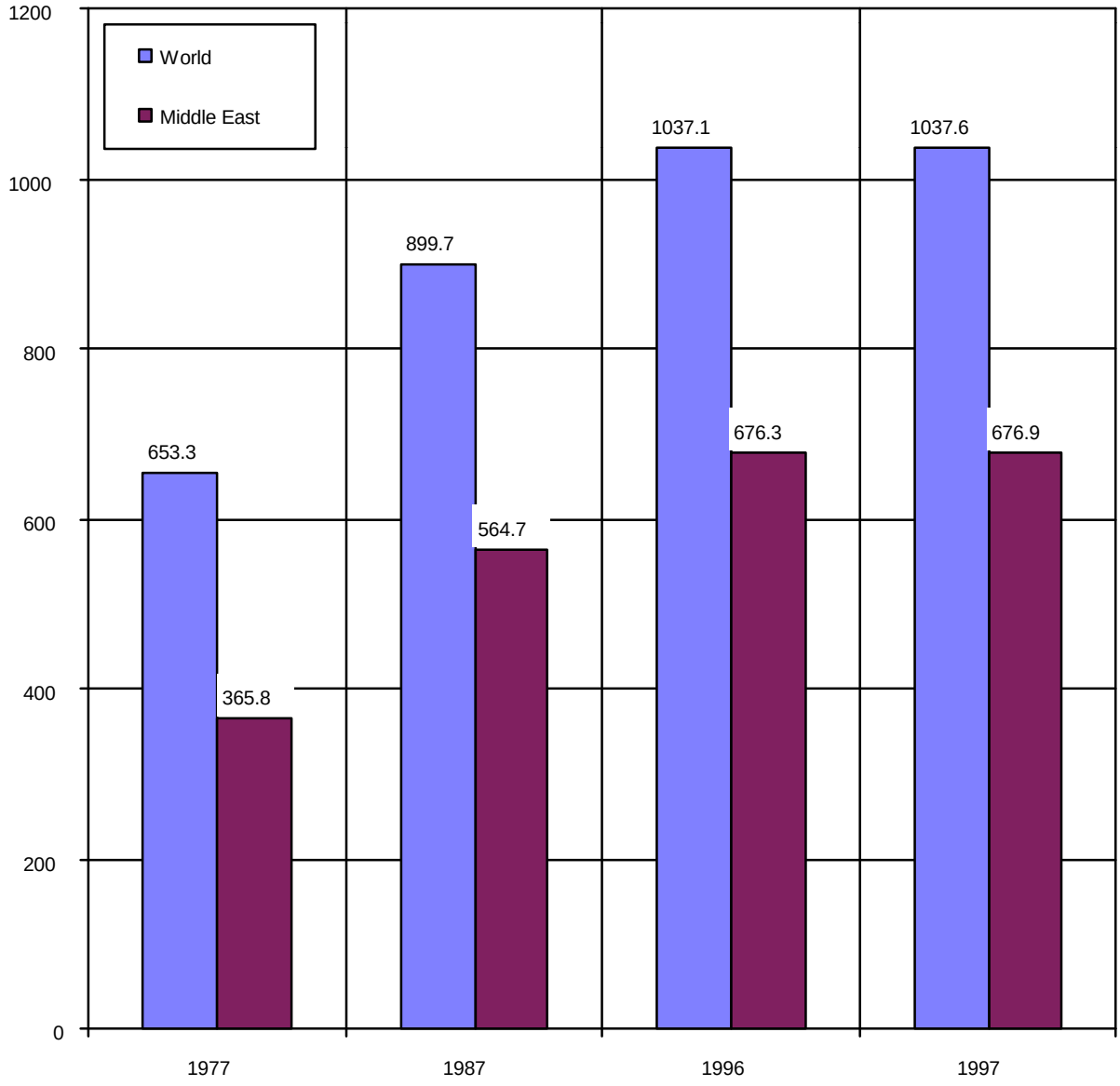
Source: Adapted by Anthony H. Cordesman from the "reference case" EIA, International Energy Outlook, 1998, DOE/EIA-0484(97), pp. 133, 147, 161.

Projected Total Energy Supply for the World Economy

Key Supply Issues

- **Oil dominates future energy supply and demand.**
    - **Barring major shifts, most of oil and gas for Asia must move by tanker**
- **Growth of Coal and Gas use rank second.**
    - **China and India shape coal use.**
    - **Gas use could be much higher if new gas liquids technology takes off.**
- **Nuclear supply only breaks even.**
    - **This assumption depends on Asia solving safety and environmental problems the West has failed to solve.**
    - **Fusion is "off the map" through 2015**
- **Growth of renewables and other technology slows and global impact is minor.**
    - **Growth in this sector is driven by hydroelectric, which is becoming progressively less environmentally benign.**
    - **Net energy gain is often highly uncertain as are net environmental effects: E.g. electric cars, fuel cells, etc.**

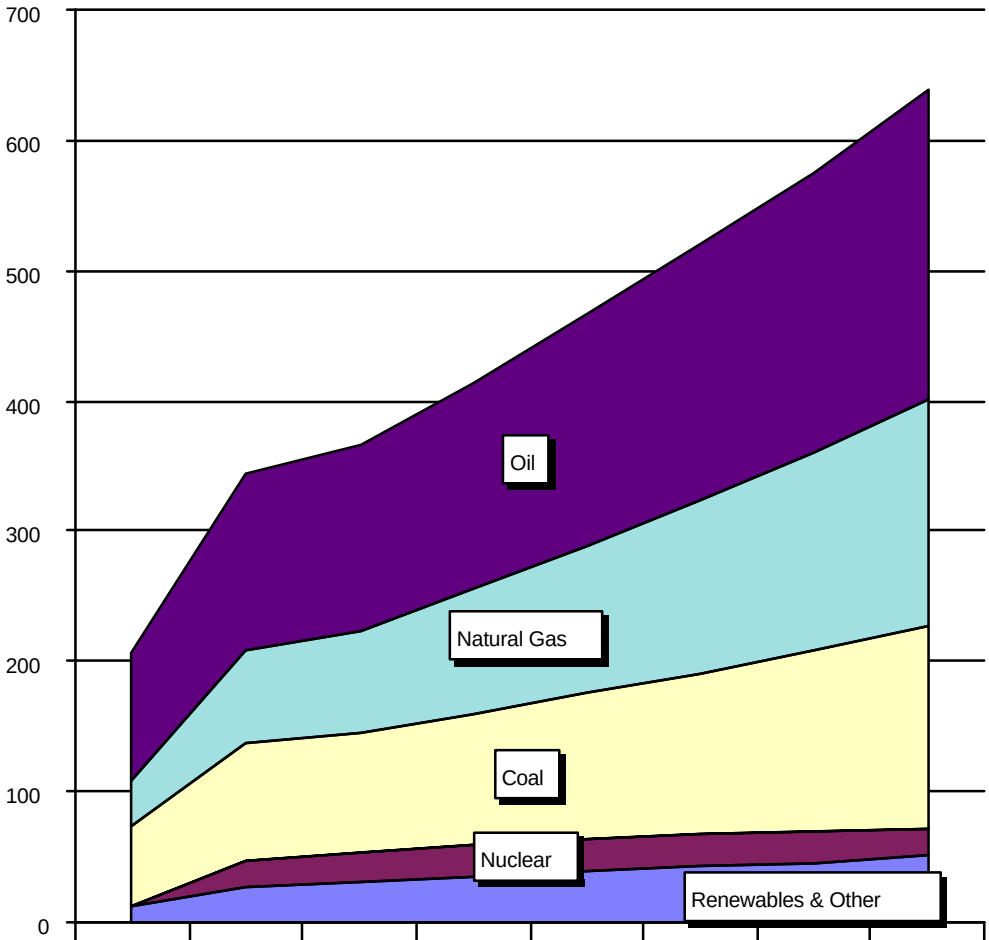
The World is Not Running Out of Oil: The Steady Increase in Proven Global Oil Reserves in Billions of Barrels



Source: Oil and Gas Journal, and BP Statistical Review of World Energy, 1998, p. 4.

Oil and Gas Continue to Dominate Rising World Energy Demand: 1970-2020

(Quadrillion BTU)

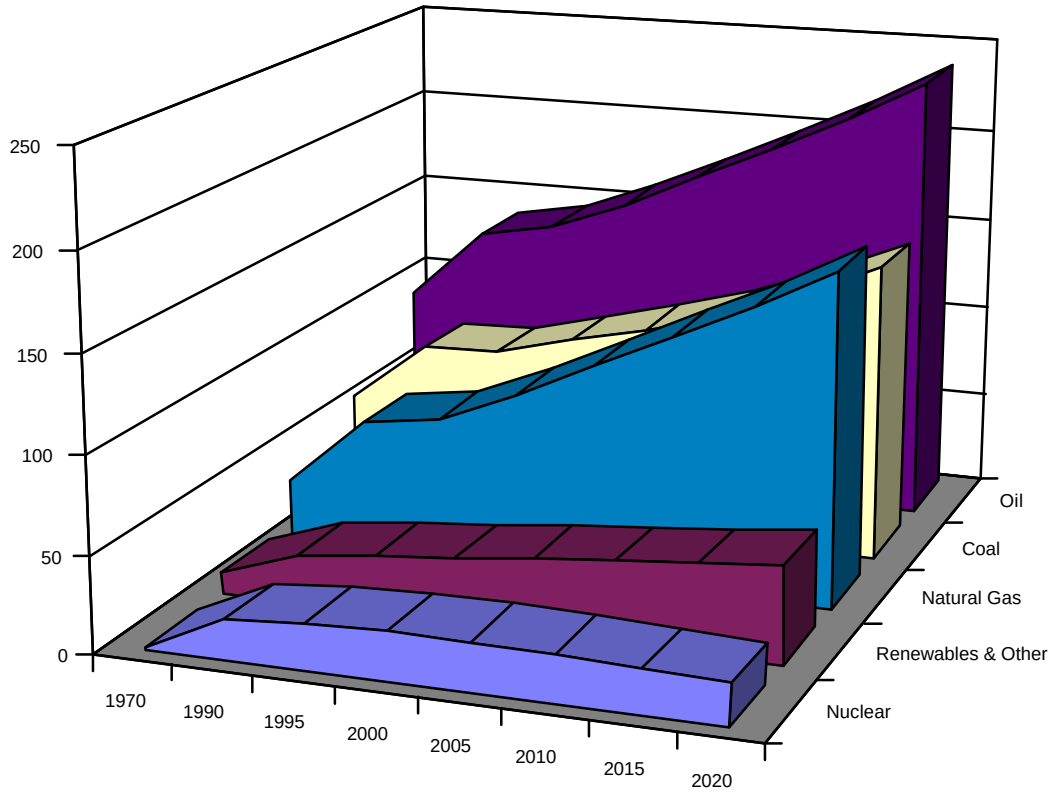


	1970	1990	1995	2000	2005	2010	2015	2020
Oil	97.8	134.9	142.5	157.8	176.3	195.5	215.3	237.3
Natural Gas	36.1	72	78.1	94.8	113.8	133.3	152.5	174.2
Coal	59.7	90.6	91.6	102	112	123.6	138.6	156.4
Nuclear	0.9	20.4	23.3	24.7	25	24.9	23.3	21.3
Renewables & Other	12.2	25.9	30.1	33.8	38.6	42.4	46	50.2

Source: Adapted by Anthony H. Cordesman from EIA, Internet, July 4, 1996, and International Energy Outlook, 1996, DOE/EIA-484(97), p. 7 and 117, and the "reference case" EIA, International Energy Outlook, 1998, DOE/EIA-0484(97), p. 135.

Fossil Fuels Still Dominate World growth in Energy Demand, and the Growth in Demand for Oil is By Far the Most Critical Factor

(Growth in Demand by Type of Energy: 1970-2020 in Quadrillion BTU, EIA Reference Case)



	1970	1990	1995	2000	2005	2010	2015	2020
Nuclear	0.9	20.4	23.3	24.7	25	24.9	23.3	21.3
Renewables & Other	12.2	25.9	30.1	33.8	38.6	42.4	46	50.2
Natural Gas	36.1	72	78.1	94.8	113.8	133.3	152.5	174.2
Coal	59.7	90.6	91.6	102	112	123.6	138.6	156.4
Oil	97.8	134.9	142.5	157.8	176.3	195.5	215.3	237.3

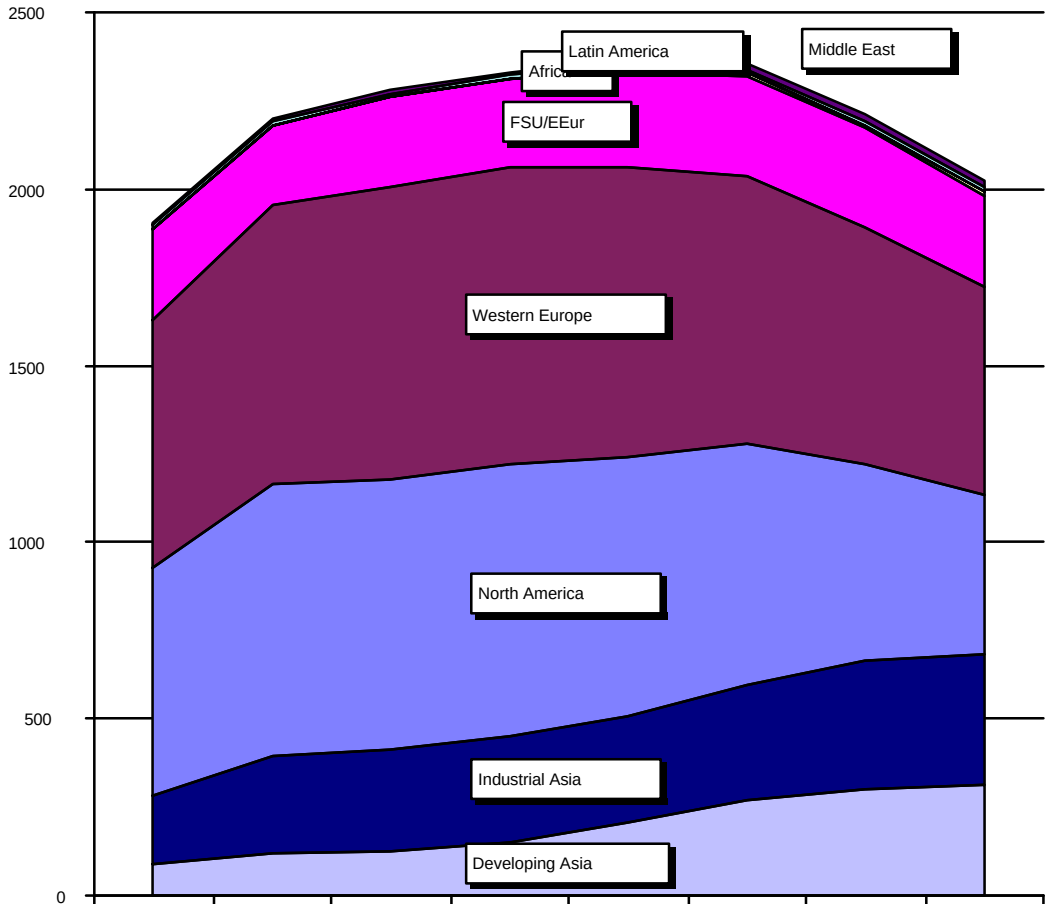
Source: Adapted by Anthony H. Cordesman from EIA, Internet, July 4, 1996, and International Energy Outlook, 1996, DOE/EIA-484(97), p. 7 and 117, and the "reference case" EIA, International Energy Outlook, 1998, DOE/EIA-0484(97), p. 135.

Nuclear Issues

- **Gains are offset by losses.**
    - **US demand projected to drop at an annual average of -1.8% per year through 2015, with cut accelerating as older reactors phase out without replacement after 2010.**
    - **Western Europe peaks in 2000, but output then drops steadily as older reactors phase out without replacement.**
    - **Japan assumed to raise nuclear power output by 1% per year, going from 275 to 339 billion kilowatts.**
    - **China assumed to raise nuclear power output by 11.6% per year, going from 12 to 112 billion kilowatts.**
    - **India assumed to raise nuclear power output by 6.7% per year, going from 7 to 26 billion kilowatts.**
    - **Rest of Asia increases nuclear power by average of 3.2% per year**
    - **Middle East, Africa, Latin and Central America show no real growth.**
- **Demand would be far higher if safety and permitting responded to market forces.**

Asia Will Drive Future Increase in Demand for Nuclear: Total World Consumption by Region: 1990-2020

(Billion Kilowatt Hours)

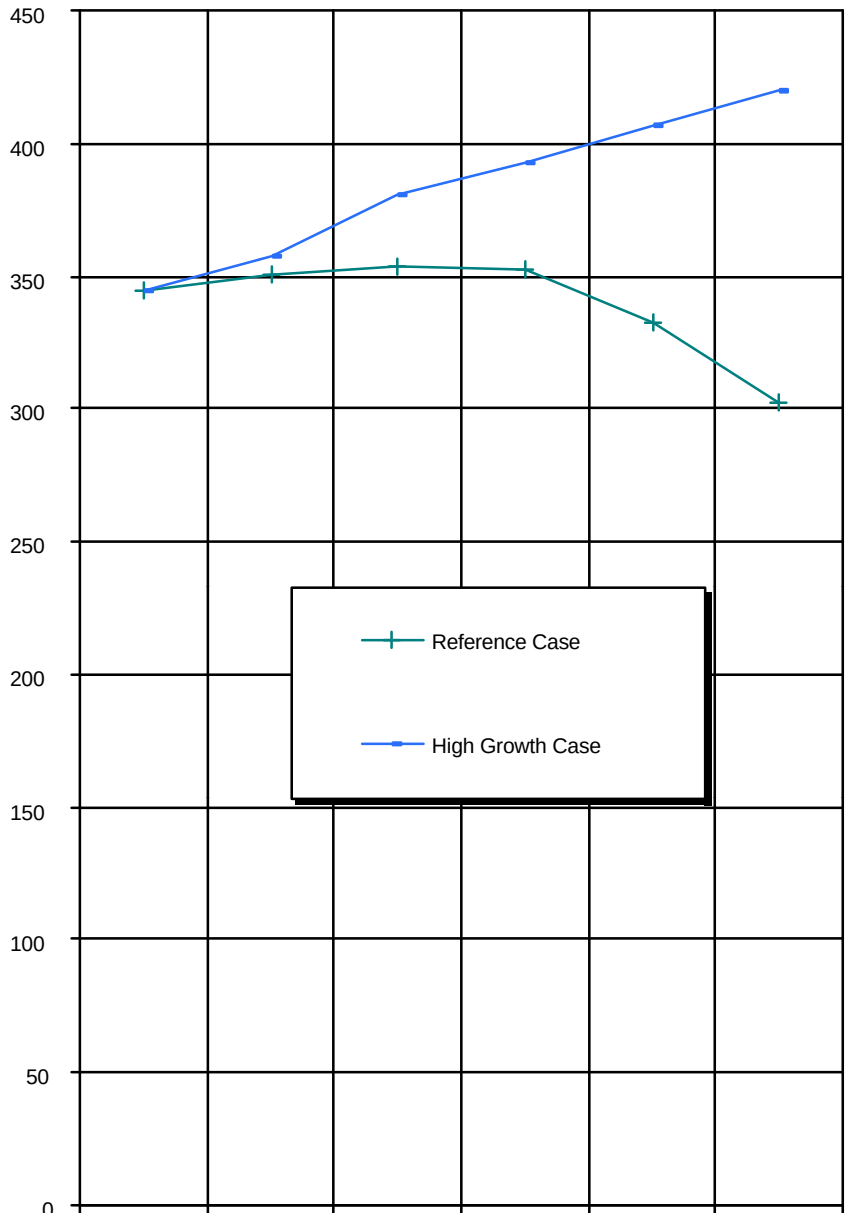


	1990	1995	1996	2000	2005	2010	2015	2020
Latin America	9	9	9	10	17	17	17	17
Africa	8	11	12	11	11	11	11	11
Middle East	0	0	0	0	10	10	10	10
FSU/EEur	256	229	254	248	271	279	278	261
Western Europe	703	785	824	841	821	763	674	588
North America	649	774	770	773	730	683	559	451
Industrial Asia	192	277	283	298	303	324	363	370
Developing Asia	88	117	128	152	205	269	299	313

Source: Adapted by Anthony H. Cordesman from DOE/EIA, International Energy Outlook, 1996, Washington, DOE, EIA-0484(96), May, 1996, p. 92, and International Energy Outlook, 1998, April, 1998, DOE/EIA-484(97), Reference Case, p139.

Nuclear Potential is Far Greater if Safety and Permitting Problems Can Be Solved

(Net Gigawatts)



	1995	2000	2005	2010	2015	2020
Reference Case	344.2	351	354	353	332.5	302.5
High Growth Case	344.2	357.1	380.3	392.6	406.8	419.7

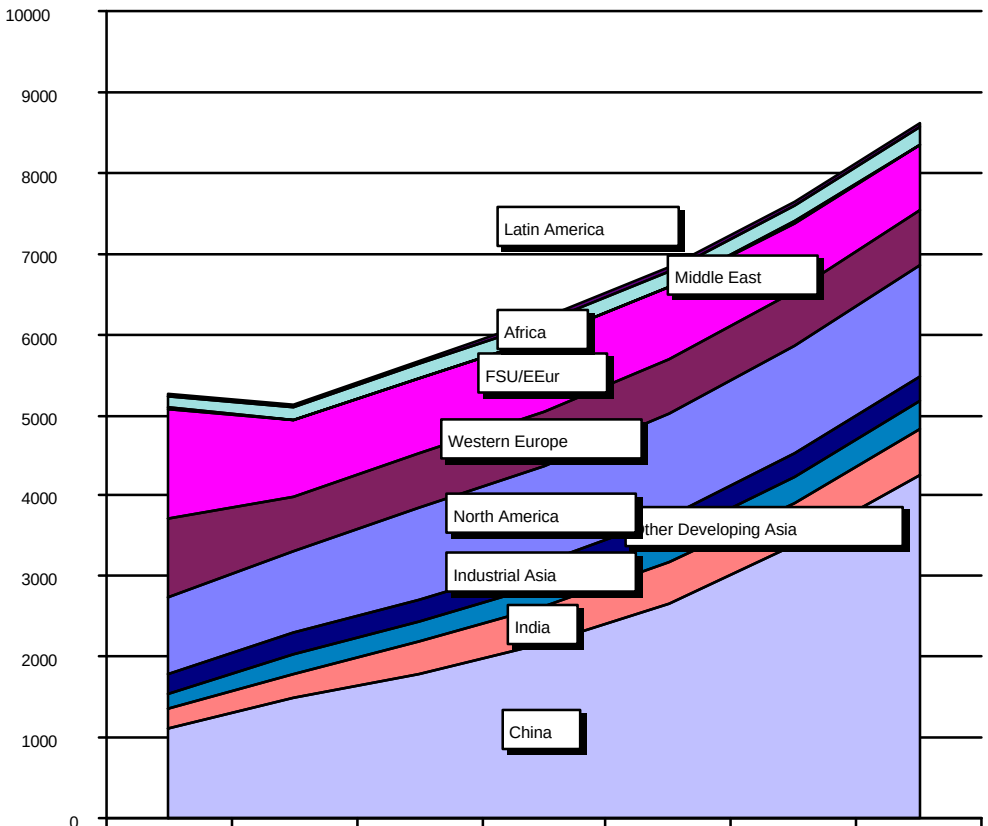
Source: Adapted by Anthony H. Cordesman from the "reference case" EIA, International Energy Outlook, 1998, DOE/EIA-0484(97), pp. 89.

Coal Issues

- **Gains are driven by China, India, and Latin America.**
    - **US rises slowly at an annual average of 1.1% per year through 2015, from 1,019 to 1,264 million short tons (MST).**
    - **Western Europe dropped from 951 MST in 1990 to 678 in 1995, but will recover slightly to 699 MST in 2015, but output then drops steadily as older reactors phase out without replacement.**
    - **FSU and Eastern Europe dropped from 1,374 MST in 1990 to 904 MST in 1995, and will dropped to 845 in 2015.**
    - **China will increase coal use by 3.8% per year, going from 1,464 MST to 3,089 MST.**
    - **India will increase coal use by 3.1% per year, going from 327 MST to 605 MST.**
    - **Rest of Asia will increase coal use by 2.0% per year, going from 222 MST to 330 MST.**
    - **Latin and Central America will increase coal use by 2.6% per year, going from 12,238 MST to 4,285 MST.**
    - **Middle East and Africa show no real growth.**
- **Coal exports will steadily increase in geopolitical significance.**

China and India Will Drive Future Increase in Demand for Coal: Total World Consumption by Region: 1990-2020

(Million Short Tons)

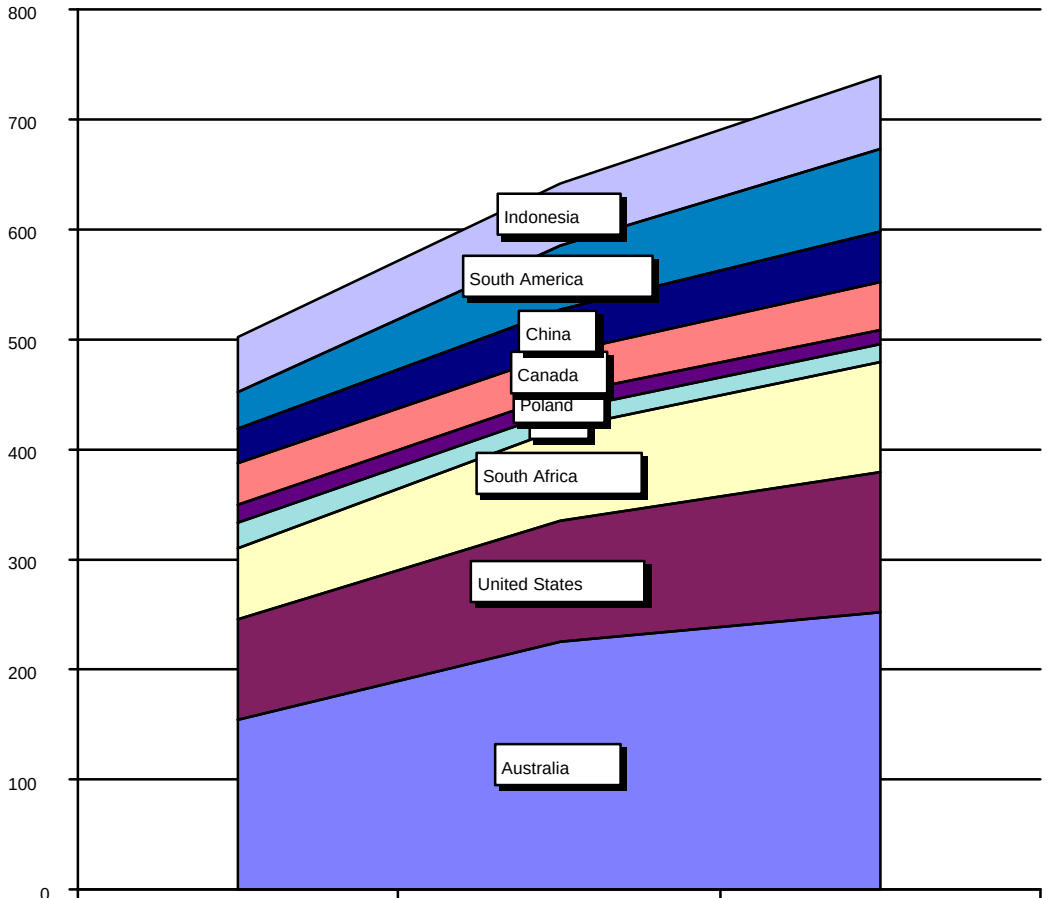


	1990	1995	2000	2005	2010	2015	2020
Latin America	30	32	37	44	47	53	59
Africa	152	172	171	178	191	203	217
Middle East	6	8	10	12	13	15	16
FSU/EEur	1372	934	919	918	887	848	805
Western Europe	958	674	679	670	676	681	686
North America	957	1013	1148	1209	1263	1319	1365
Industrial Asia	233	257	267	273	286	292	301
Other Developing Asia	190	244	247	273	298	324	355
India	242	312	387	444	499	537	581
China	1124	1489	1796	2176	2666	3374	4242

Source: Adapted by Anthony H. Cordesman from DOE/EIA, International Energy Outlook, 1996, Washington, DOE, EIA-0484(96), May, 1996, p. 92, and International Energy Outlook, 1998, April, 1998, DOE/EIA-484(97), Reference Case, p. 138.

Coal is the Forgotten Energy Export: 1990-2020

(Million Short Tons)

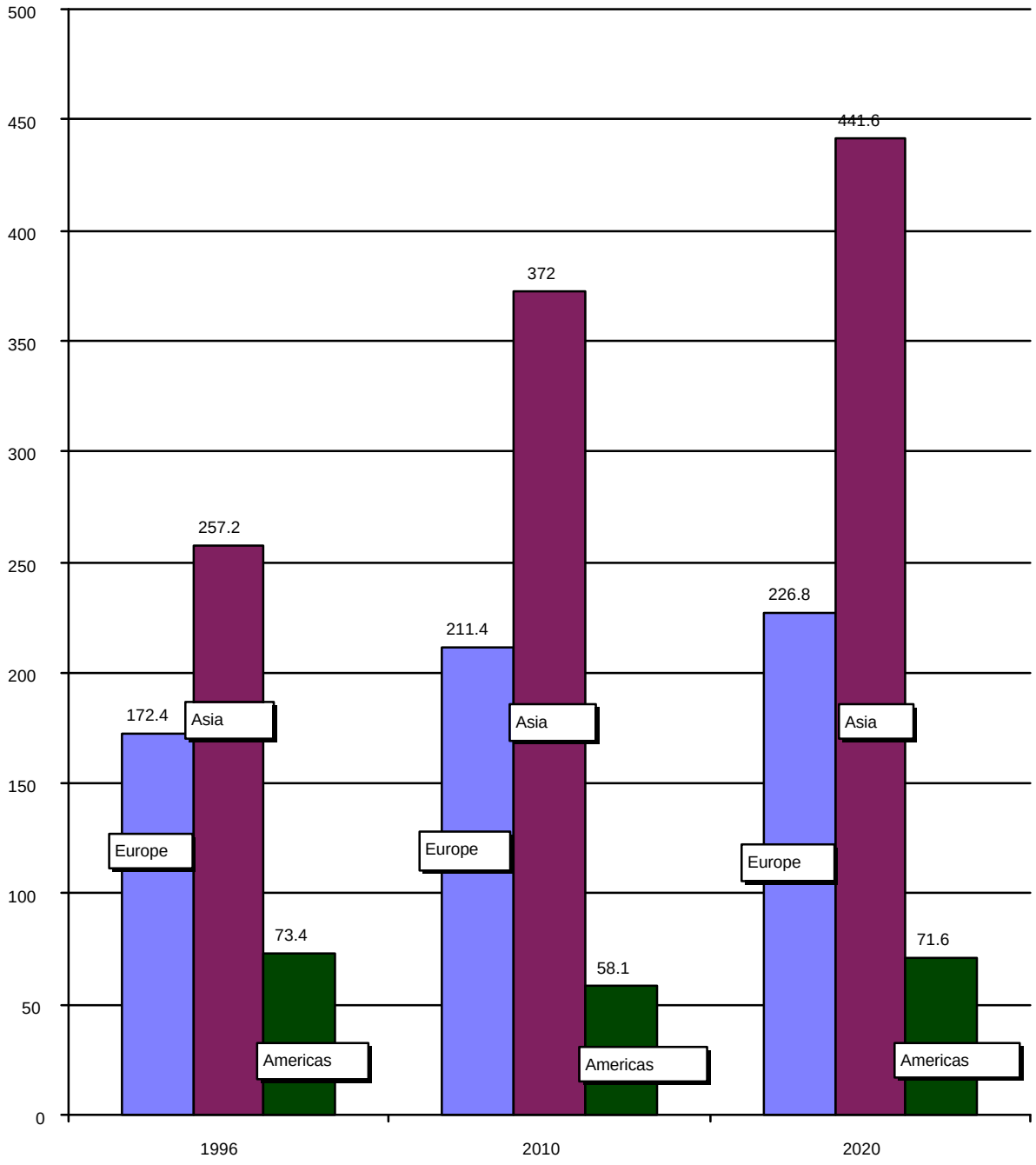


	1996	2010	2020
Indonesia	51.9	56	66.6
South America	32.3	57.8	74.7
China	31	39.2	45.9
Canada	38.1	39.4	43.5
Poland	16.8	14.1	13.9
FSU	22.2	16	16.4
South Africa	65.6	82.8	100.1
United States	90.5	111.6	127.7
Australia	154.7	224.6	251.1

Source: Adapted by Anthony H. Cordesman from DOE/EIA, International Energy Outlook, 1996, Washington, DOE, EIA-0484(96), May, 1996, p. 92, and International Energy Outlook, 1997, April, 1998, DOE/EIA-484(97), Reference Case, p. 81.

Demand for Coal Imports: 1990-2020

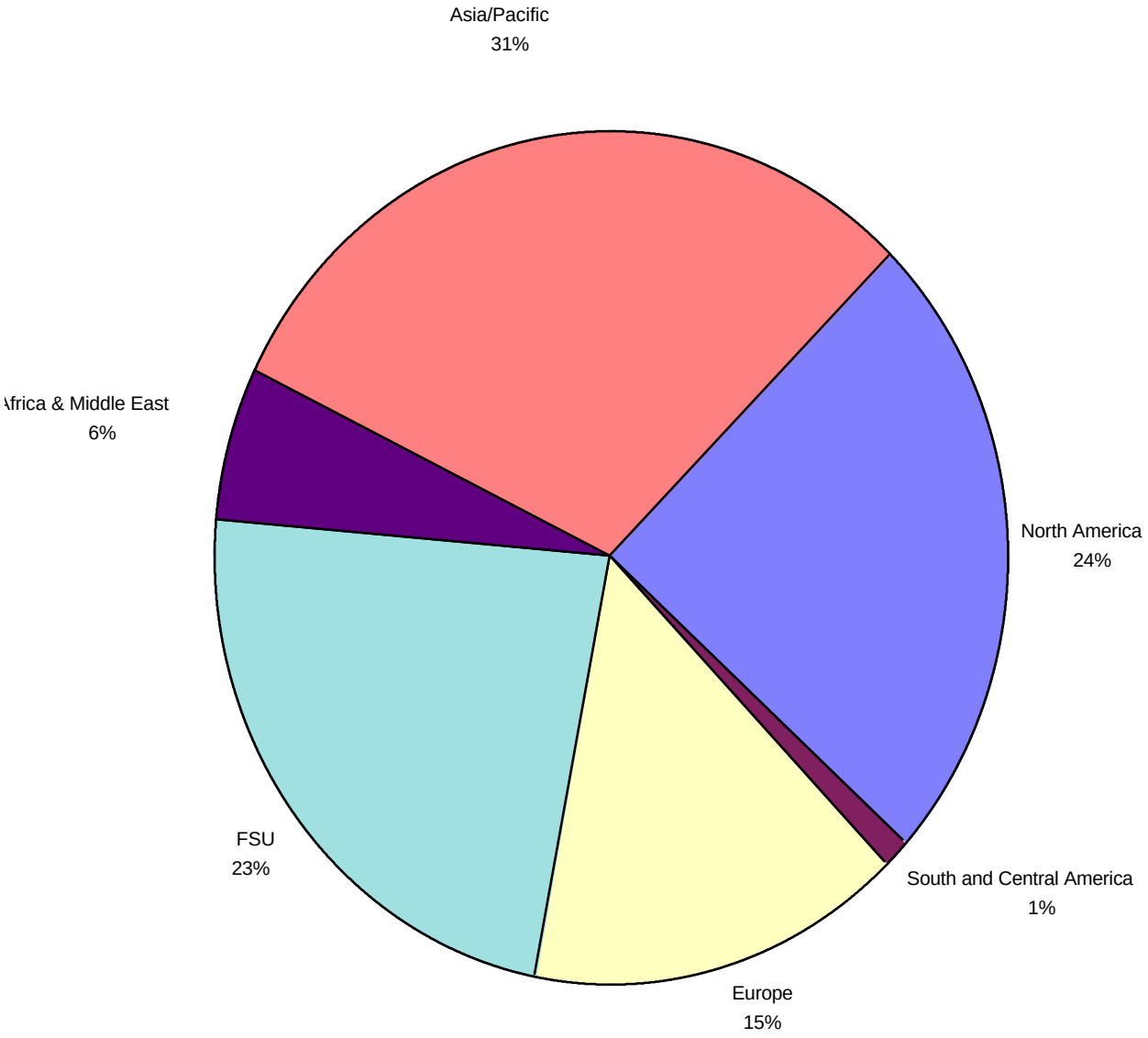
(Million Short Tons)



Source: Adapted by Anthony H. Cordesman from DOE/EIA, International Energy Outlook, 1996, Washington, DOE, EIA-0484(96), May, 1996, p. 92, and International Energy Outlook, 1998, April, 1997, DOE/EIA-484(97), Reference Case, p. 81.

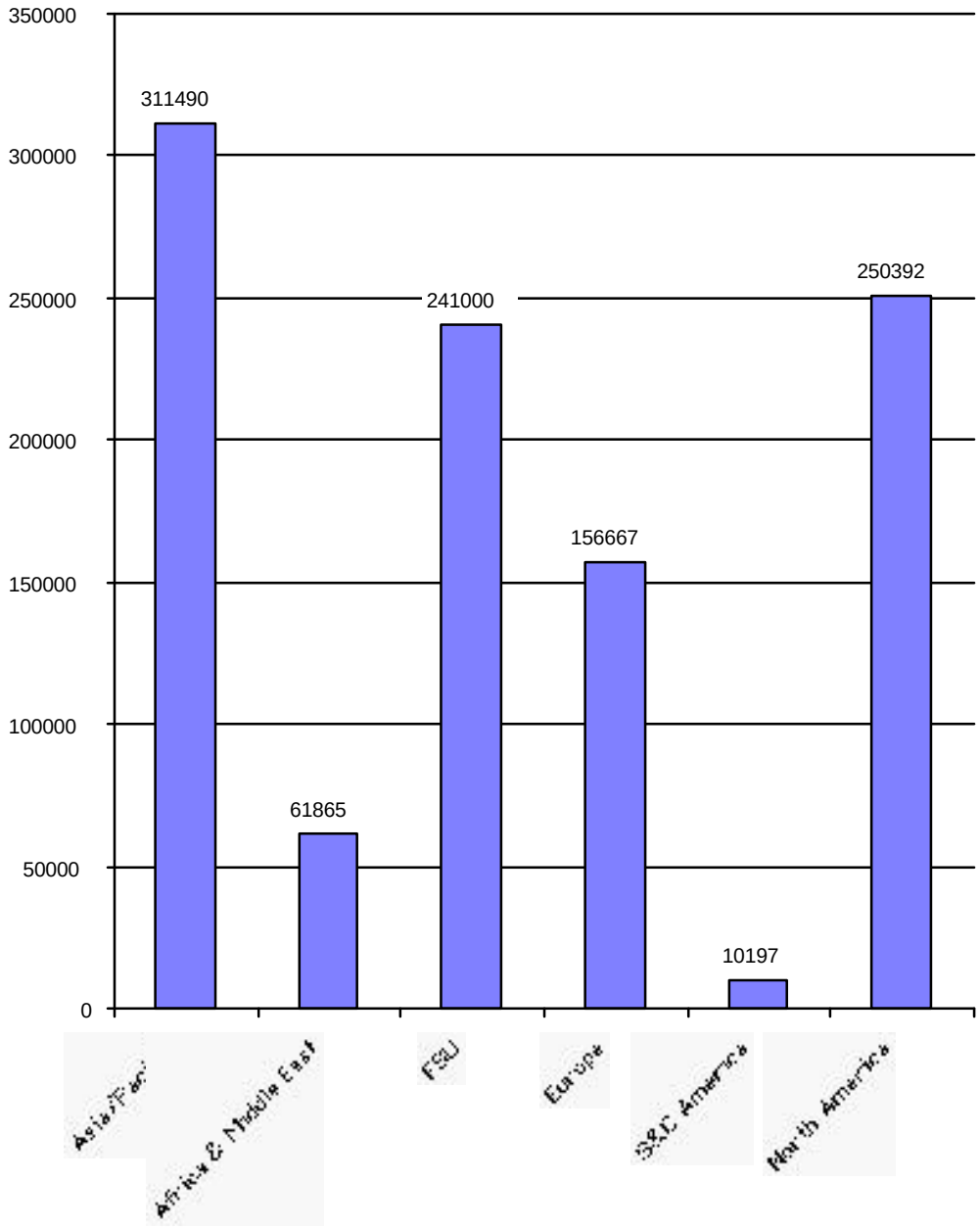
Regional Coal Reserves as a Percent of World Total

(Based on Oil and Gas Journal Forecast for a World Total of 1,031,610 Million Tons)



Source: Oil and Gas Journal, and BP Statistical Review of World Energy, 1998, p. 30.

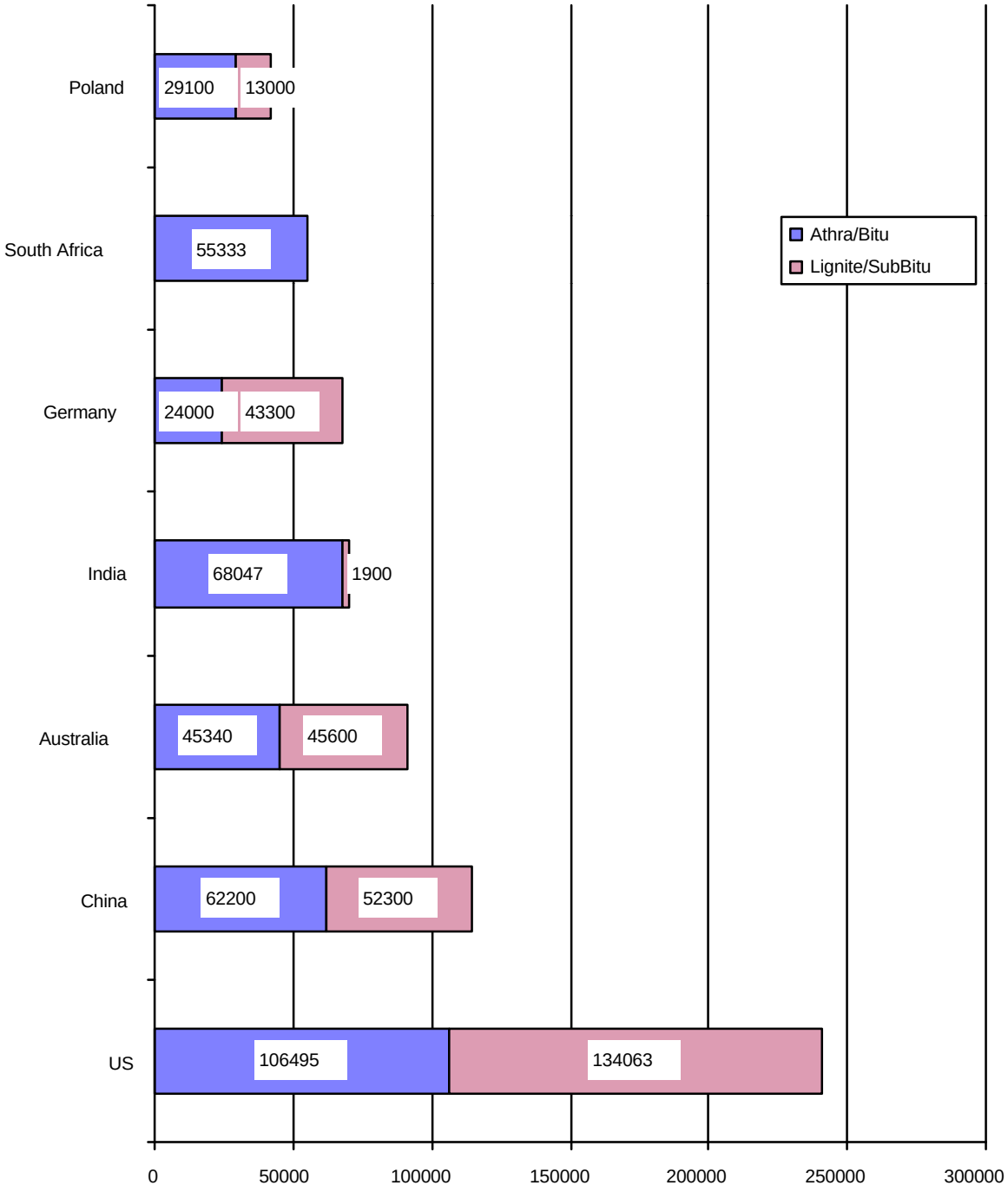
World Coal Reserves by Region in Millions of Tons



Source: Oil and Gas Journal, and BP Statistical Review of World Energy, 1998, p. 30.

Coal Reserves by Key Nation

(Nations with More than 40,000 Thousand Million Tons)



Source: Oil and Gas Journal, and BP Statistical Review of World Energy, 1998, p. 20.

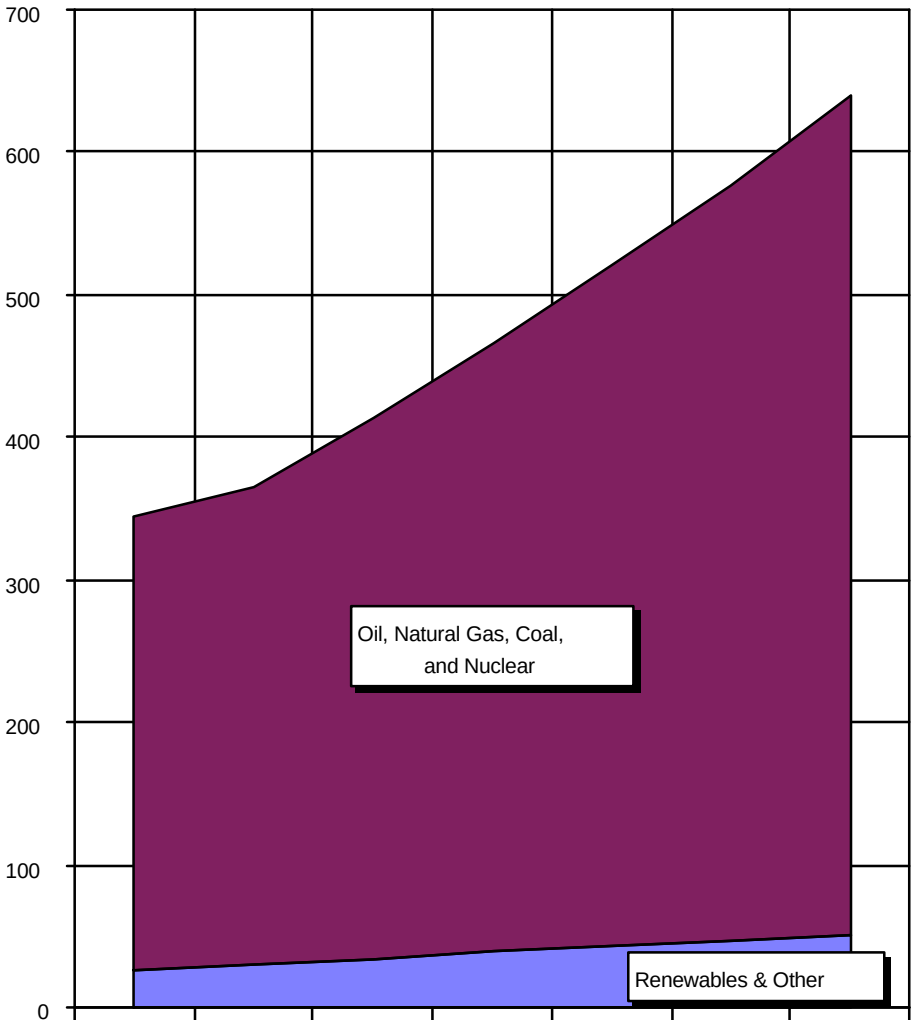
.

Renewables and New Sources of Energy

- **Gains are driven by hydroelectric and burning of waste and biomass, not new technology.**
  - **No major near to mid-term breakthroughs are anticipated.**
  - **Hydroelectric may prove to have significant risk and negative environmental impacts in some Asian countries.**
  - **Issues like clean coal, gas liquifaction, and safe nuclear will *each* be far more important than all issues affecting new sources of energy.**
- **Total net environmental impact on many new technologies -- like methanol, battery-powered cars, and some forms of solar electric -- may be a negative as burning petroleum.**
- **The US is now virtually the only nation conducting major experiments in significant commercialization of new technologies, and the impact on the US is very limited and produces questionable net energy gain and environmental impacts.**
  - **Developing nations cannot afford regulation and non-economic choices.**
  - **They lack the research and industrial base to conduct major programs.**
- **Fusion is effectively a non-starter for the near to mid-term, and no prediction is possible for the long-term.**
- **Geothermal is a non-starter.**
- **Biomass shows little sign of major technology growth.**
- **Solar electric is the area where a significant breakthrough is at least technically possible.**

The Growth of Renewables and New Sources of Energy Will Have Little Impact on Rising World Energy Demand: 1970-2020

(Quadrillion BTU)

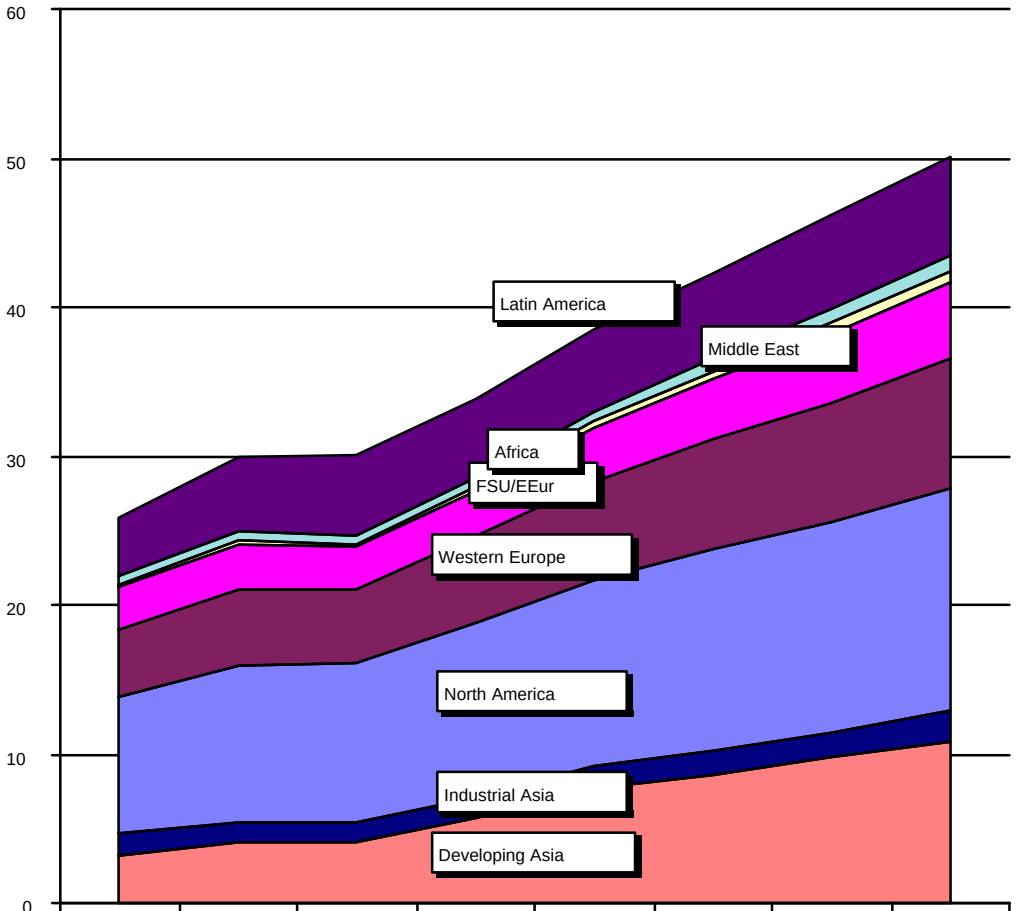


	1990	1995	2000	2005	2010	2015	2020
Oil, Natural Gas, Coal, and Nuclear	319	335.5	379.2	427.1	477.2	529.6	589.2
Renewables & Other	25.9	30.1	33.8	38.6	42.4	46	50.2

Source: Adapted by Anthony H. Cordesman from the "reference case" EIA, International Energy Outlook, 1998, DOE/EIA-0484(97), p. 135.

North America and Asia Will Lead in Increase in Hydroelectric, Geothermal, Wind, Solar and Other Renewables: 1990-2020

(Quadrillions of BTUs)



	1990	1995	1996	2000	2005	2010	2015	2020
Latin America	3.9	5.1	5.4	5.3	5.5	5.8	6.2	6.6
Africa	0.6	0.6	0.6	0.6	0.7	0.8	1	1.1
Middle East	0.1	0.2	0.2	0.3	0.4	0.5	0.7	0.8
FSU/EEur	2.8	3	2.9	3.1	3.6	4	4.6	5.1
Western Europe	4.6	5.1	4.9	5.8	6.6	7.4	8	8.7
North America	9.2	10.6	10.7	11.7	12.6	13.5	14.1	14.8
Industrial Asia	1.4	1.4	1.4	1.4	1.5	1.7	1.8	2.1
Developing Asia	3.2	4	4	5.7	7.6	8.6	9.7	10.9

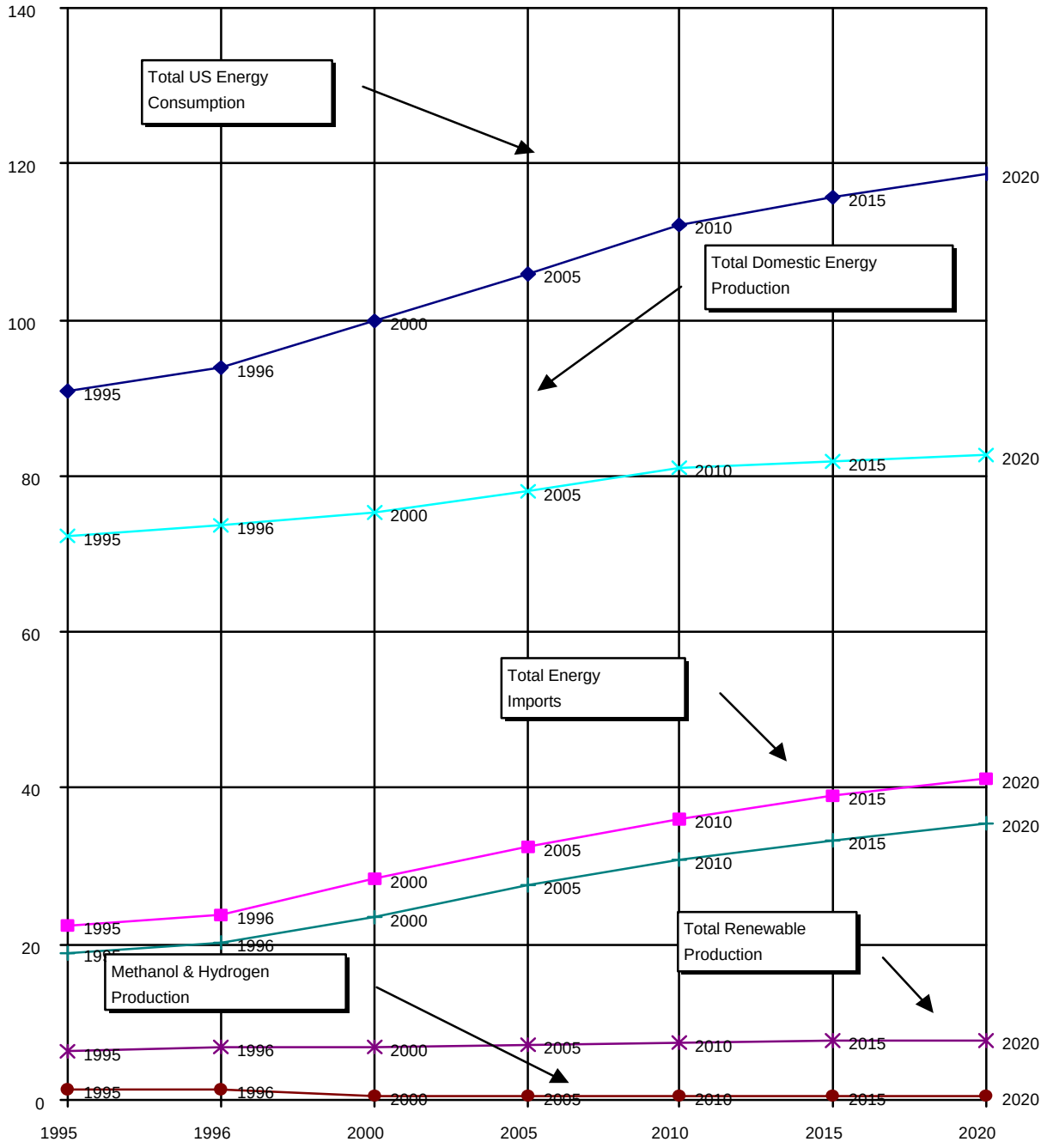
Source: Adapted by Anthony H. Cordesman from DOE/EIA, International Energy Outlook, 1996, Washington, DOE, EIA-0484(96), May, 1996, p. 92, and International Energy Outlook, 1997, April, 1998, DOE/EIA-484(97), Reference Case, p. 140.

Barring an Unanticipated Breakthrough, Technology Gain in Oil, Gas, Coal, and Nuclear Will Be Far More Important Than the Petty Increases From New Sources of Energy

- **No useful model seems to be available for global adoption of new technologies.**
- **The US is, however, a potential model because legislation and regulation force the pace over market driven demand. The US is the high demand case.**
- **If so, the model is not reassuring.**
    - **Increase from all renewables is small, and has limited impact on energy balances.**
    - **If only new fuels are examined, the imp-act of renewables is truly negligible.**
- **The US model for the transportation sector seems to be a politically correct nightmare.**
    - **DOE/EIA projects that cars using new fuels will do more harm than good.**

Even in the US, Renewables & New Fuels Will Have a Negligible Near to Mid Term Future Growth: Total Consumption Versus Domestic Production, Imports, and New Fuels: 1990-2015

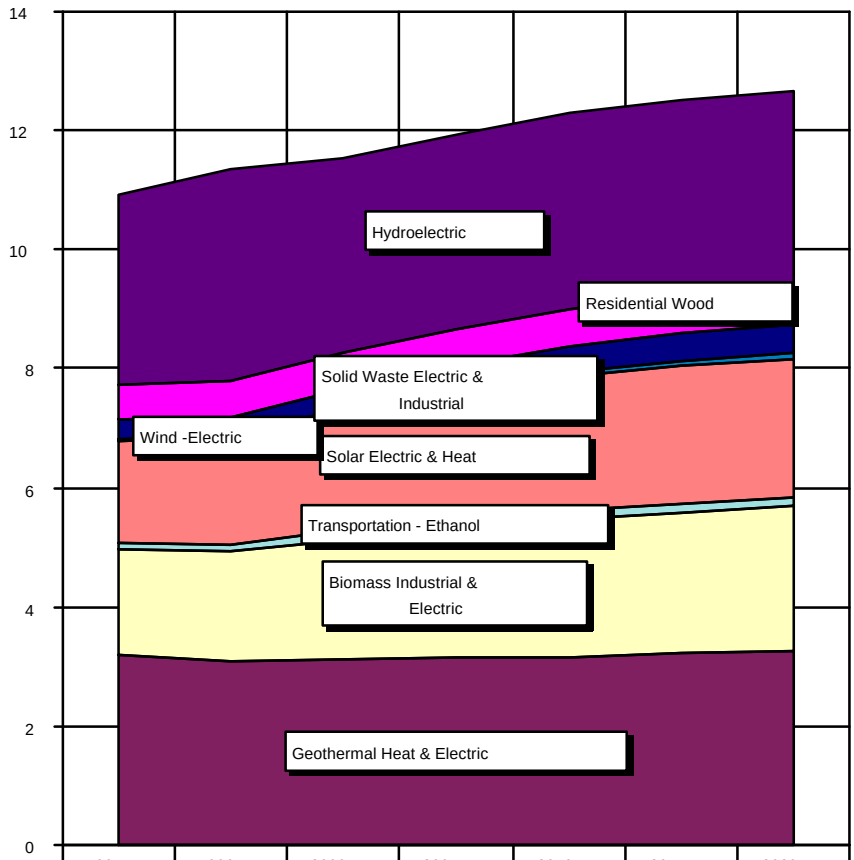
(Quadrillions of BTUs)



Source: Adapted by Anthony H. Cordesman from DOE/EIA, Annual Energy Outlook, 1997, Washington, DOE, EIA-0383(97), December, 1996, p. 96.

US Use of Renewables Shows Little Impact from Advanced Technologies: 1990-2020

(Quadrillions of BTUs)

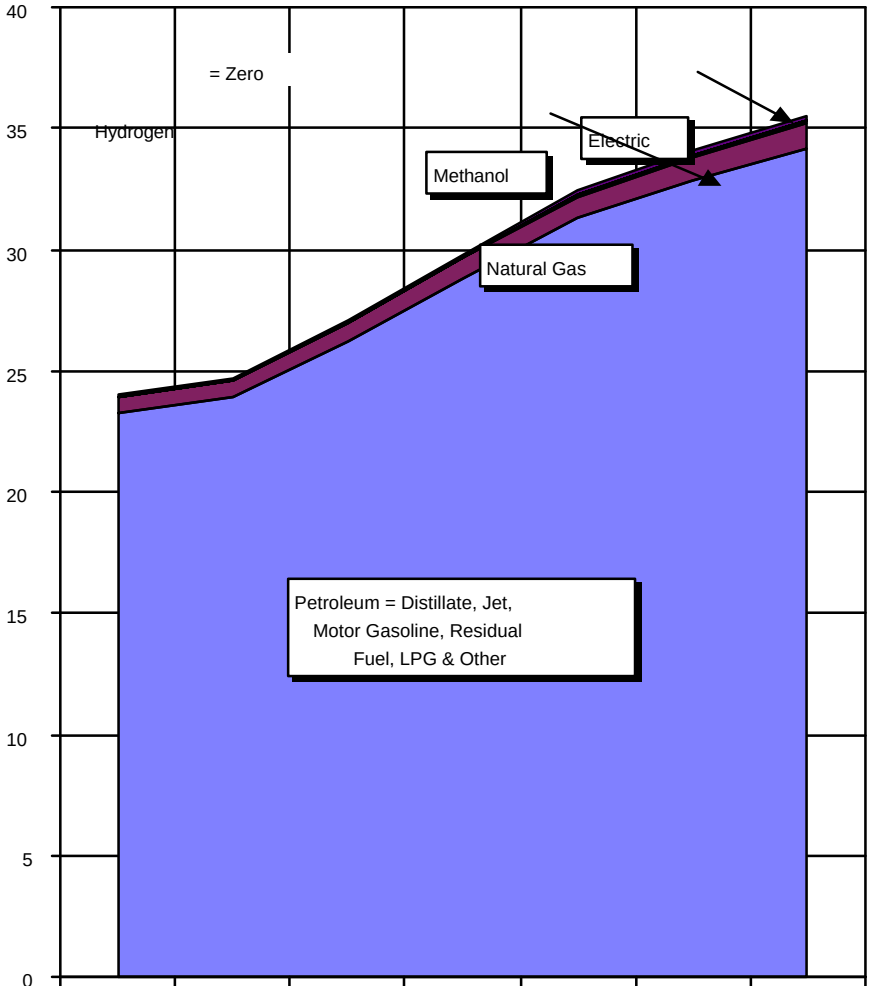


	1995	1996	2000	2005	2010	2015	2020
Hydroelectric	3.18	3.56	3.25	3.27	3.28	3.28	3.28
Residential Wood	0.59	0.61	0.61	0.62	0.63	0.64	0.64
Solid Waste Electric & Industrial	0.3	0.3	0.34	0.38	0.43	0.47	0.48
Wind -Electric	0.03	0.03	0.06	0.08	0.08	0.09	0.1
Solar Electric & Heat	1.73	1.82	1.96	2.1	2.24	2.31	2.34
Transportation - Ethanol	0.11	0.1	0.17	0.17	0.17	0.14	0.15
Biomass Industrial & Electric	1.76	1.84	2	2.15	2.29	2.37	2.41
Geothermal Heat & Electric	3.2	3.1	3.13	3.16	3.17	3.22	3.27

Source: Adapted by Anthony H. Cordesman from DOE/EIA, Annual Energy Outlook, 1997, Washington, DOE, EIA-0383(97), December, 1996, p. 119.

The US Will Make Negligible Net Progress in Reforming Energy Use in the Transportation Sector

(Quadrillions of BTUs)

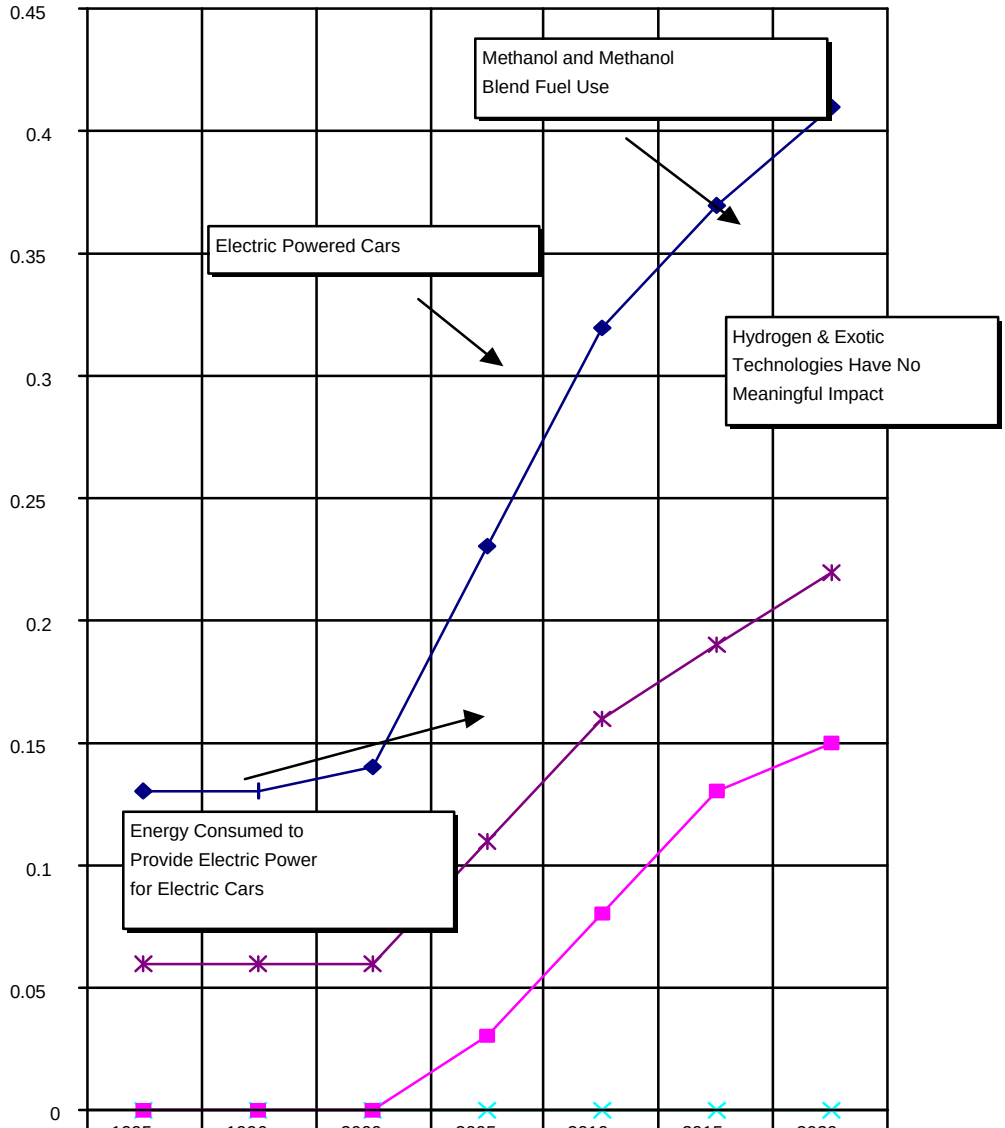


	1995	1995	2000	2005	2010	2015	2020
Electric	0.06	0.06	0.06	0.11	0.16	0.19	0.22
Hydrogen	0	0	0	0	0	0	0
Methanol	0	0	0	0.03	0.08	0.13	0.15
Natural Gas	0.72	0.73	0.8	0.85	0.95	0.99	1.03
Petroleum = Distillate, Jet, Motor Gasoline, Residual Fuel, LPG & Other	23.21	23.91	26.22	28.81	31.25	32.8	34.14

Source: Adapted by Anthony H. Cordesman from DOE/EIA, Annual Energy Outlook, 1998, Washington, DOE, EIA-0383(97), December, 1996, p. 102.

US Efforts to Create Truly New Energy Sources Are So Inefficient They Will Produce No Net Energy Gain or Emission Savings

(Quadrillions of BTUs)



	1995	1996	2000	2005	2010	2015	2020
Hydrogen	0	0	0	0	0	0	0
Electric	0.06	0.06	0.06	0.11	0.16	0.19	0.22
Electricy Related Losses	0.13	0.13	0.14	0.23	0.32	0.37	0.41
Methanol	0	0	0	0.03	0.08	0.13	0.15

Source: Adapted by Anthony H. Cordesman from DOE/EIA, Annual Energy Outlook, 1998, Washington, DOE, EIA-0383(97), December, 1996, p. 102.

Energy and Pollution:

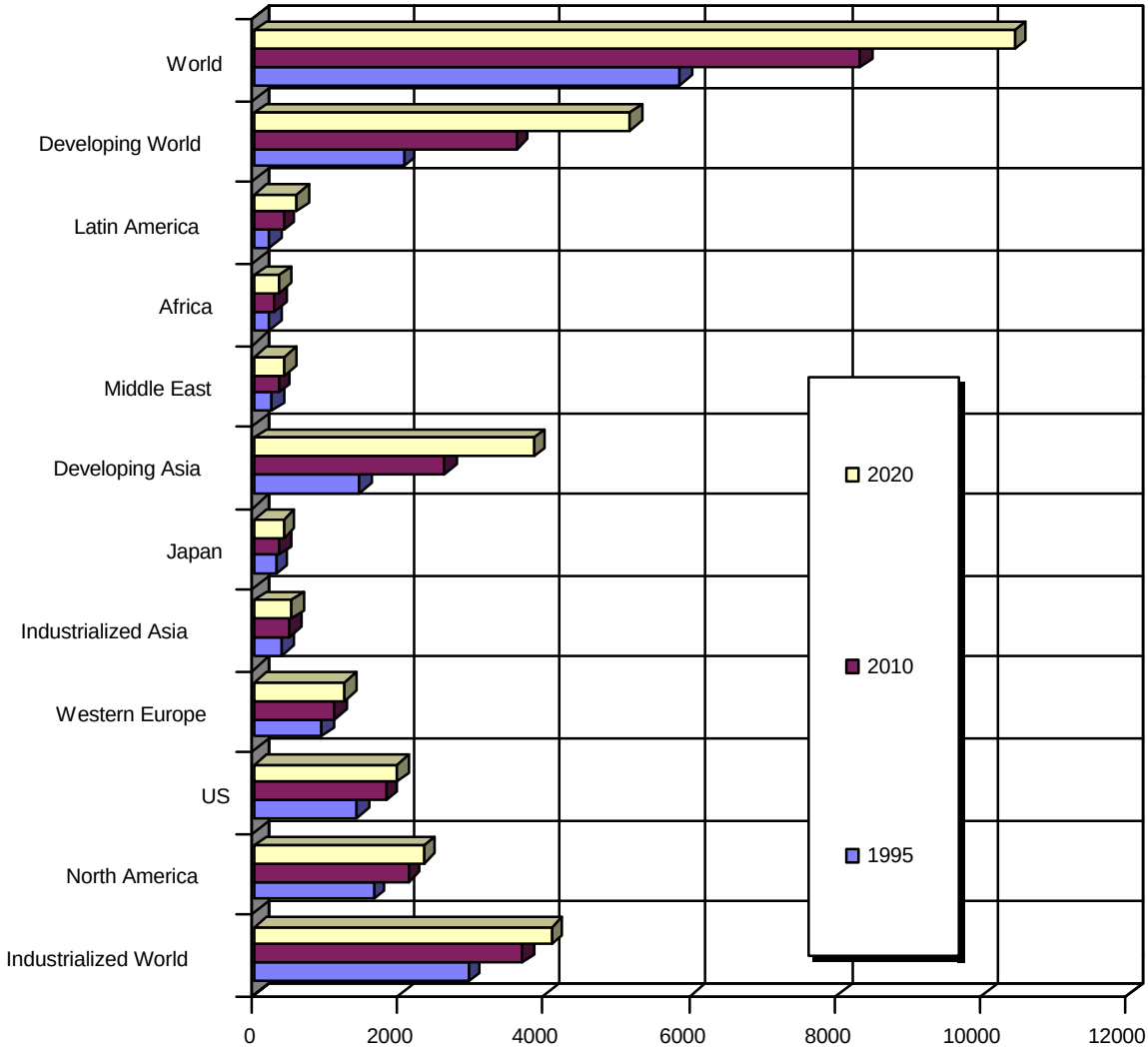
Global Warming is Only Part of the Problem

Key Issues Affecting Energy Impacts

- **Global warming may be uncertain, but vast increases in emissions, effluents and solid wastes are not.**
- **In the near to mid-term, the problem is more regional and national than global.**
    - **High growth countries dominate the problem**
    - **This means China and emerging Asian states will dominate the problem.**
- **Selective controls and standards merely export industrial activity and problems to less controlled regions.**
- **Trade-offs often exist between emissions, effluents, and solid wastes. These are poorly modeled and it is often impossible to relate energy trade-offs to overall environmental impacts.**
- **Nuclear power and hydroelectric energy are often assumed to be safe because they do not emit. This does not make them "safe."**
- **Estimates of "clean coal" use are extremely uncertain in terms of cost, net emissions, and size effluents and solid wastes.**
    - **No advanced use of coal has yet been proven cost-effective at commercial scale.**
    - **Land impact, waste, transportation impacts, and byproducts remain key issues.**
- **Net pollution relative to net energy gain at net economic cost is the real issue, but the literature and analytic base is highly ideological.**

Who Pollutes? The Developing World and Asia Will Overtake the Industrialized World and The West: Total World Carbon Emissions 1995-2020

(Total Carbon Emissions in Millions of Metric Tons, EIA Reference Case)

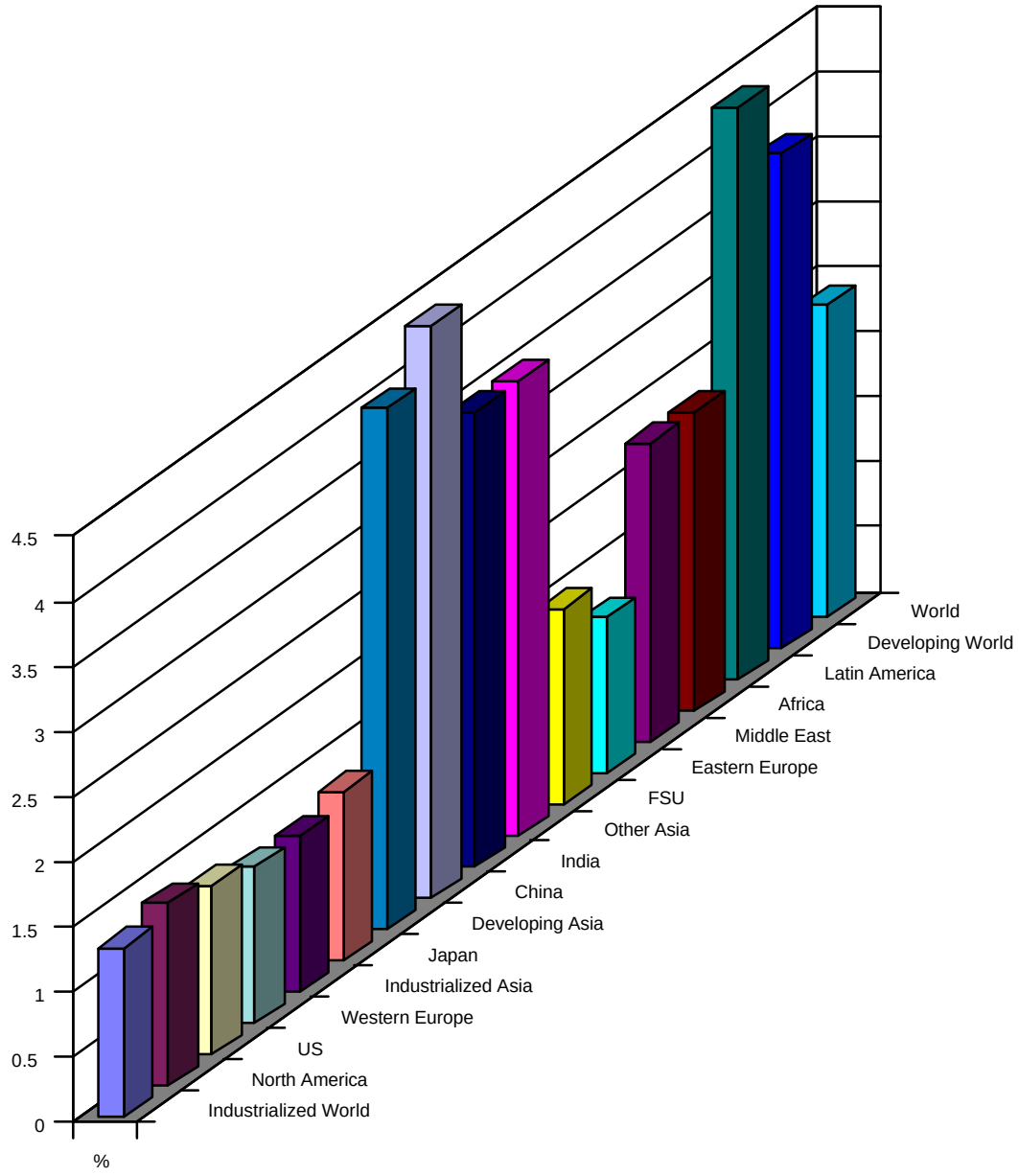


	Industrialized World	North America	US	Western Europe	Industrialized Asia	Japan	Developing Asia	Middle East	Africa	Latin America	Developing World	World
2020	4066	2313	1956	1239	514	385	3835	409	341	574	5158	10447
2010	3667	2105	1803	1101	461	342	2603	322	276	391	3591	8330
1995	2933	1629	1411	925	379	281	1427	229	192	194	2043	5841

Source: Adapted by Anthony H. Cordesman from EIA, International Energy Outlook, 1998, DOE/EIA-0484 (97), April 1997, p. 142.

Who Makes Pollution Grow? Developing Asia is Clearly the Problem

(Average Annual Increase in Total Carbon Emissions 1995-2015 In Millions of Metric Tons, EIA Reference Case)



Source: Adapted by Anthony H. Cordesman from EIA, International Energy Outlook, 1998, DOE/EIA-0484 (97), April 1997, p. 142.

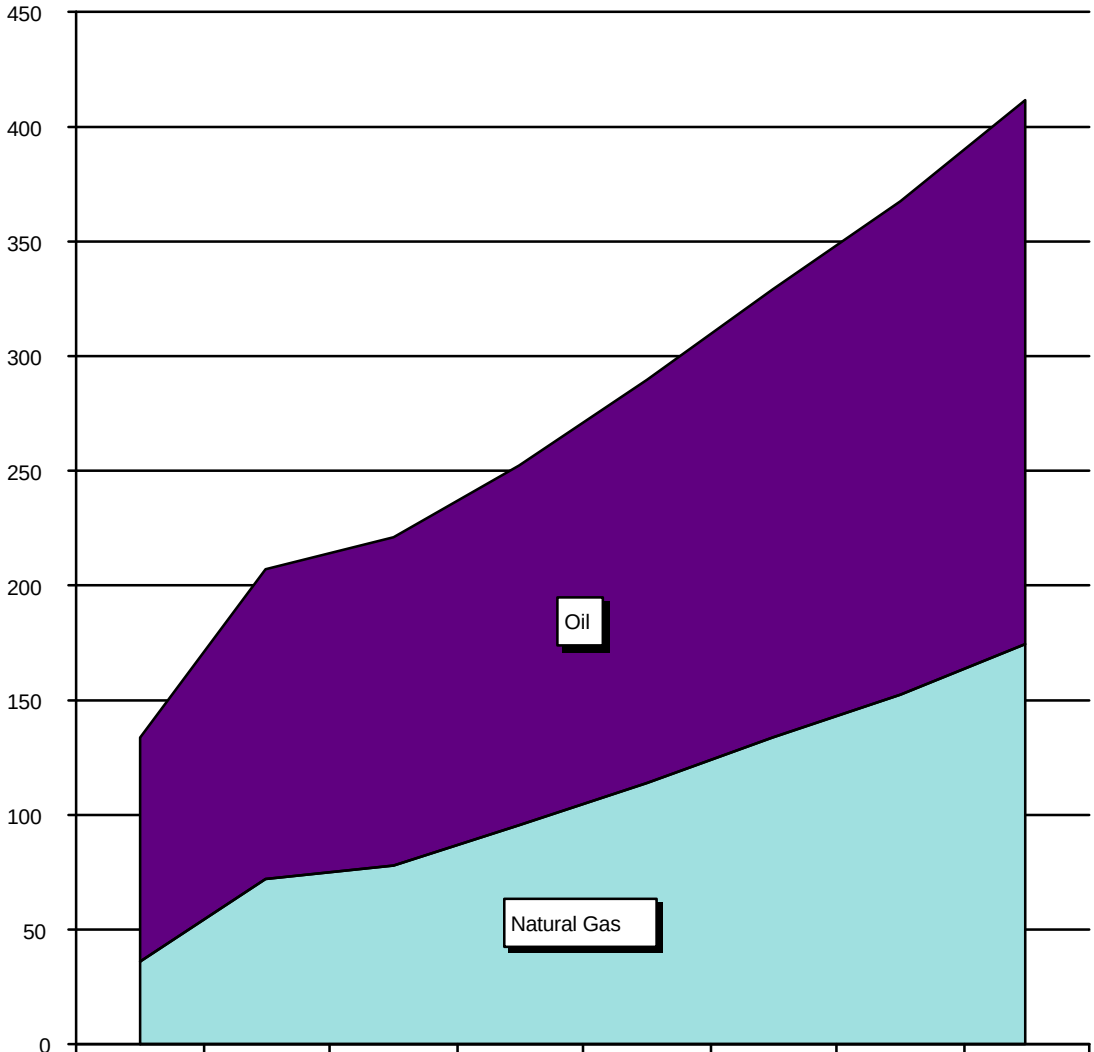
Impact of Oil and Gas on Present and Future Global Energy Demand

Key Oil Issues

- **Oil and gas energy use rises by 75% in BTUs between 1997 and 2020.**
- **Industrialized world and US become steadily more dependent on imports, with economic growth and Enhanced Oil Recovery (EOR) acting as the major uncertainty.**
- **Demand from the industrialized world, however, no longer dominates growth.**
    - **Asian demand has leapt since early 1960s.**
    - **Asia will become the dominant consuming region by 2010.**
    - **Asia's Imports will increase accordingly.**
    - **China is actively competing in the "Great Game" for Central Asia oil and has outbid US firms in some areas.**
- **The Middle East and the Gulf are projected to dominate increases in oil supply.**
- **The growing domestic demand for oil in other developing regions will become a major factor and with steadily limit the export capabilities of the Middle East, Africa, and FSU.**
- **Pipeline, port, and tanker geopolitics will change fundamentally during 1998-2020.**
- **Iran, Iraq, Libya, and Russia represent "high risk" oil suppliers with major potential geopolitical impacts.**

Estimated Growth of Oil and Gas Use: 1970-2020

(Quadrillion BTU)

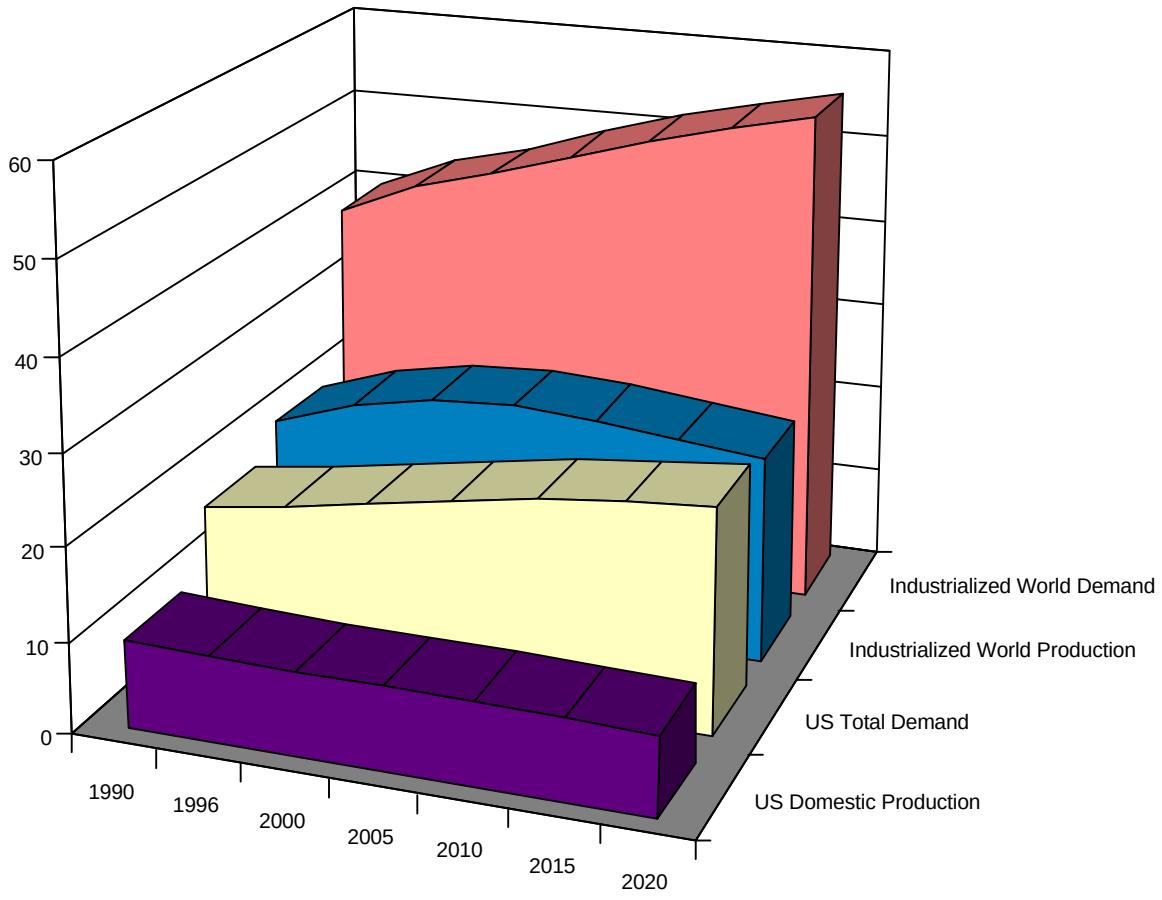


	1970	1990	1995	2000	2005	2010	2015	2020
Oil	97.8	134.9	142.5	157.8	176.3	195.5	215.3	237.3
Natural Gas	36.1	72	78.1	94.8	113.8	133.3	152.5	174.2

Source: Adapted by Anthony H. Cordesman from EIA, Internet, July 4, 1996, and International Energy Outlook, 1998, DOE/EIA-484(97), p. 8 and 135.

Growing World and US Dependence on Imported Oil: 1990-2020

(Average Daily Domestic Production vs. Demand in Millions of Barrels Per Day)

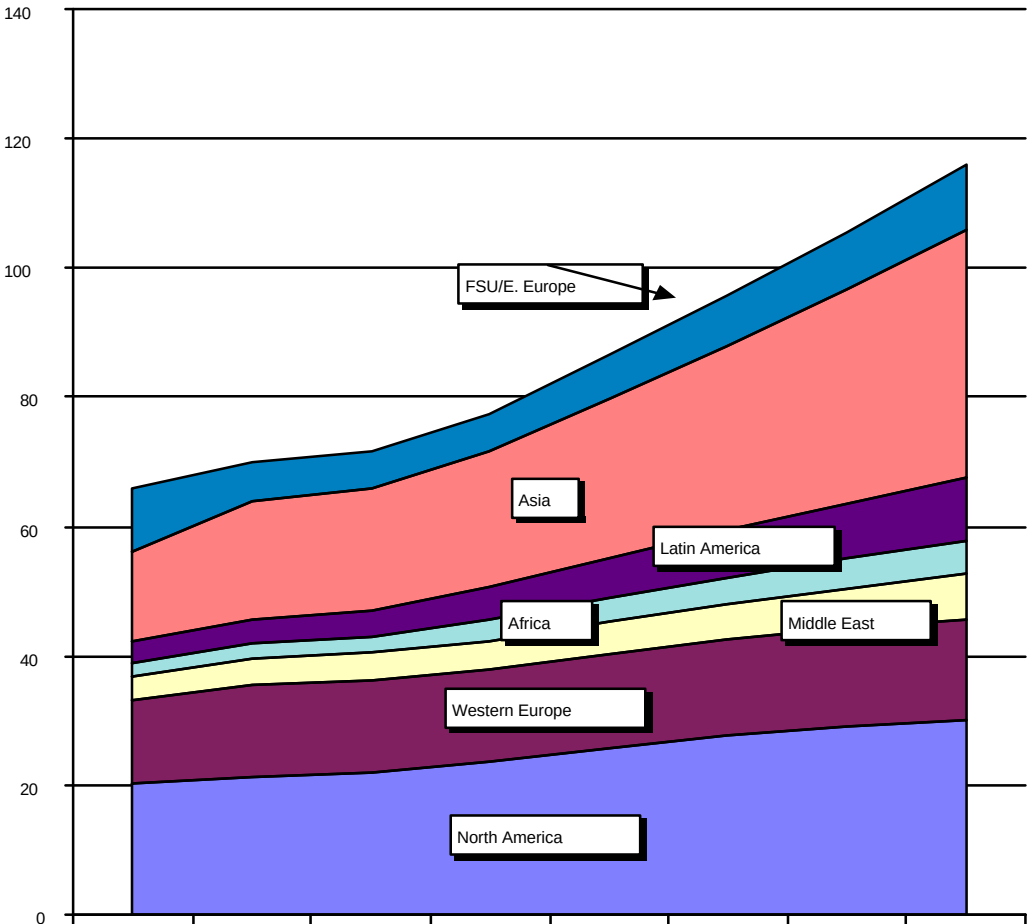


	1990	1996	2000	2005	2010	2015	2020
US Domestic Production	9.7	9.4	9.1	9	8.9	8.7	8.5
US Total Demand	17	18.3	19.6	21.3	22.7	23.7	24.4
Industrialized World Production	20.1	23	24.7	25.4	24.8	23.7	22.9
Industrialized World Demand	39.5	43.4	45.6	48.4	51.1	53.3	55.3

Source: DOE/EIA, International Energy Outlook, 1997, p. 136 and 175.

Asia Will Drive Most of the Future Increase in Demand for Oil: Total World Oil Consumption by Region: 1990-2020

(Millions of Barrels per Day)



	1990	1995	1996	2000	2005	2010	2015	2020
FSU/E. Europe	10	5.9	5.7	5.9	6.7	7.8	9	10.1
Asia	13.8	18.3	19	21	24.8	28.5	33	38.4
Latin America	3.4	3.9	4	5.2	6.2	7.3	8.5	9.8
Africa	2.1	2.3	2.4	3.1	3.7	4.1	4.6	5.1
Middle East	3.4	4.1	4.2	4.4	5	5.6	6.3	7.1
Western Europe	12.9	14.1	14.3	14.3	14.6	14.9	15.2	15.4
North America	20.4	21.3	22	23.7	25.6	27.6	29	30.1

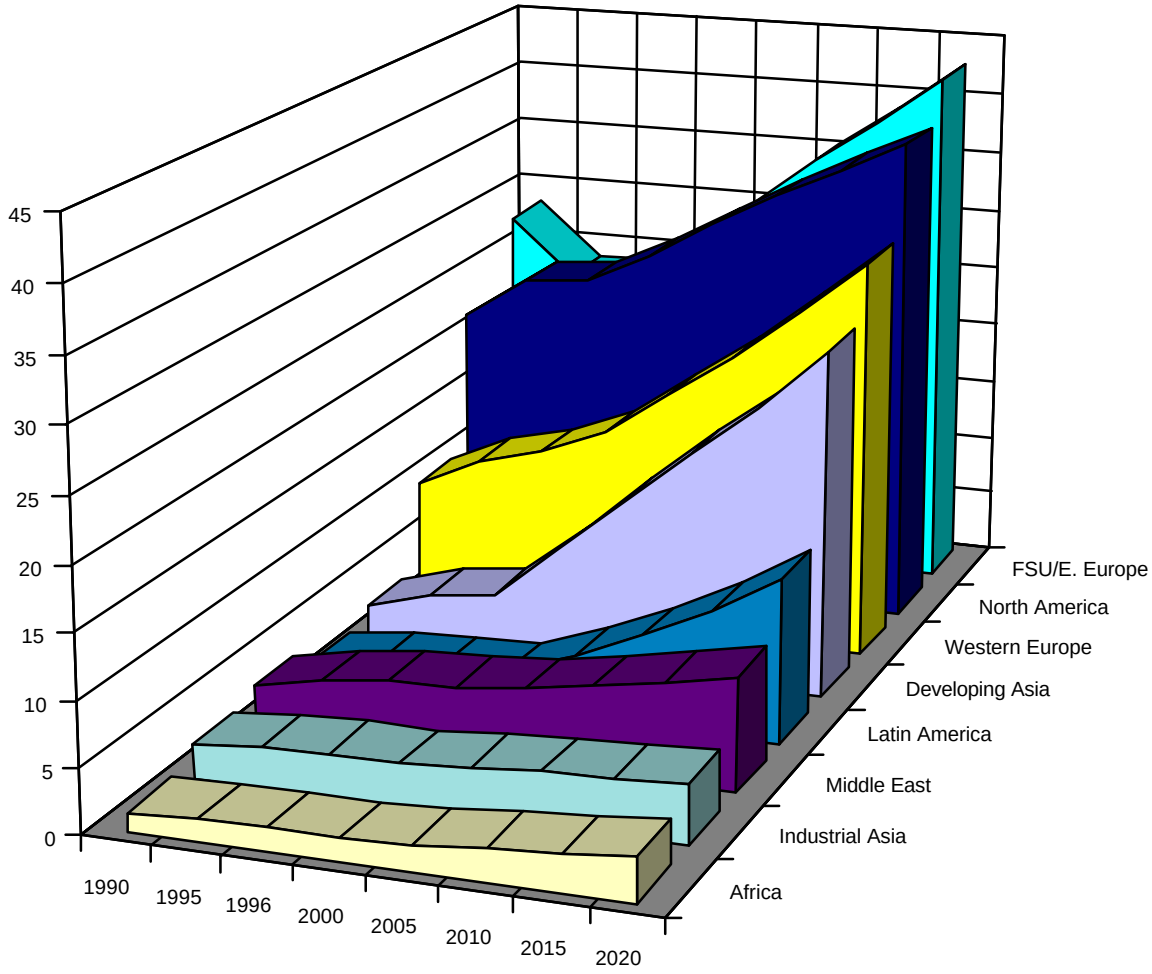
Source: Adapted by Anthony H. Cordesman from DOE/EIA, International Energy Outlook, 1996, Washington, DOE, EIA-0484(96), May, 1996, p. 92, and International Energy Outlook, 1998, April, 1998, DOE/EIA-484(97), Reference Case, p. 136.

Key Gas Issues

- **Massive uncertainties exist regarding the size of reserves and major changes could occur in current estimates by 2020.**
    - **Iran is a key uncertainty.**
- **Changes in gas liquids technology could change the definition of economic reserves, the value of gas, and the entire market for gas.**
- **Pipeline geopolitics are even more important for gas than for oil.**
- **North America, Europe, and FSU will dominate gas use, but Asian demand will rise sharply.**
    - **The growth of gas use in the Pacific Rim states will be particularly high.**
    - **Tanker traffic will increase because of both oil and gas demand.**
- **Russia may create pipelines to service China, Korea, and Japan -- altering current estimates of dependence on oil.**

North America, the FSU, and Western Europe Will Stay the Largest Consumers, but Asia Will Drive Most of the Increase in Gas Demand

(Total World Gas Consumption by Region: 1990-2020, Trillion Cubic Feet, EIA Reference Case)



	1990	1995	1996	2000	2005	2010	2015	2020
Africa	1.4	1.7	1.8	1.7	1.9	2.4	2.9	3.4
Industrial Asia	2.6	3.1	3.3	3.3	3.7	4.1	4.3	4.6
Middle East	3.6	4.7	5.2	5.4	6	6.8	7.8	8.9
Latin America	2	2.6	2.9	3.1	5	7.2	9.8	13
Developing Asia	3	4.7	5.3	9.5	14.1	18.5	22.6	27.7
Western Europe	10.3	12.7	14.1	16.2	19.9	23.5	27.7	32.1
North America	22	25.4	26	28.5	31.5	34.4	36.9	39.4
FSU/E. Europe	28.1	23.4	23.7	26.8	31	35.2	38.7	42.7

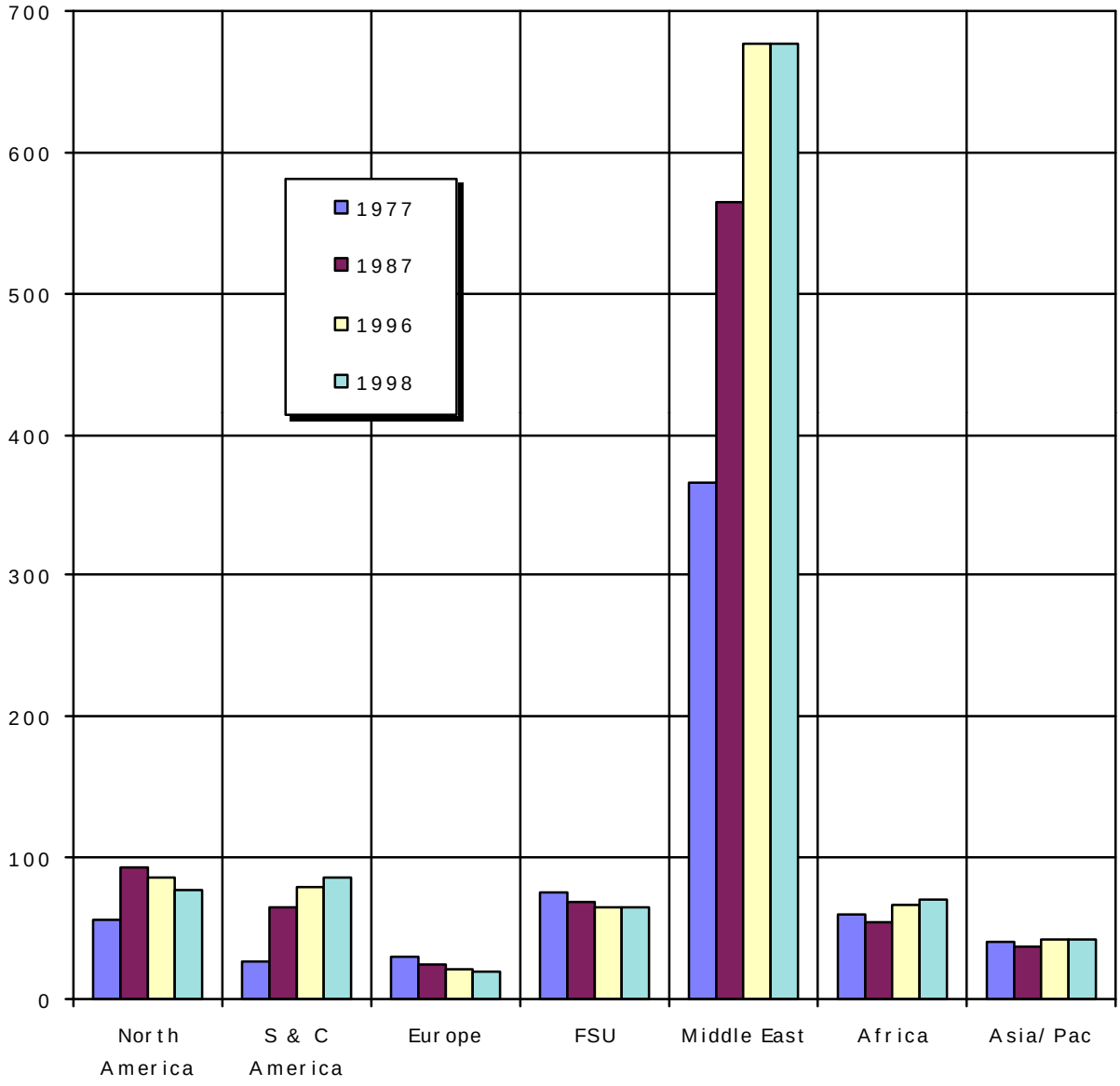
Source: Adapted by Anthony H. Cordesman from DOE/EIA, International Energy Outlook, 1996, Washington, DOE, EIA-0484(96), May, 1996, p. 92, and International Energy Outlook, 1998, April, 1998, DOE/EIA-484(97), Reference Case, p. 137.

Oil Reserves and Geopolitics

- **Enhanced Oil Recovery (EOR) is steadily change reserve estimates and help the US and Northern Europe maintain reserve ratios for much longer than previously expected.**
- **Asia is "oil poor" in reserves, and reserves are depleting faster than new discoveries.**
    - **China is having little success in finding new reserves.**
    - **Offshore oil reserves in South China Sea may be myth.**
    - **India has virtually no oil.**
    - **Enhanced oil recovery (EOR) unlikely to provide much help.**
- **Russia's ability to exploit its reserves is economically and technically uncertain. Siberia is a particular problem.**
- **Gulf has about two-thirds of world's known oil reserves. Algeria and Libya have major reserves, and Egypt, Syria, and Tunisia have some oil.**
    - **North African reserves exceed reserves of all Sub-Saharan states: Angola, Nigeria, etc.**
    - **Far Eastern reserves are comparatively low, with little potential for major new discoveries.**
    - **Other regions have a faster growth of domestic consumption as a ratio of reserves.**
- **Gulf and Middle Eastern oil reserves are just as important even if ultimate oil reserves are considered.**
- **New reserves in other regions tend to be offset by depletion of existing reserves.**

Shifts in the Regional Balance of Oil Reserves

(Billions of Barrels)

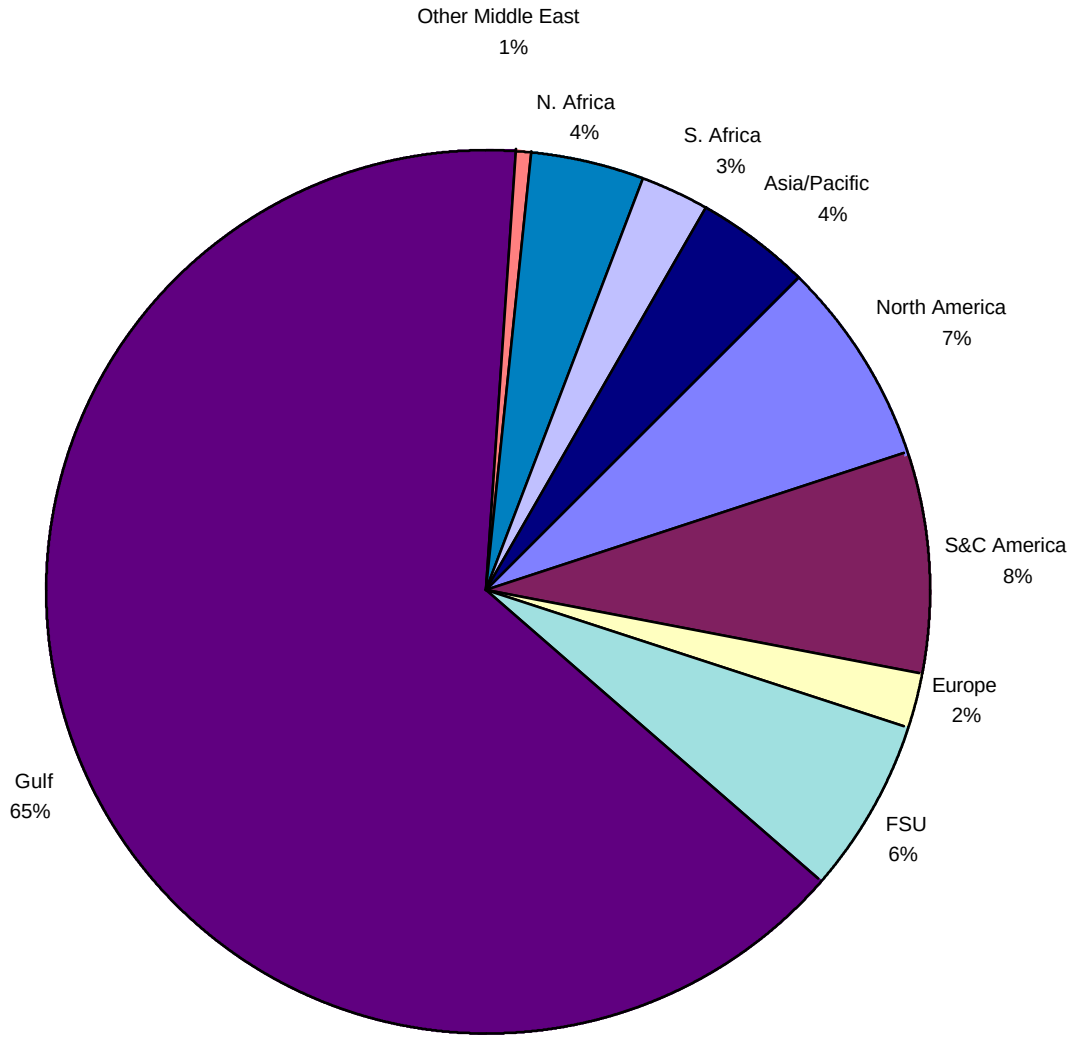


1977	56.9	26.4	30.3	75	365.8	59.2	39.7
1987	93	65.7	24.2	69	564.7	55.3	37.8
1996	85.9	79.1	20.5	65.5	676.3	67.5	42.4
1998	76.6	86.2	20.2	65.4	676.9	70	42.3

Source: Oil and Gas Journal, and BP Statistical Review of World Energy, 1998, p. 4.

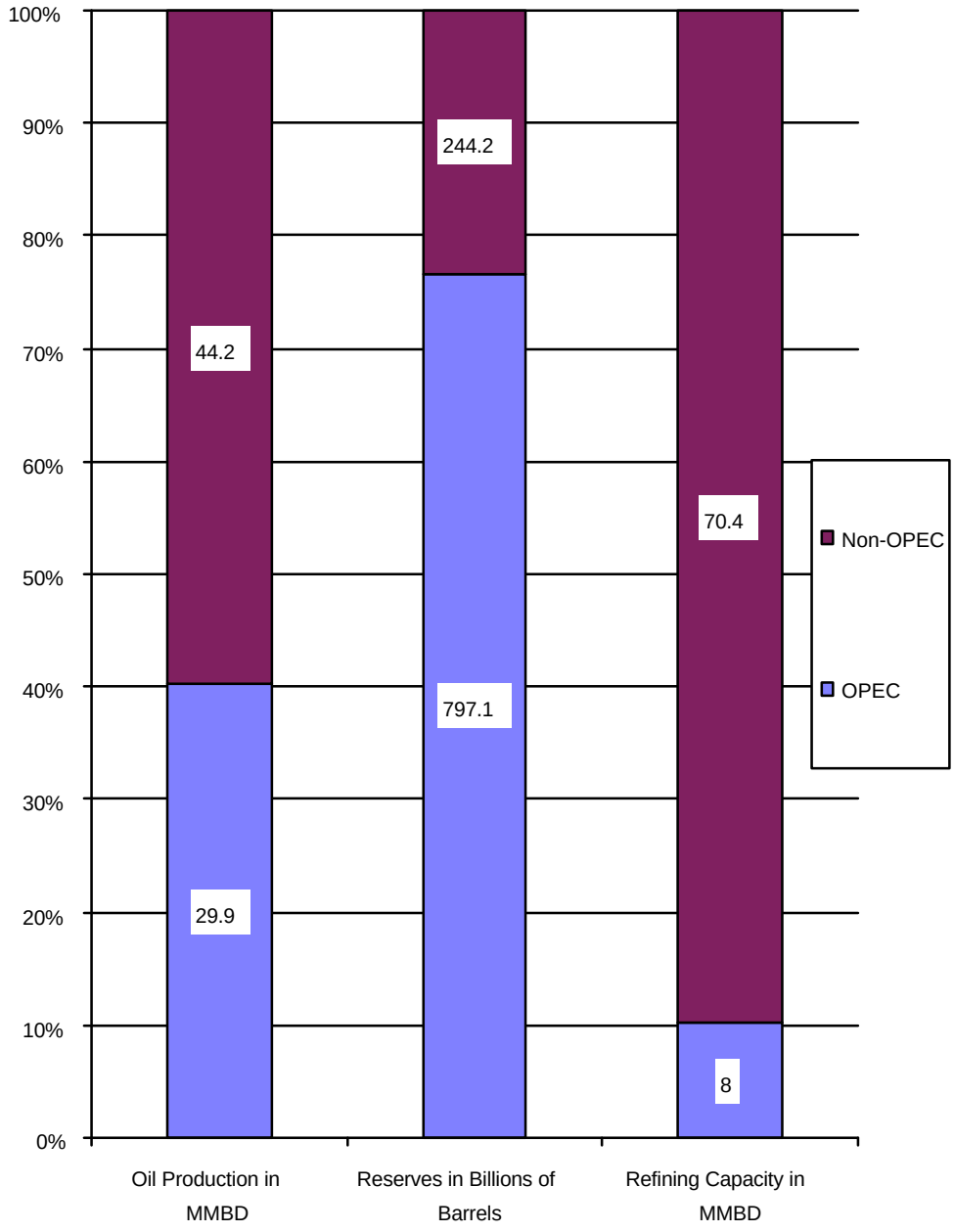
The Middle East and the Gulf Dominate Future Oil Supply: World Oil Reserves by Region as a Percent of World Total

(Based on Oil and Gas Journal Forecast for and a World Total of 1,037.6 billion barrels)



Source: Oil and Gas Journal, and BP Statistical Review of World Energy, 1998, p. 4.

OPEC versus Non-OPEC Production, Reserves and Refining Capacity



Source: DOE/EIA, Non-OPEC Fact Sheet, 3/98.

OPEC Status by Country

(Thousands of Barrels Per Day

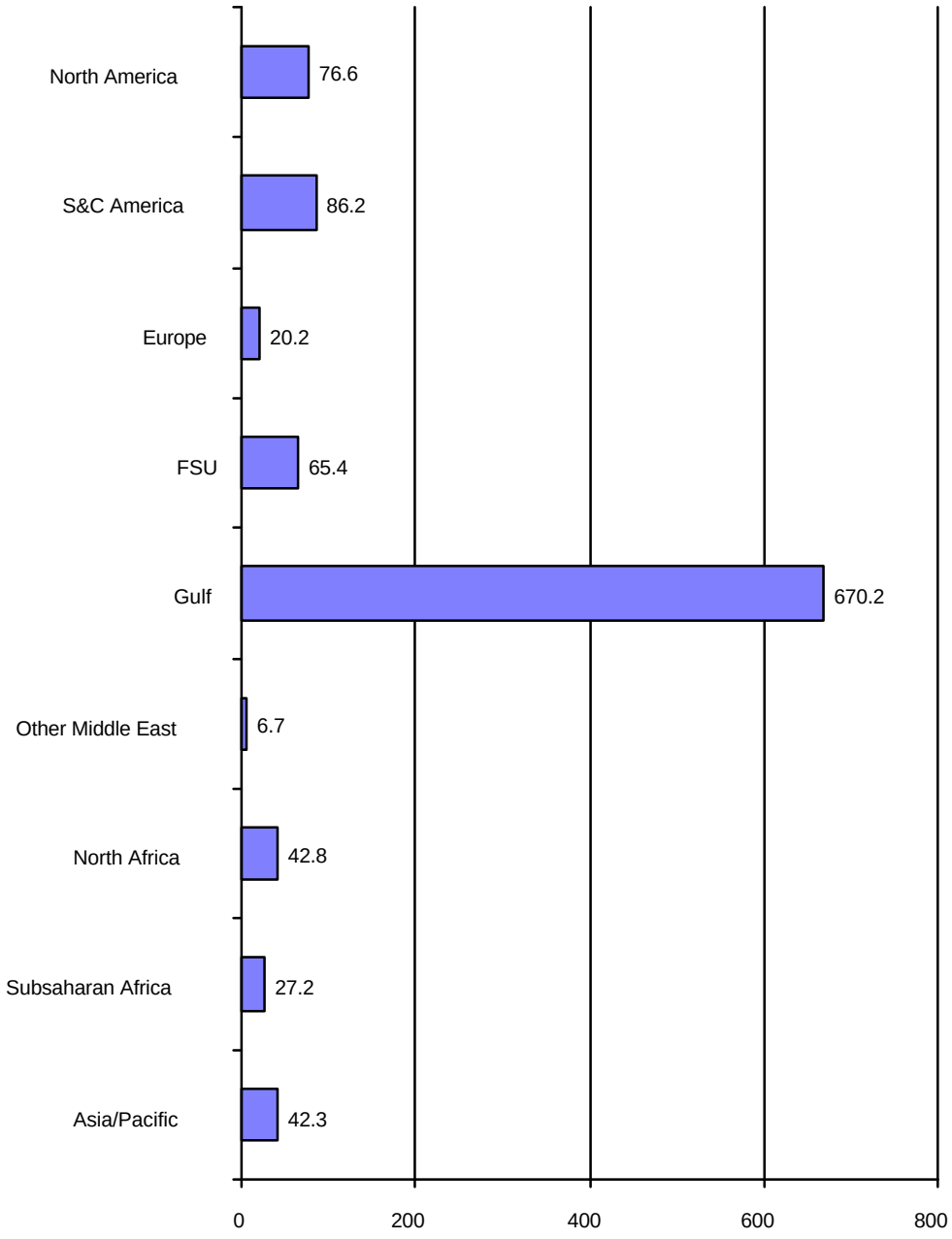
Country	1997 Quota	1998 Quota	1998 Cutbacks*	Crude Oil Production	
				1997	3/98
Algeria	750	909	50,000	847	860
Indonesia	1,300	1,456	70,000	1,366	1,340
Iran	3,650	3,942	140,000	3,629	3,600
Iraq	1,200	1,314	0	1,182	1,820
Kuwait	2,000	2,190	125,000	2,038	2,210
Libya	1,390	1,522	80,000	1,446	1,450
Nigeria	1,865	2,042	125,000	2,217	2,270
Qatar	378	414	30,000	614	700
Saudi Arabia	8,000	8,761	525,000	8,562	8,460
UAE	2,161	2,366	125,000	2,236	2,400
Venezuela	2,359	2,583	325,000	3,275	3,370
TOTAL OPEC	25,033	27,500	-	27,457	28,480
Mexico	-	-	200,000	-	-
Norway	-	-	100,000	-	-
Oman	-	-	30,000	-	-
Yemen	-	-	20,000	-	-
TOTAL	-	-	1,945,000	-	-

* Combined from the March 22, 1998, March 30 OPEC, and June 4 Amsterdam agreements.

Source: Adapted by Anthony H. Cordesman from DOE/EIA OPEC Fact Sheet, June, 1998, and Oil Production Agreements of 1998, June 5, 1998.

The Middle East and the Gulf Dominate Future Oil Supply: World Oil Reserves by Region in Billions of Barrels

(Based on Oil and Gas Journal Forecast for and a World Total of 1,037.6 billion barrels)



Source: Oil and Gas Journal, and BP Statistical Review of World Energy, 1998, p. 4.