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Society of Petroleum Engineers
Distinguished Lecturer Program
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Putting The Energy Industry In Perspective

Phil Rae
InTuition Energy Associates



Presentation Overview

- The Importance Of Energy
- Energy And Wealth
- Supply and Demand
- Pollution, Environment & Climate Change
- Alternatives to Hydrocarbons
- Impact of Improved Technology
- Future Energy Trends
- Closing Remarks

The Energy Industry in Perspective

- Energy Is The World's Most Important Commodity
- Engine of Global Growth
- Power
- Transport
- Also Provides Raw Materials for Industry
- Source of Dyes, Pharmaceuticals, Plastics, Detergents, Lubricants.....



The Importance Of Our Industry

- Hydrocarbons Have Been The Principal Source of Energy and Transport Fuel for ~250 Years
- In General, Increasing Access To Energy Improves Living Standards, Productivity and Average Lifespan While Raising Economic and Industrial Activity
- World Energy Demand Is Expected To Increase By 40% Over The Next 30 Years

Coal

- **World's Cheapest Energy Source**
- **~ 80% Used For Power Generation**
- **~ 50% of World Electricity from Coal**
- **> 80% of China's Electricity from Coal**
- **Annual Consumption – 8 BillionTonnes/yr**
- **Reserves Remaining? – 900 Billion Tonnes**

Oil

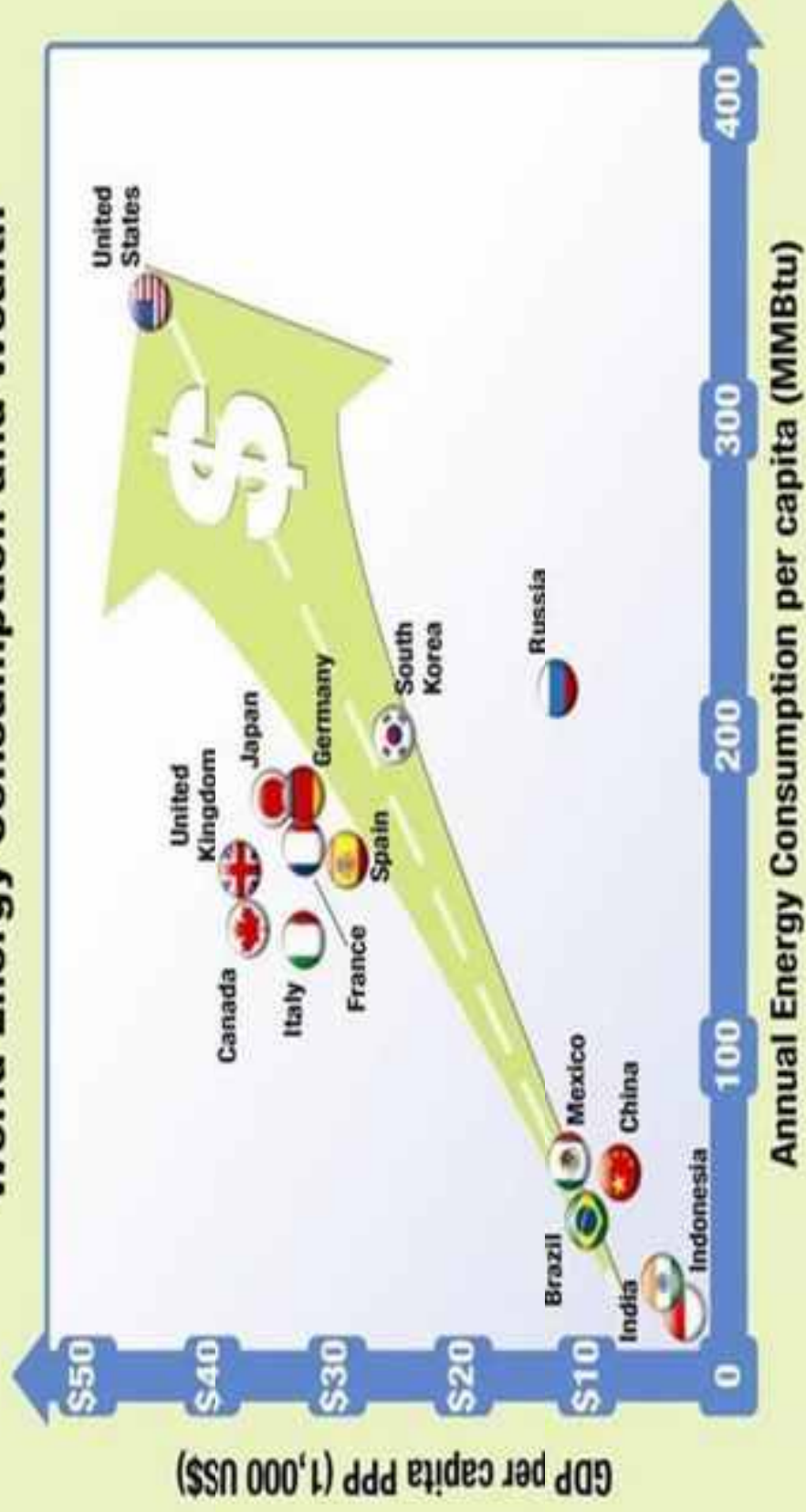
- **World's Most Important Commodity**
- **Vast Quantities Produced and Transported**
- **~33 Billion Bbls Now Produced Each Year**
- **~18 Billion Bbls/Year Shipped By Tanker**
- **~ 80% Used As Transportation Fuel**
- **Consumption To Date ~ 944 Billion Bbls**
- **Resources Remaining? ~ 2 - 10 Trillion Bbls?**

Natural Gas

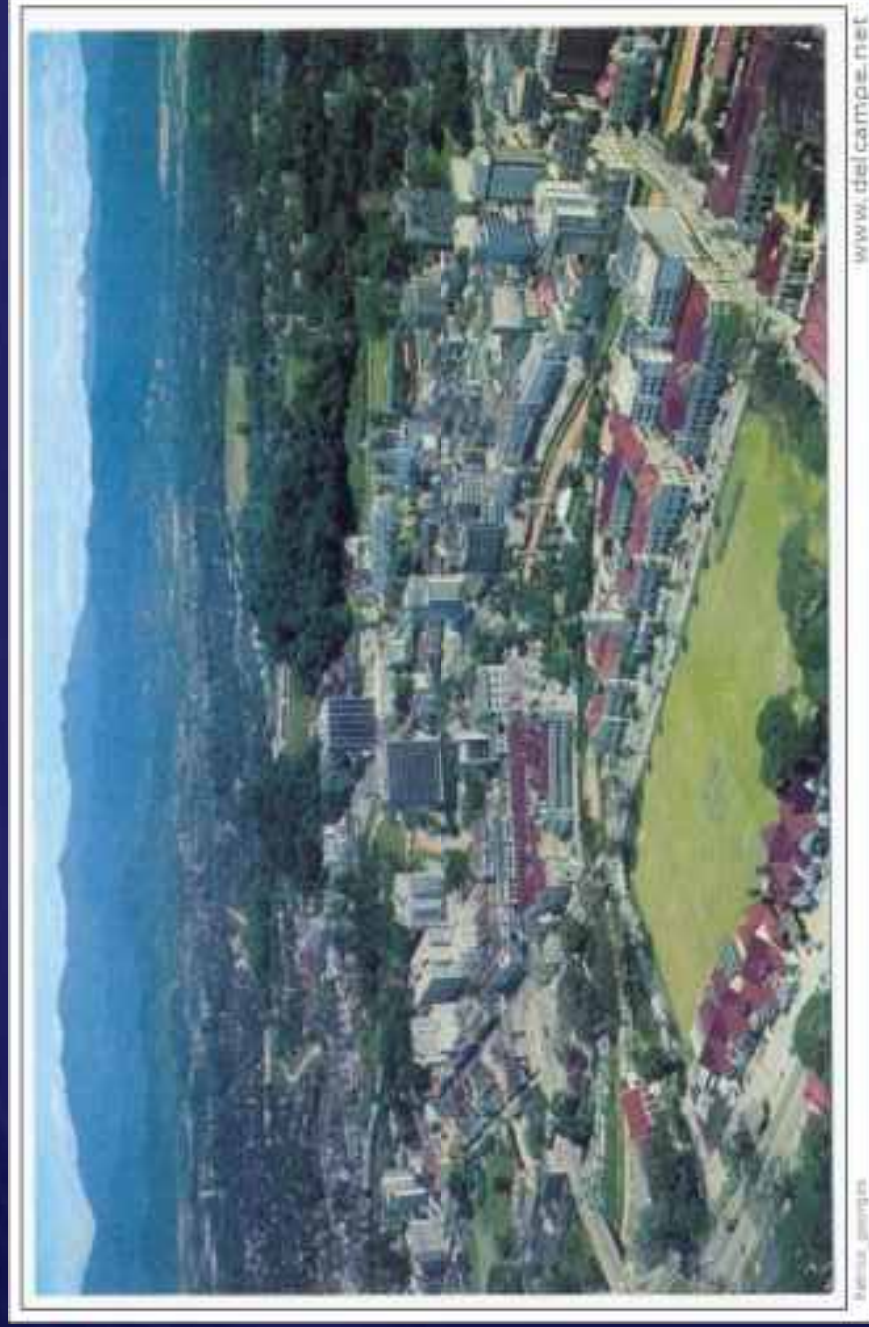
- Historically, Considered A Nuisance - Flared
- Costly Infrastructure for Exploitation
- ~110 tcf Consumed Each Year Now
- Most Transported By Pipeline
- LNG Has Made It Practical To Ship By Sea
- ~ 40% Used For Power Generation
- Resources Remaining? Good Question....

Energy and Wealth

World Energy Consumption and Wealth



Kuala Lumpur, 1970



Kuala Lumpur, 2010



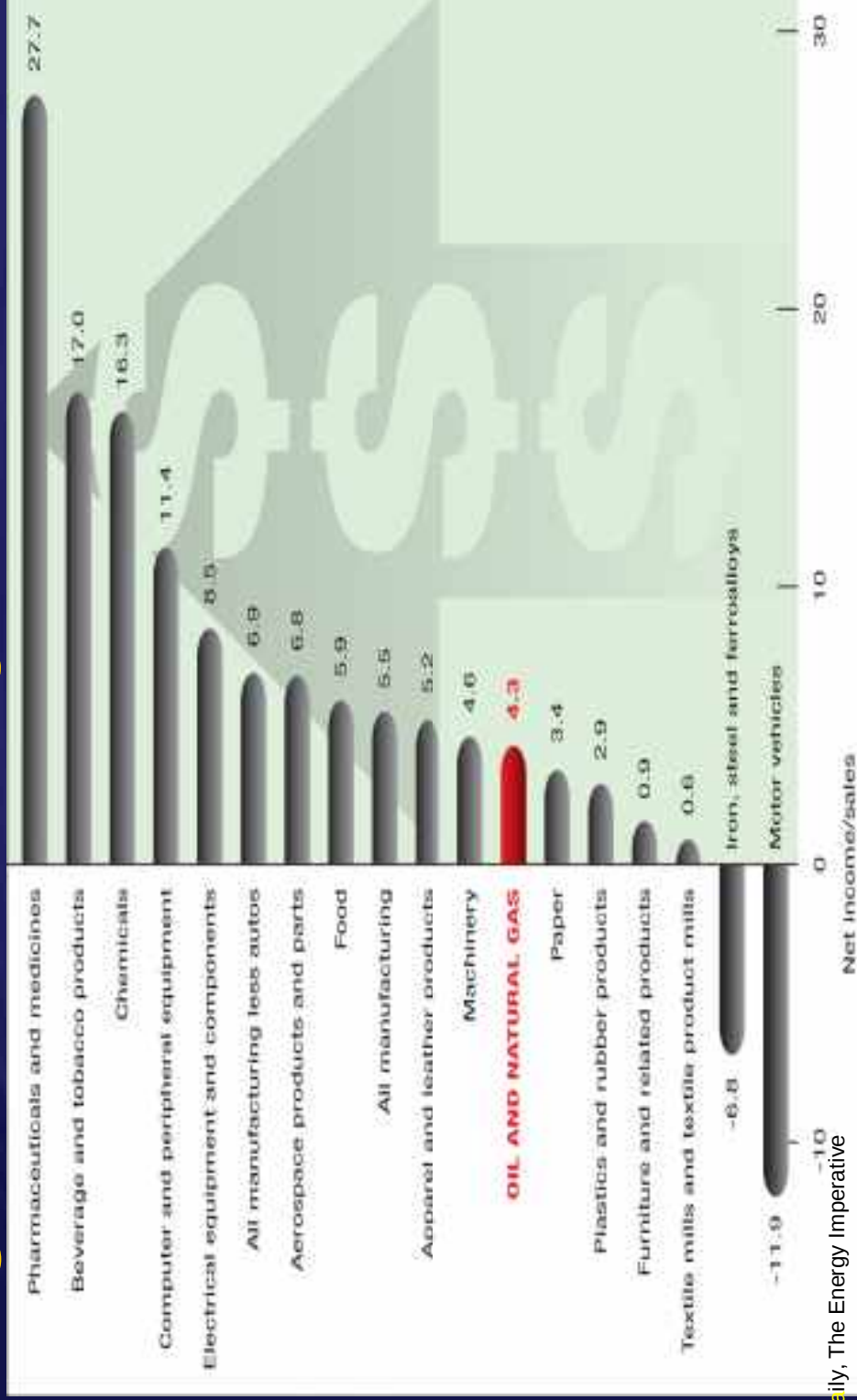
Dubai – 1980 vs 2010



Dubai, 2010

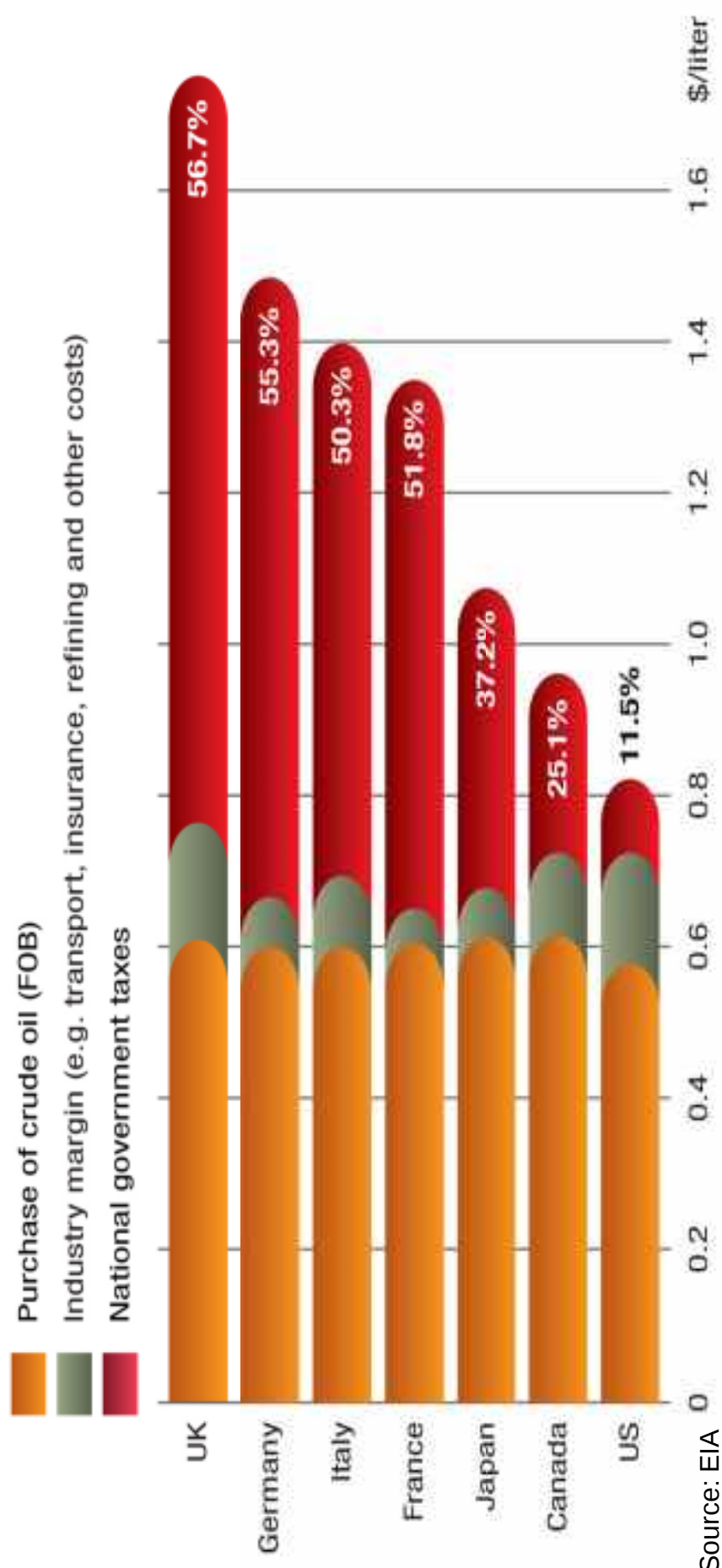


Big Bad Oil – Maybe Not So Bad?



Source: Oil Daily, The Energy Imperative

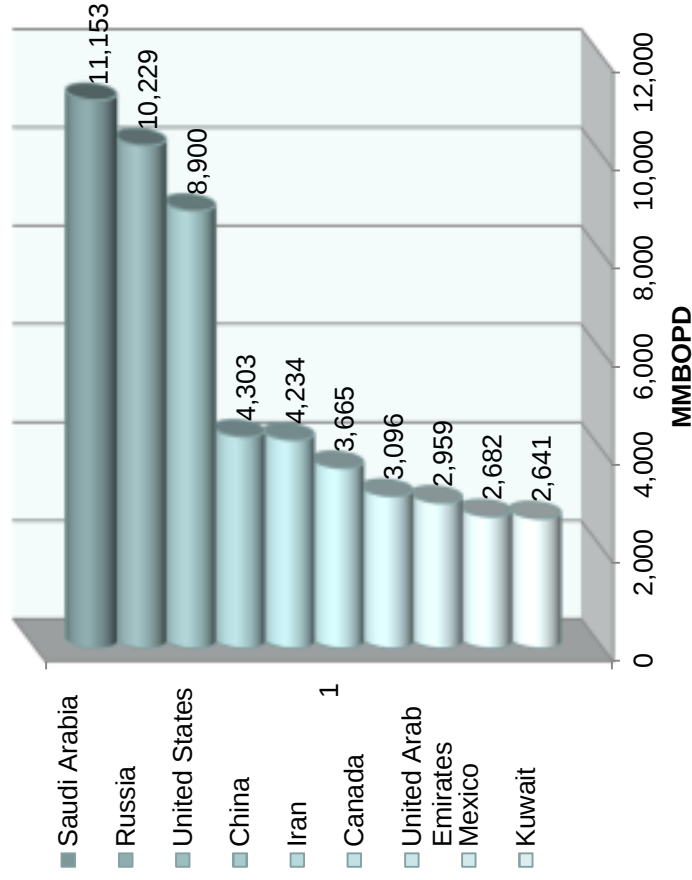
Government Energy Taxes



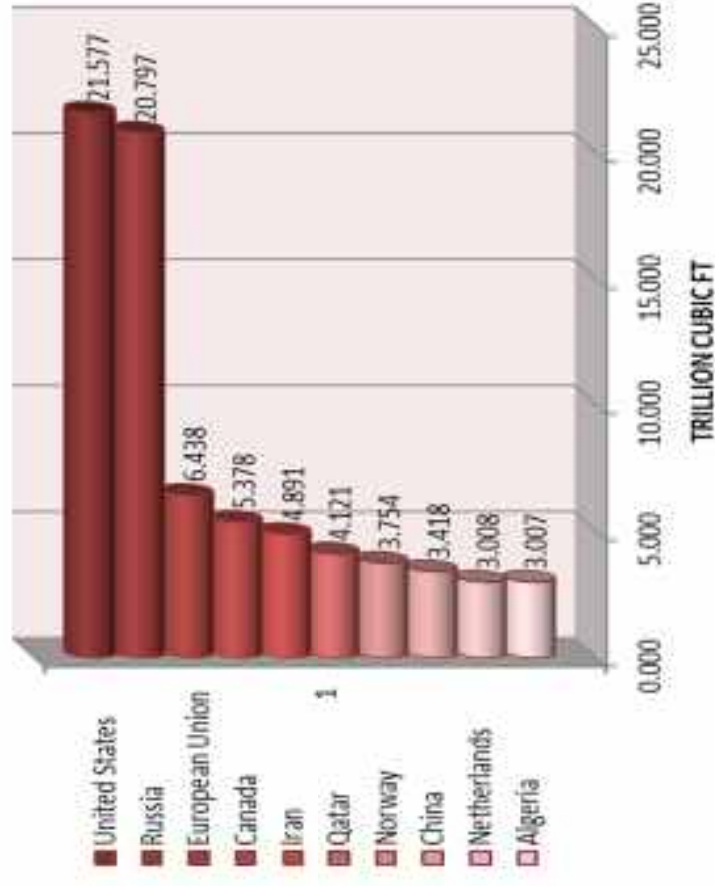
Supply and Demand

Main Oil & Gas Producers

OIL PRODUCTION MMBOPD 2011
Includes Condensate, NGLs & Refinery Gains

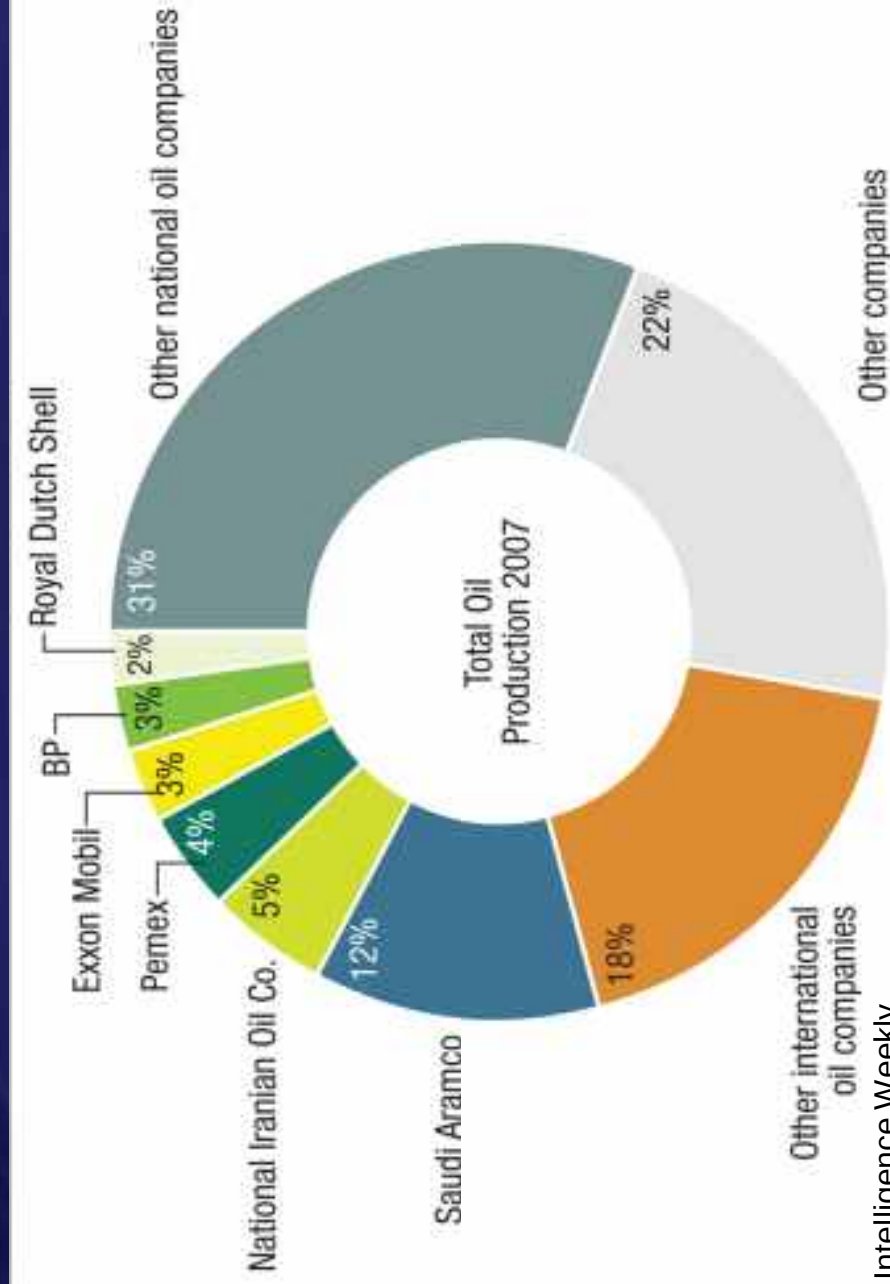


WORLD NATURAL GAS PRODUCTION 2010 (Est)



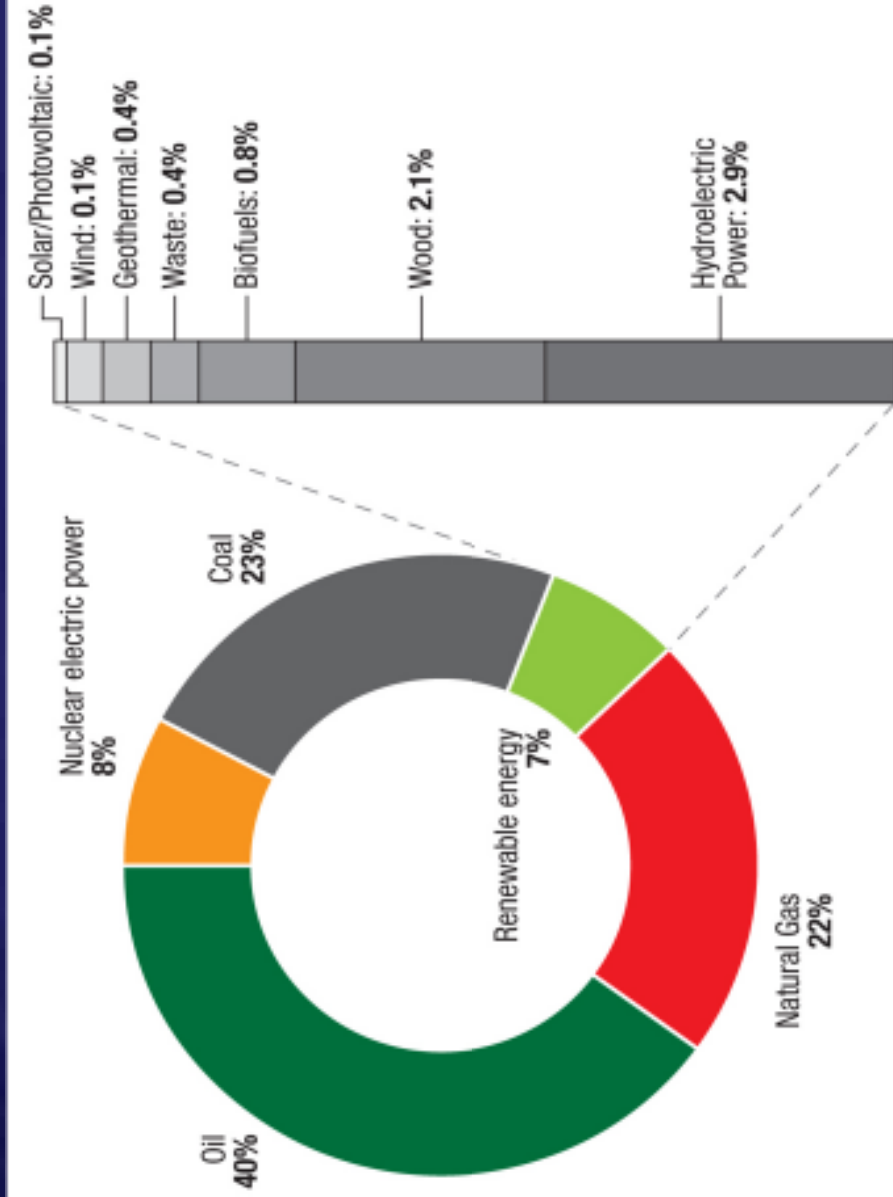
Source: EIA

NOCs Are The World's Main Producers



Source: Petroleum Intelligence Weekly

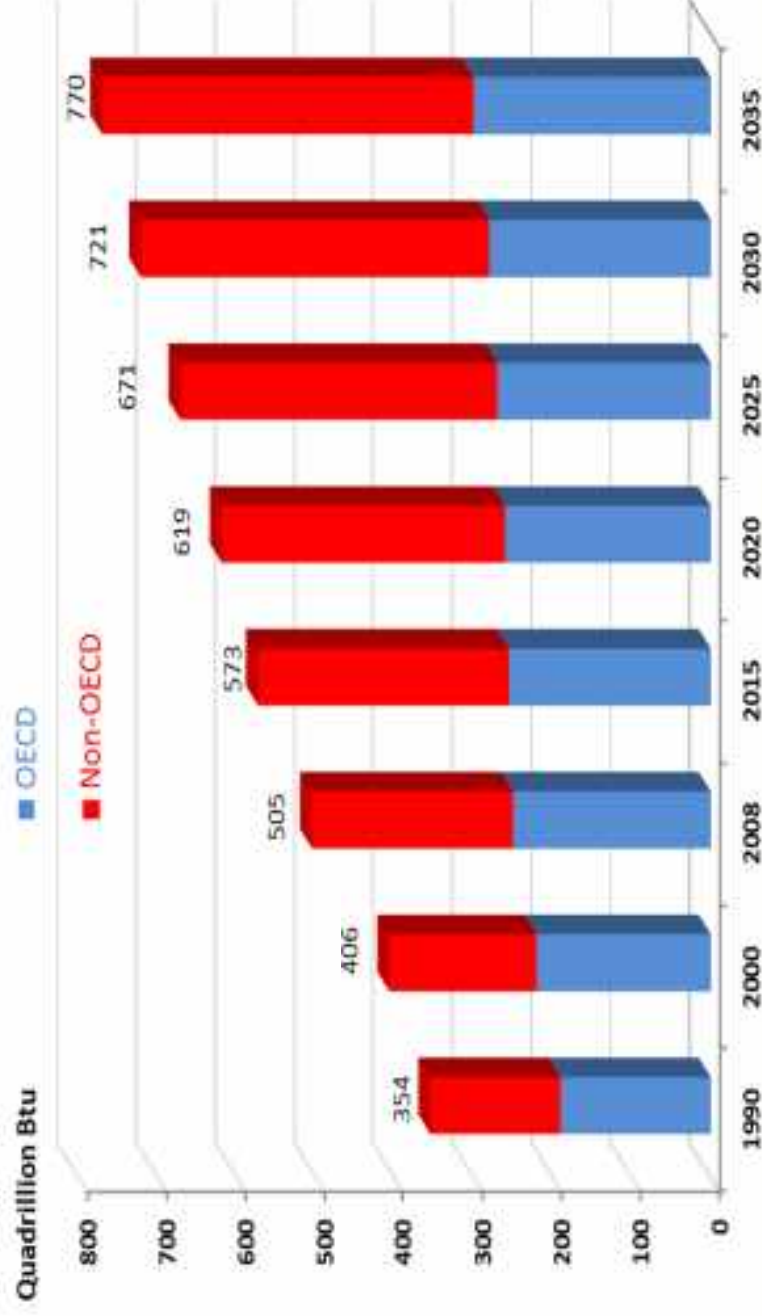
World Energy Supply- Primary Sources



Source: EIA

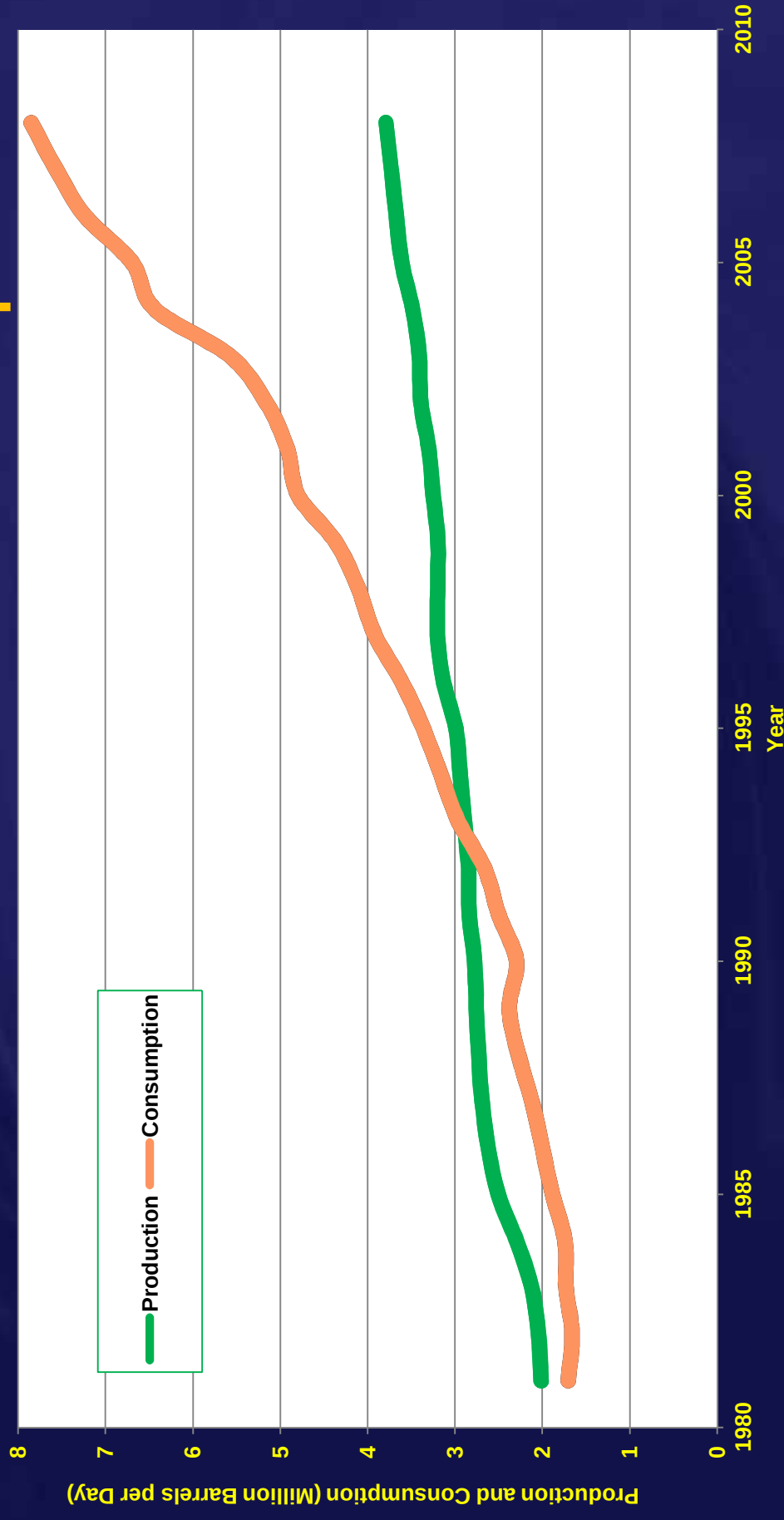
World Energy Consumption

World Energy Consumption, 1990-2035

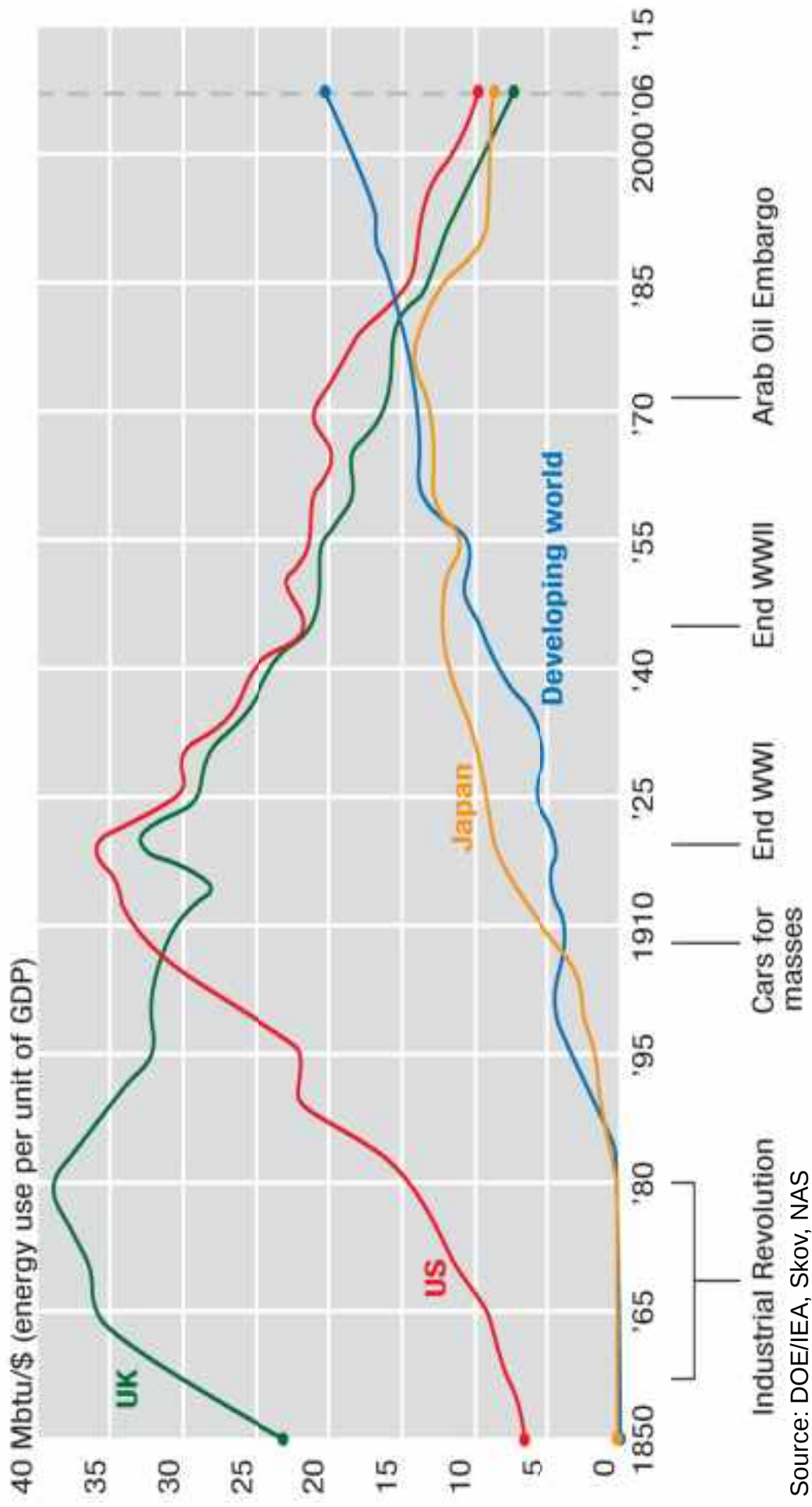


Source: EIA

China's Oil Production and Consumption



Source: The Energy Imperative

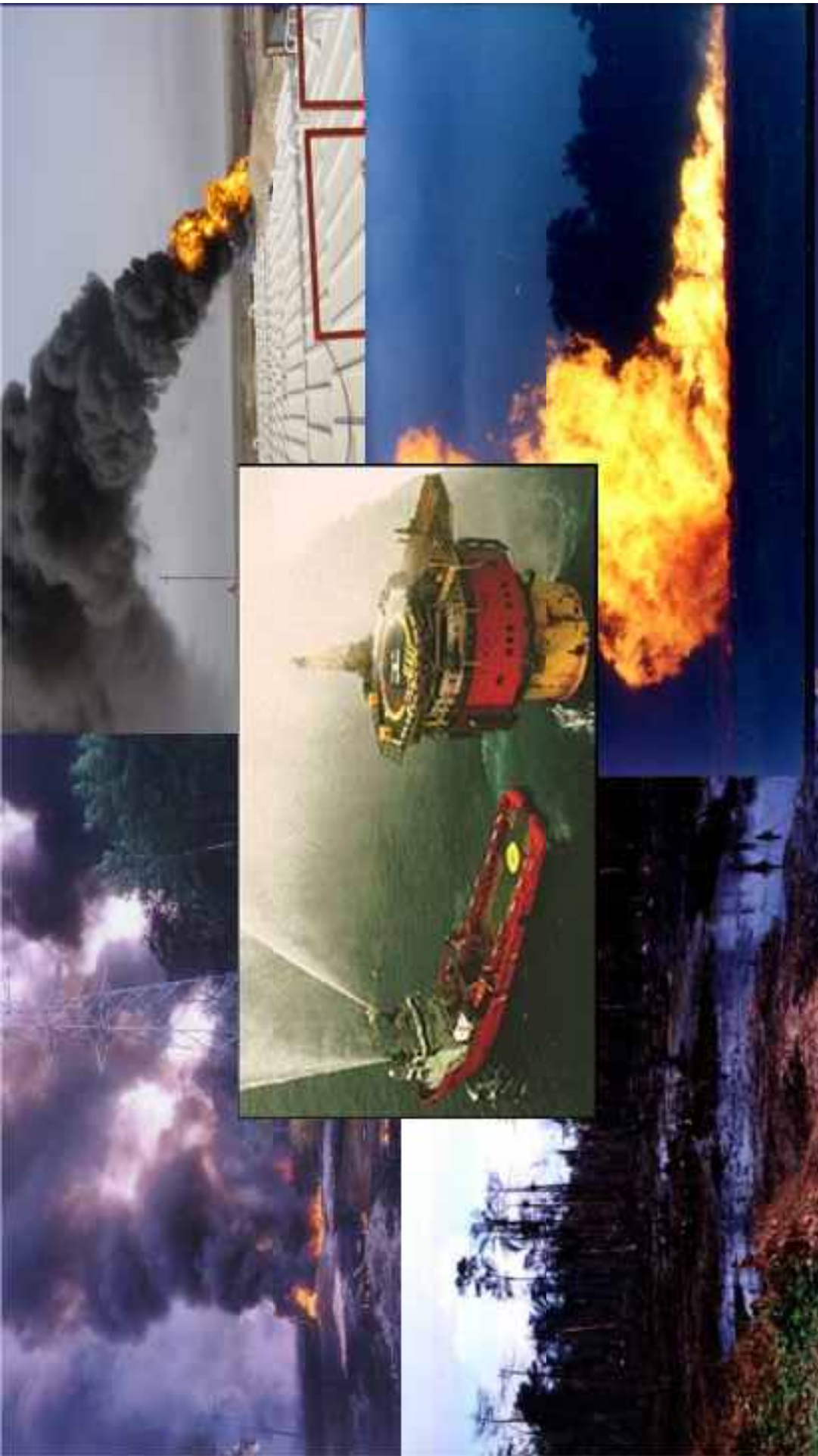


Source: DOE/IEA, Skov, NAS

Pollution and the Environment

Common Public Perceptions

- Oil and Gas Are A Nasty Addiction!
- Energy Industry Pollutes The Planet
- “Dirtier” Than Other Industries
- GHG Emissions Must Be Reduced Now
- We Will Run Out of Oil and Gas Soon
- Practical Alternatives to Oil&Gas Exist!







Some Inconvenient Truths

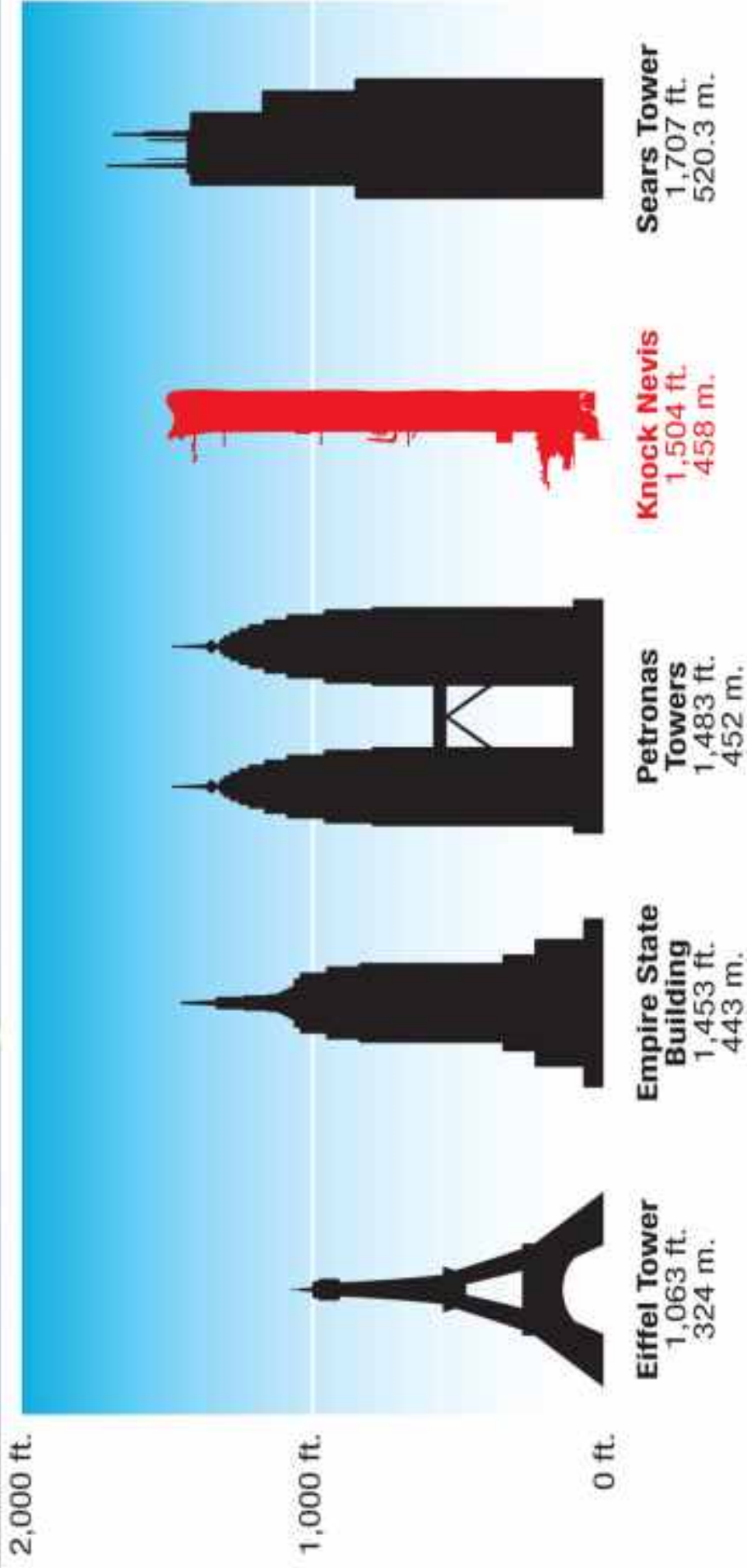
- **>230 x 10⁶ - World Energy Consumption (BOE/day)**
- **90 x 10⁶ – World Oil/NGL Production (Bbls/day)**
- **110 tcf – World Annual Natural Gas Consumption**
- **40% - Projected Energy Demand Increase by 2040**
- **<0.15% - Global Share of Energy Market From Solar**
- **>80% - Share of Energy From Hydrocarbons Today**
- **~80% - Share of Energy From Hydrocarbons in 2030**

Source: EIA, The Energy Imperative

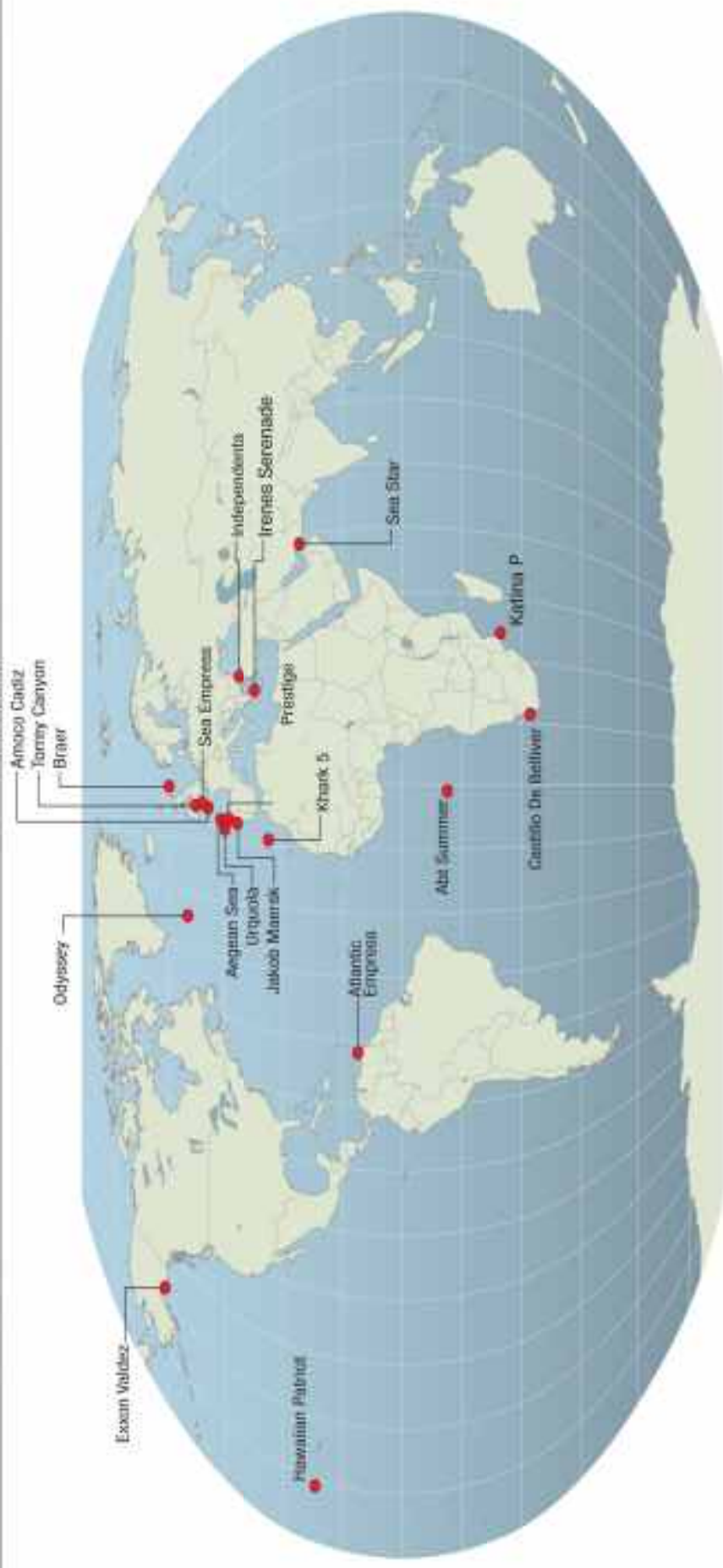
Oil

- Perceived As A Major Pollution Threat
- Vast Quantities Produced and Transported
- 33 Billion Bbls Produced Each Year
- 18 Billion Bbls/Year Shipped By Tanker
- Intense Media Coverage of Spills
- Spills Tend To Be Substantial

How Big Are Those Tankers?



Infamous Tanker Disasters

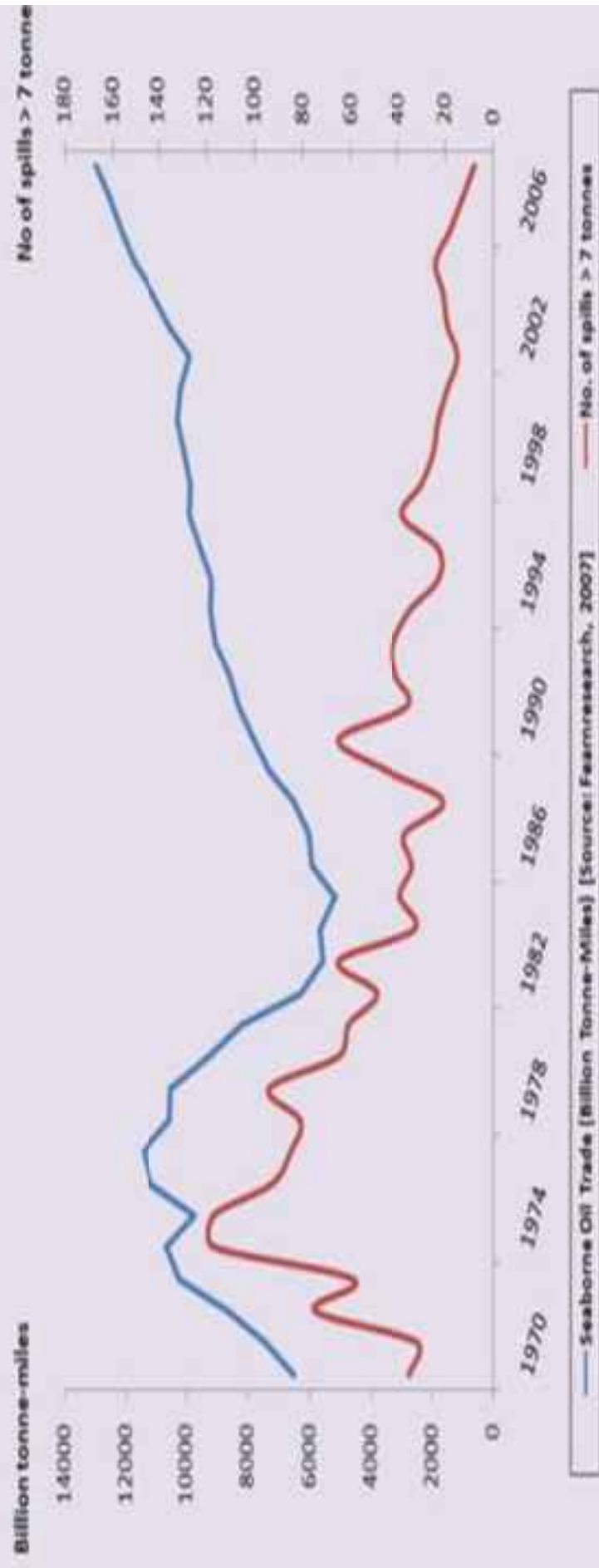




Fishing Village – Brittany Coast 1978



Tanker Spills 1970-2006



Source – itopf.com, The Energy Imperative

Wellsite MC-252-1 21st April, 2010



The Macondo Incident

- 11 Crew Killed in Explosions and Fire
- Deepwater Horizon Rig Lost
- Well Blew Out for 87 Days
- Estimated 4 – 5 Million Bbls of Oil Spilled in GoM
- Wide Scale Ban on Fishing in GoM
- Moratorium on Deep Water Drilling in GoM
- Saturation Media Coverage and Comment
- Allegations of Cutting Corners To Save Cost
- Political and Media Circus Directed Against Oil

Some Important Questions

- **Why Was British Petroleum Drilling in the USA?**
 - Because BP Was The Biggest Oil Producer in the US
- **Why Don't We Stop Drilling in the GoM?**
 - Because 30% of US Production is There!
- **Why Don't We Just Stop Using Oil Now.....**
 - OK...So How Will You Replace That Energy Supply?
- **This Is The Biggest Oil Spill Ever in the US...Right?**
 - No! The Lakeview Gusher in 1910 Spilled 9 Million Bbls

Figure 1: Comparison of Average Annual GOM Shallow and Deepwater Oil Production

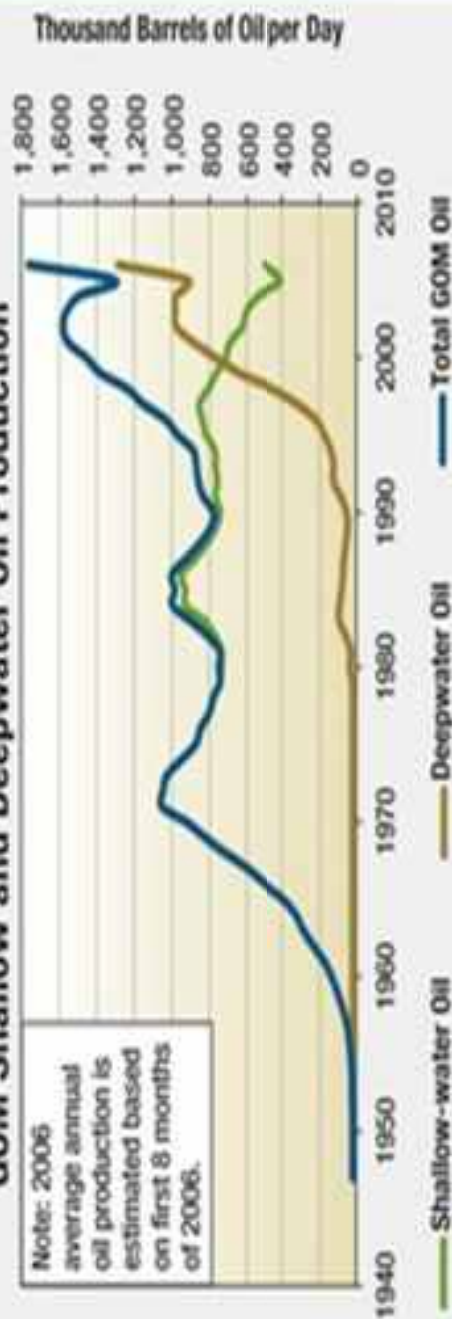
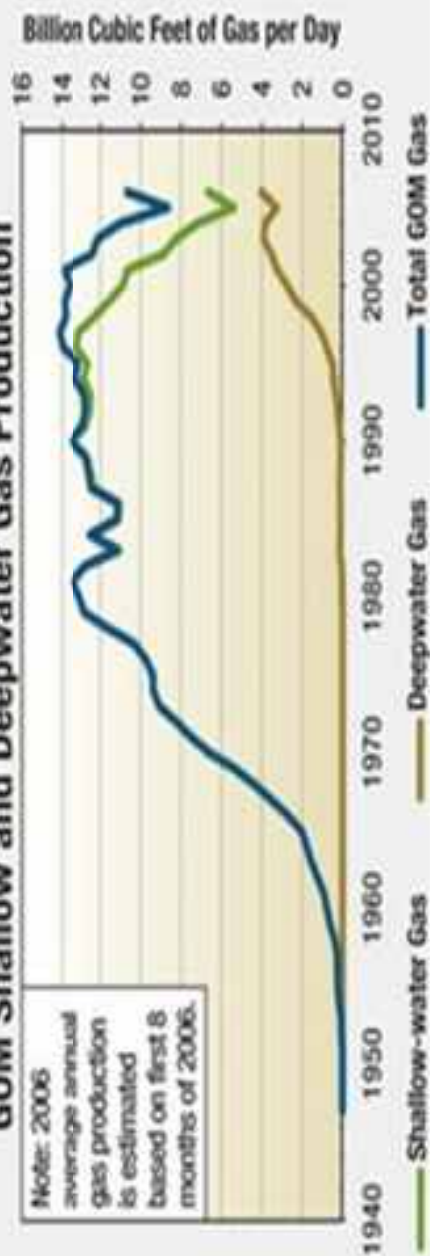


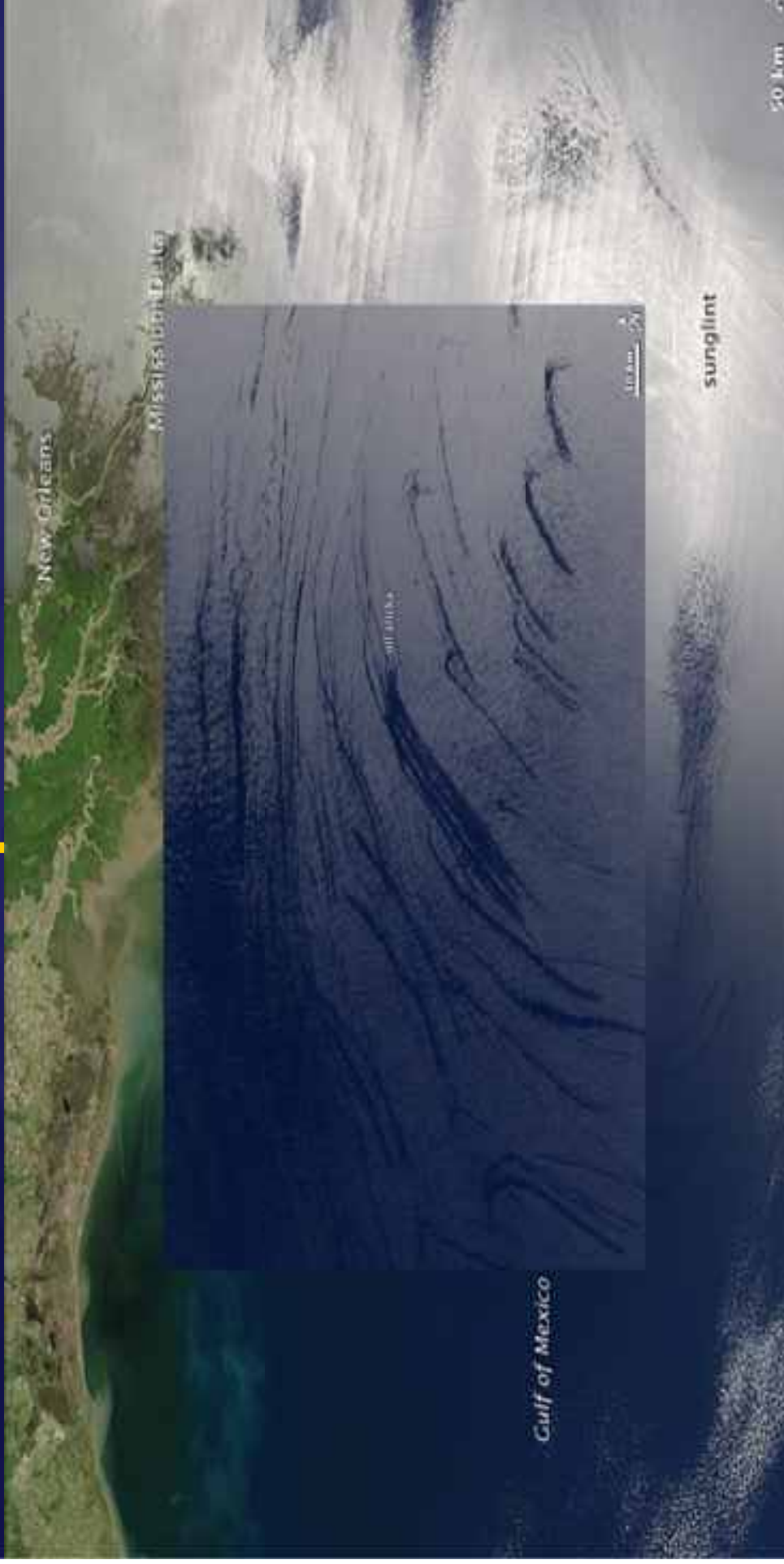
Figure 2: Comparison of Average Annual GOM Shallow and Deepwater Gas Production



Some More Inconvenient Truths

- Oil Is A Natural Product
- Routinely Seeps to Surface In Many Places
- Rich Nutrient Source....but Hydrophobic
- Major Spills Overwhelm Ecosystem
- Quickly Degrades, If Properly Dispersed

Natural Oil Seeps – Gulf of Mexico



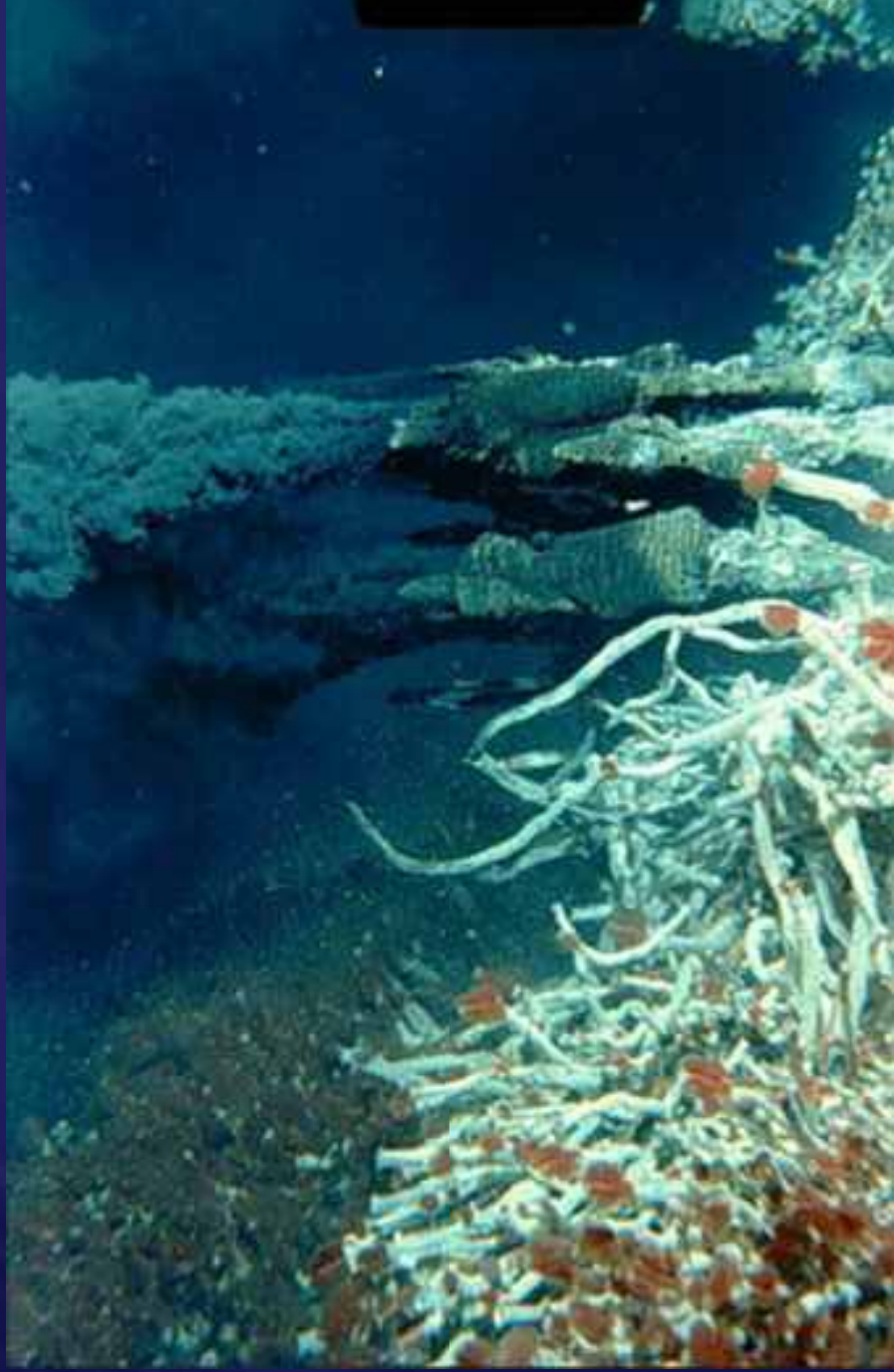
How Much Oil Goes Into the Ocean?

- Annually, ~10 Million Bbls, On Average!
- ~4.3 Million Bbls/Year (45%) from Natural Seeps
- In US Waters, Seeps = ~1 Million Bbls/Year, Mainly in GoM
- Upstream (E&P) Sector? ~300K Bbls/Year, Globally
- O&G Industry Activity Probably Reduces Natural Seeps*
- (* Due To Pressure Reduction and Depletion Processes)

Close It Now! – It Will Kill Everything

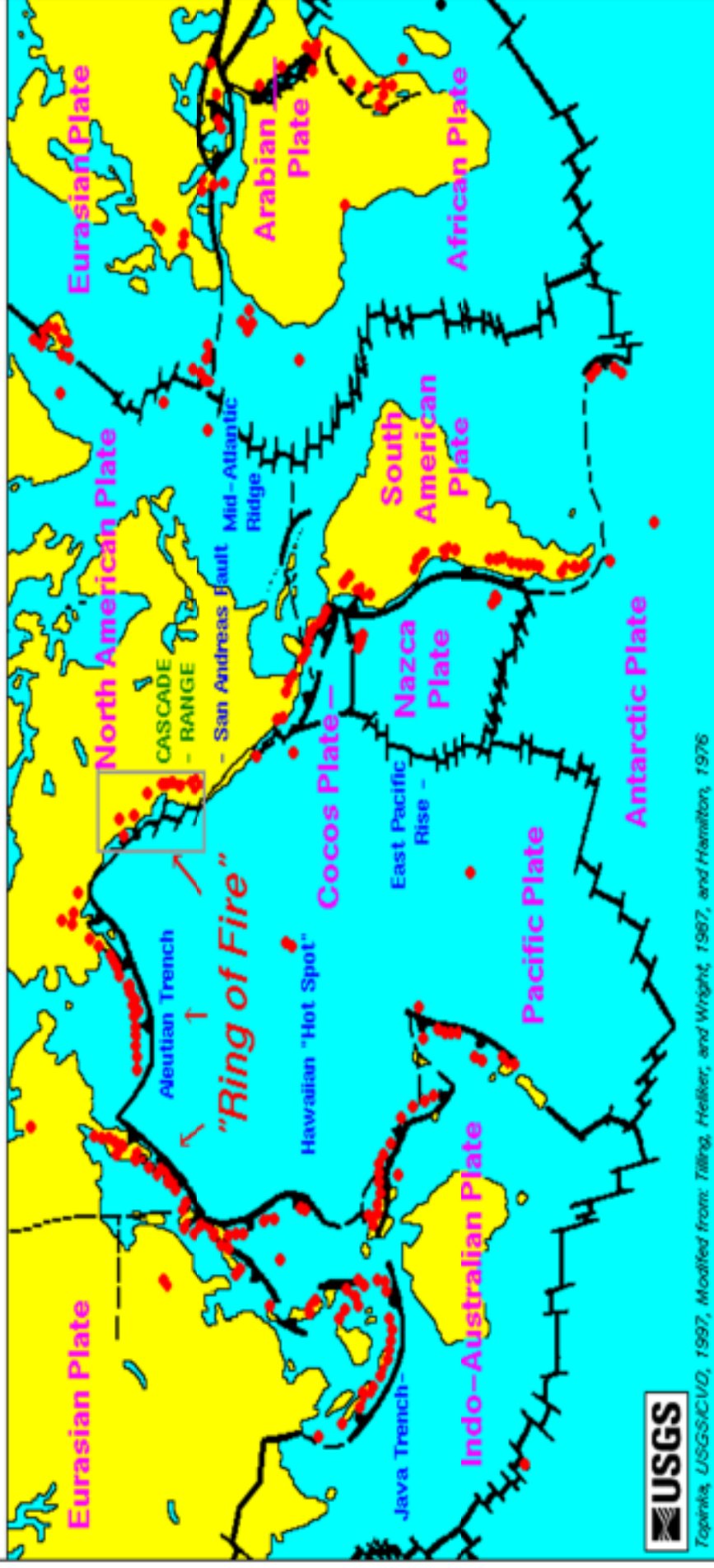


Another Source of Marine Pollution



Mid-Ocean Ridges – Hydrothermal Vents

Active Volcanoes, Plate Tectonics, and the "Ring of Fire"



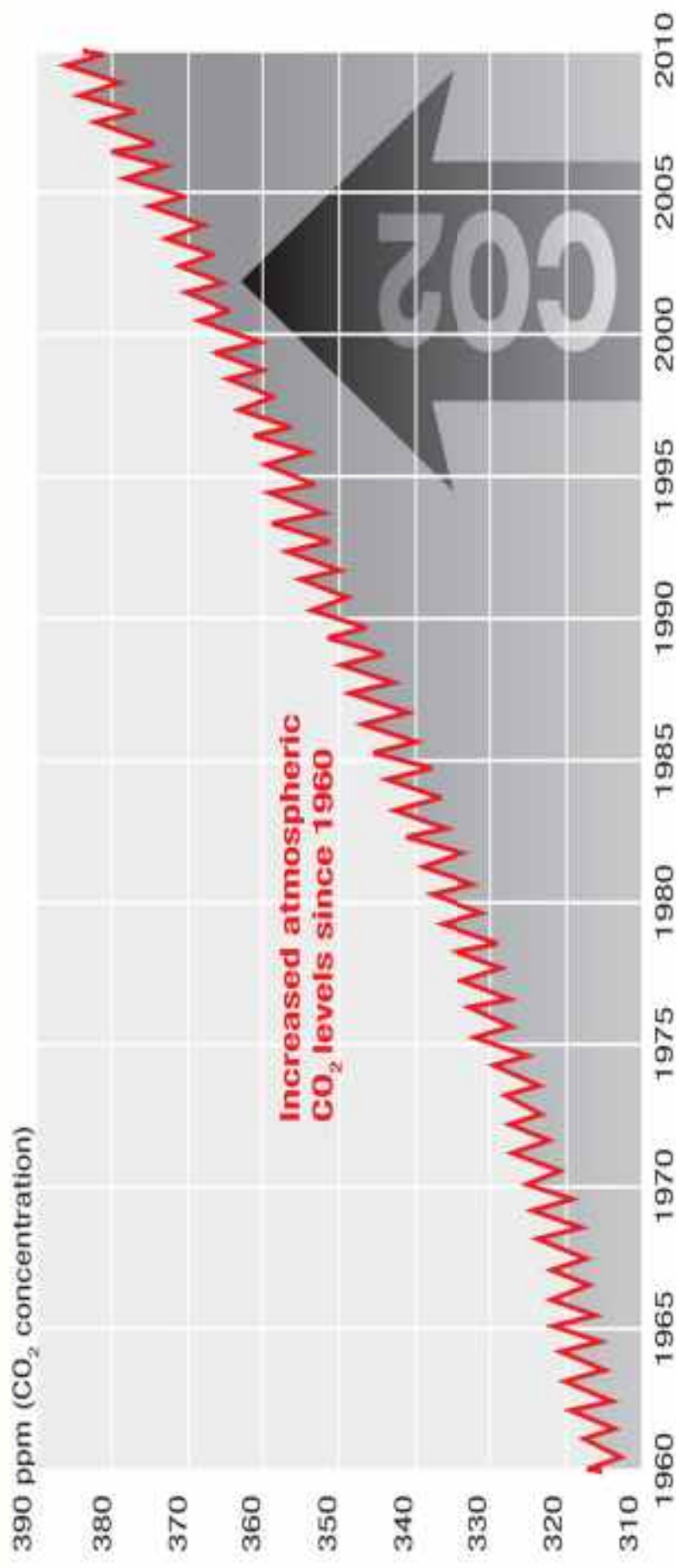
Topinka, USGS/CVO, 1997, Modified from: Tilling, Heiler, and Wright, 1987, and Hamilton, 1976

No Room for Complacency

- Risk of Escape Will Always Be Present
- Consumption Will Continue To Rise
- Technical Frontiers Continue to Advance
 - HPHT Wells
 - Extreme Deep Water Drilling
- Terrorism/Sabotage
- Natural Disasters

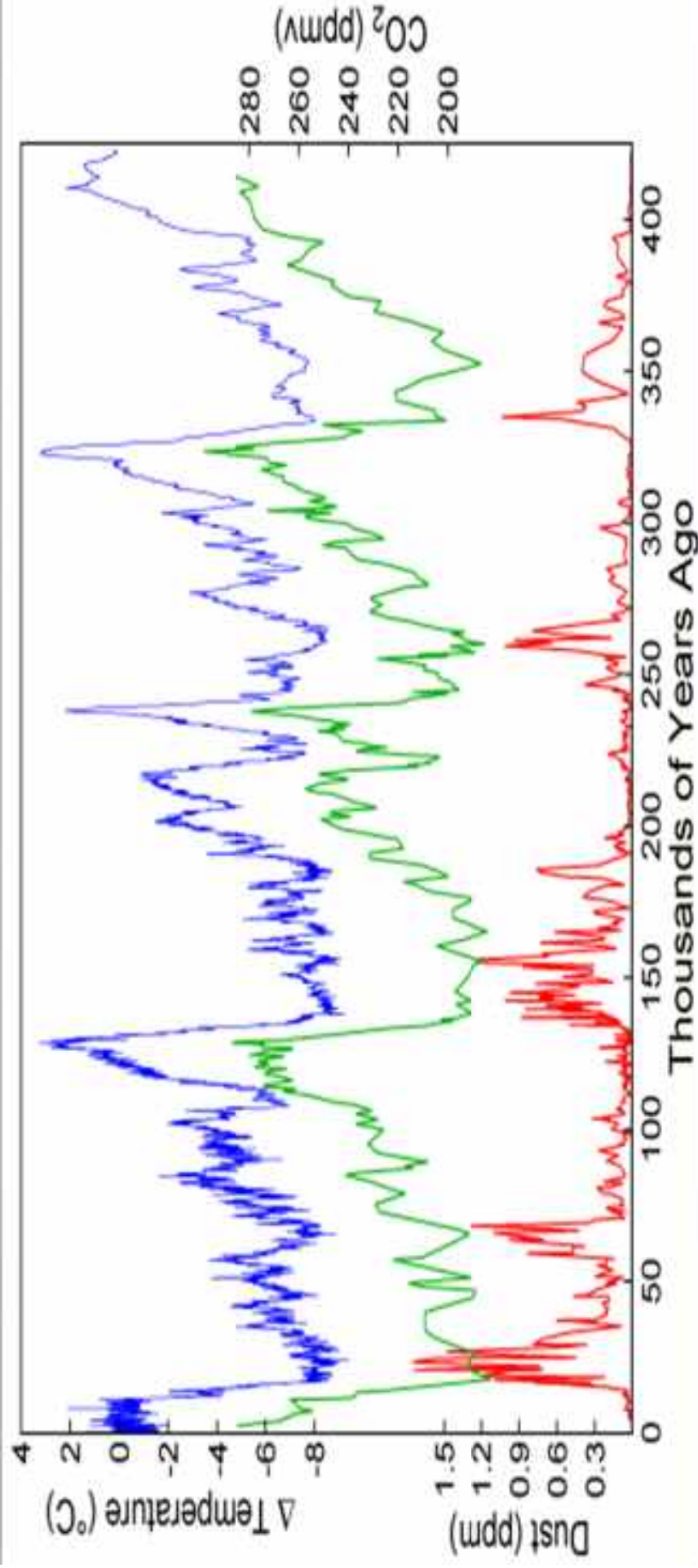
Climate Change

The Keeling Curve



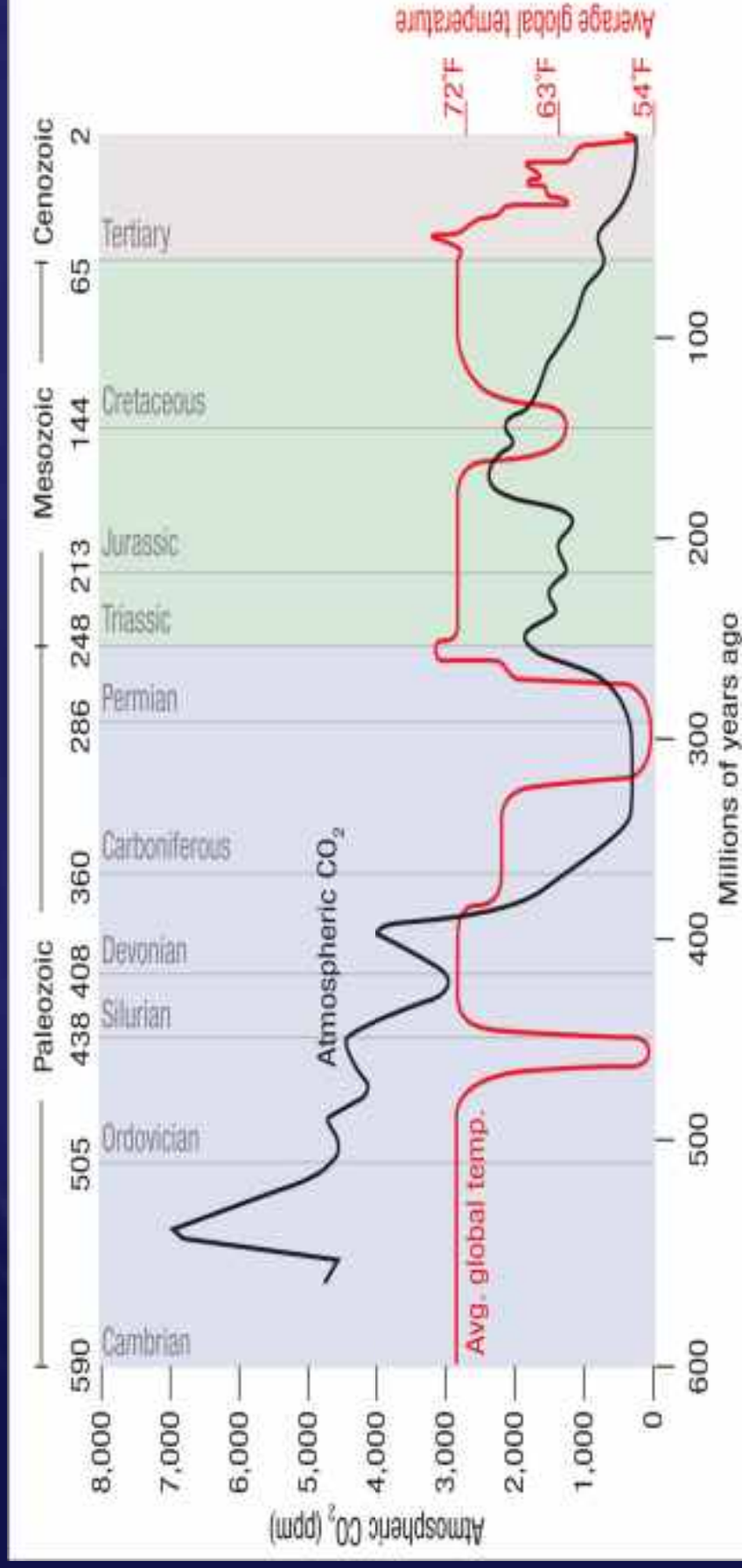
Source: The Energy Imperative

Vostok Ice Core Data



Source: IPCC, The Energy Imperative

Let's Extend The Time Scale, Shall We?



Source: Geocraft.com, The Energy Imperative

No Power For The People!!!



Climate Change

- The World Is In a Warming Trend – May Be Part of Natural Cycle
- CO₂ Emissions Are Probably Exacerbating This Warming Trend
- No Measures To Date (e.g. Kyoto) Have Been Effective
- Implementation of Such Measures Affect Economic Growth
- Carbon Taxes Of Some Form Will Likely Be Introduced
- These Will Disproportionately Affect Poorer Stakeholders
- There Is A Significant Risk Of Carbon Market Speculation
- This Will Have a Far Worse Effect Than Any Oil Crisis
- Why? Because It Will Affect ~80% of Our Energy Supply

Alternatives to Hydrocarbons

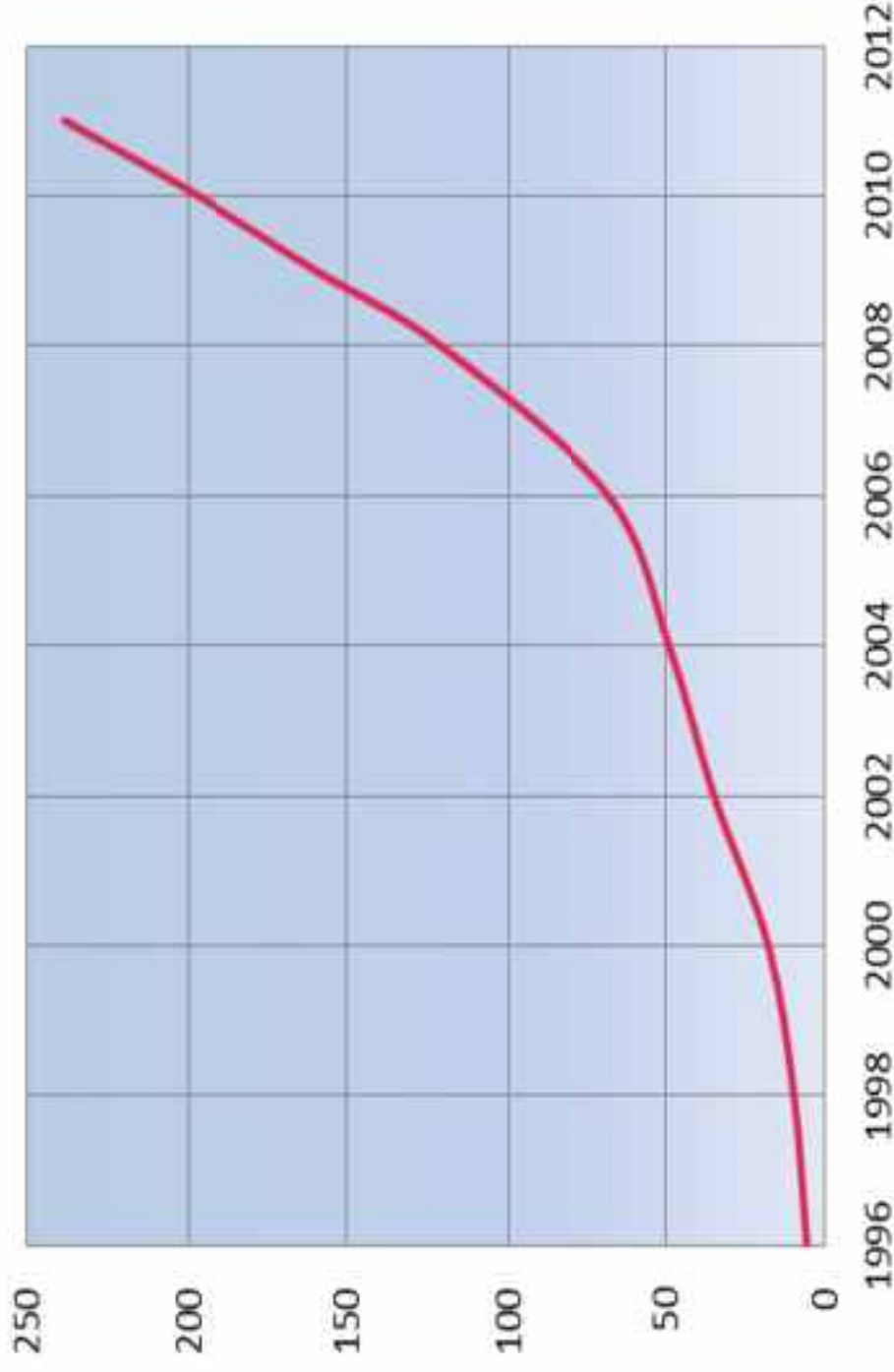
Potential Replacements for Hydrocarbon Fuels

- Wind
- Solar
- Nuclear
- Geothermal & Hydro
- Biofuels

Where Are You Hiding The Others?



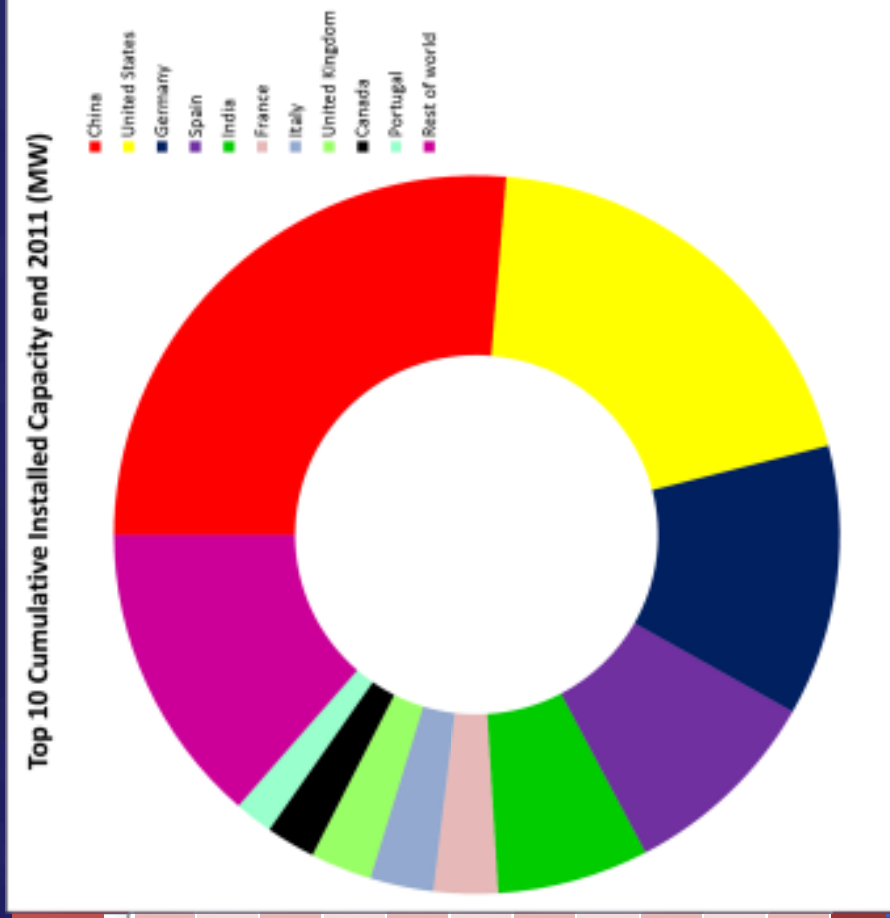
Growth of Global Installed Wind Energy Market



Source: GWEC

Who's Got Wind?

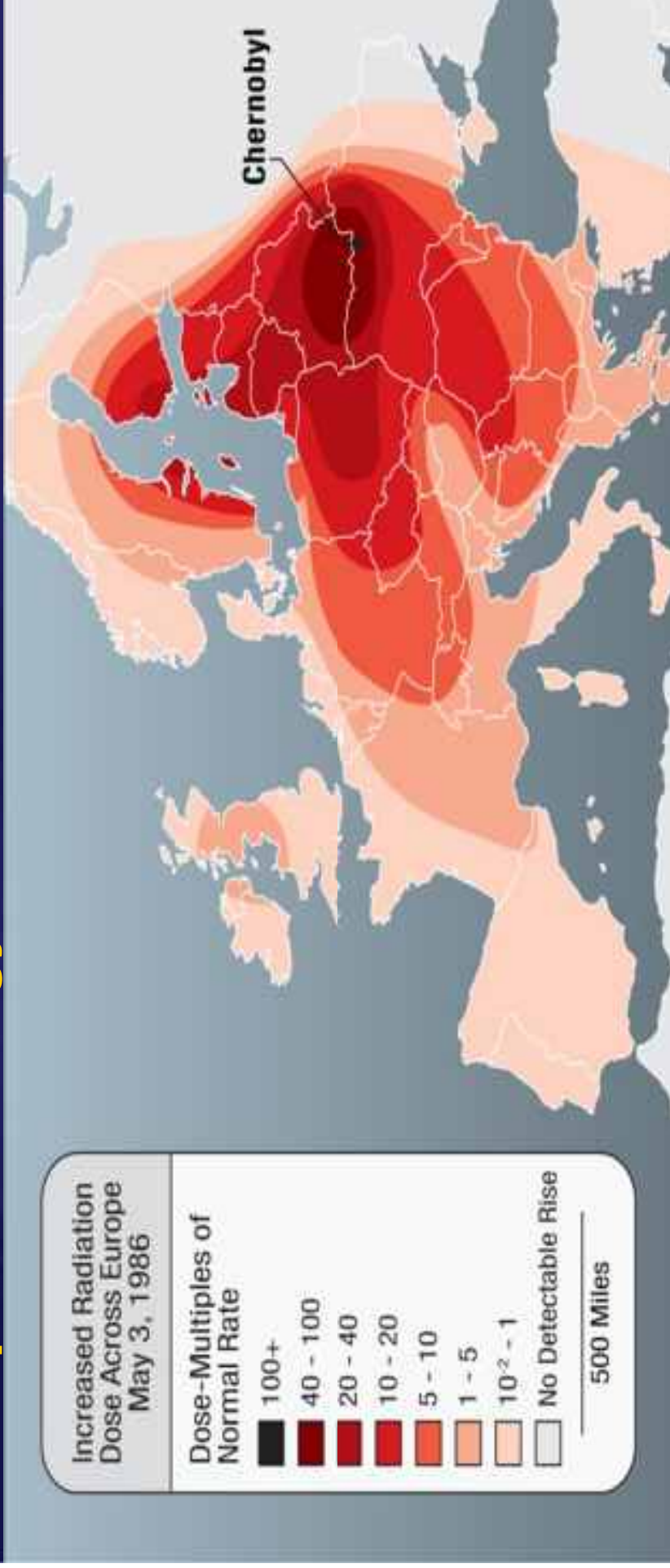
Country	Total capacity end 2011 (MW)	%
China	62,733	26%
United States	46,919	20%
Germany	29,060	12%
Spain	21,674	9%
India	16,084	7%
France	6,800	3%
Italy	6,747	3%
United Kingdom	6,540	3%
Canada	5,265	2%
Portugal	4,083	2%
Rest of world	32,444	14%
World Total	238,351	100%



Source: GWEC

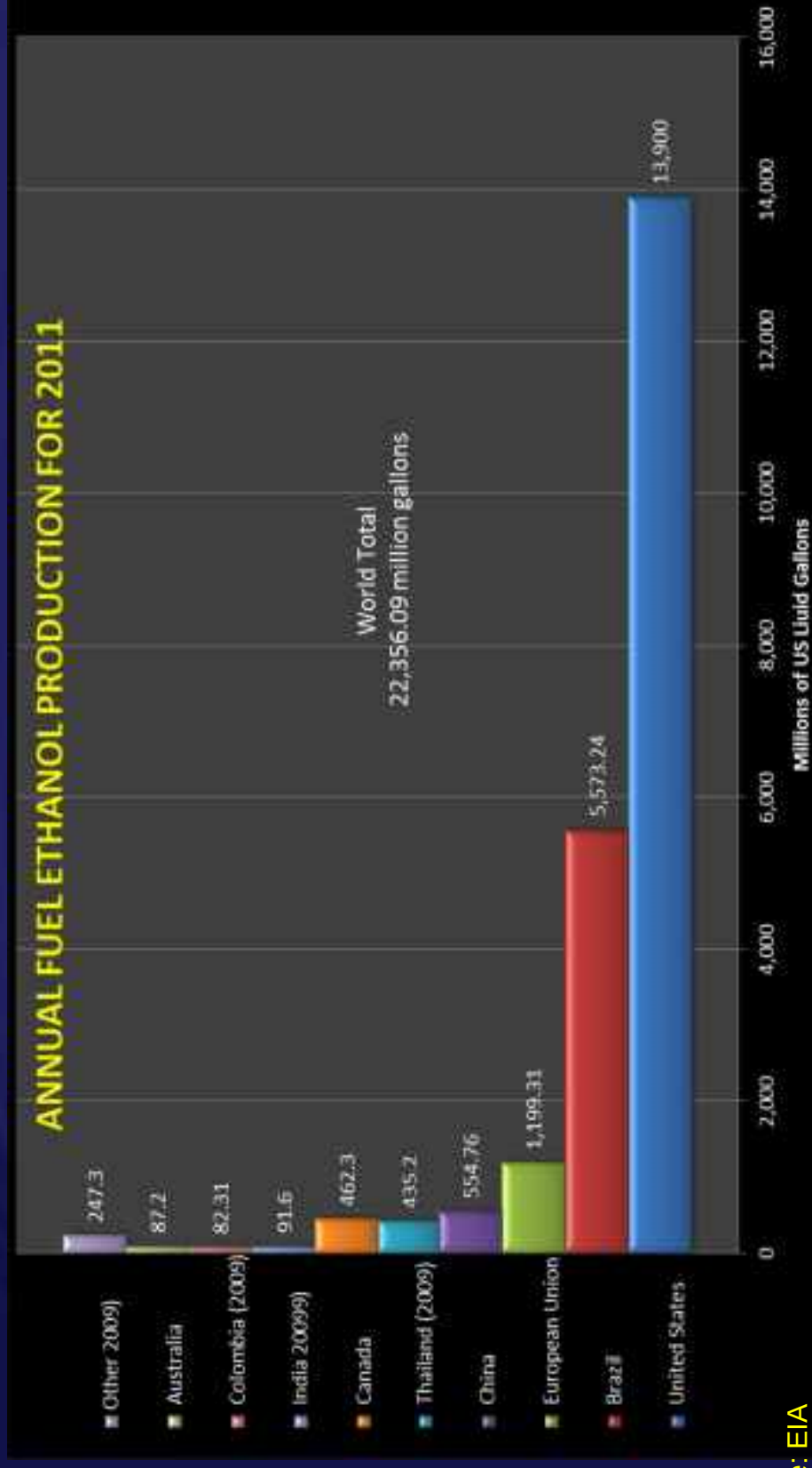
Nuclear Power

An Important Energy Source But Not Failsafe Either



Source: The Open University, The Energy Imperative

World Ethanol Production 2011



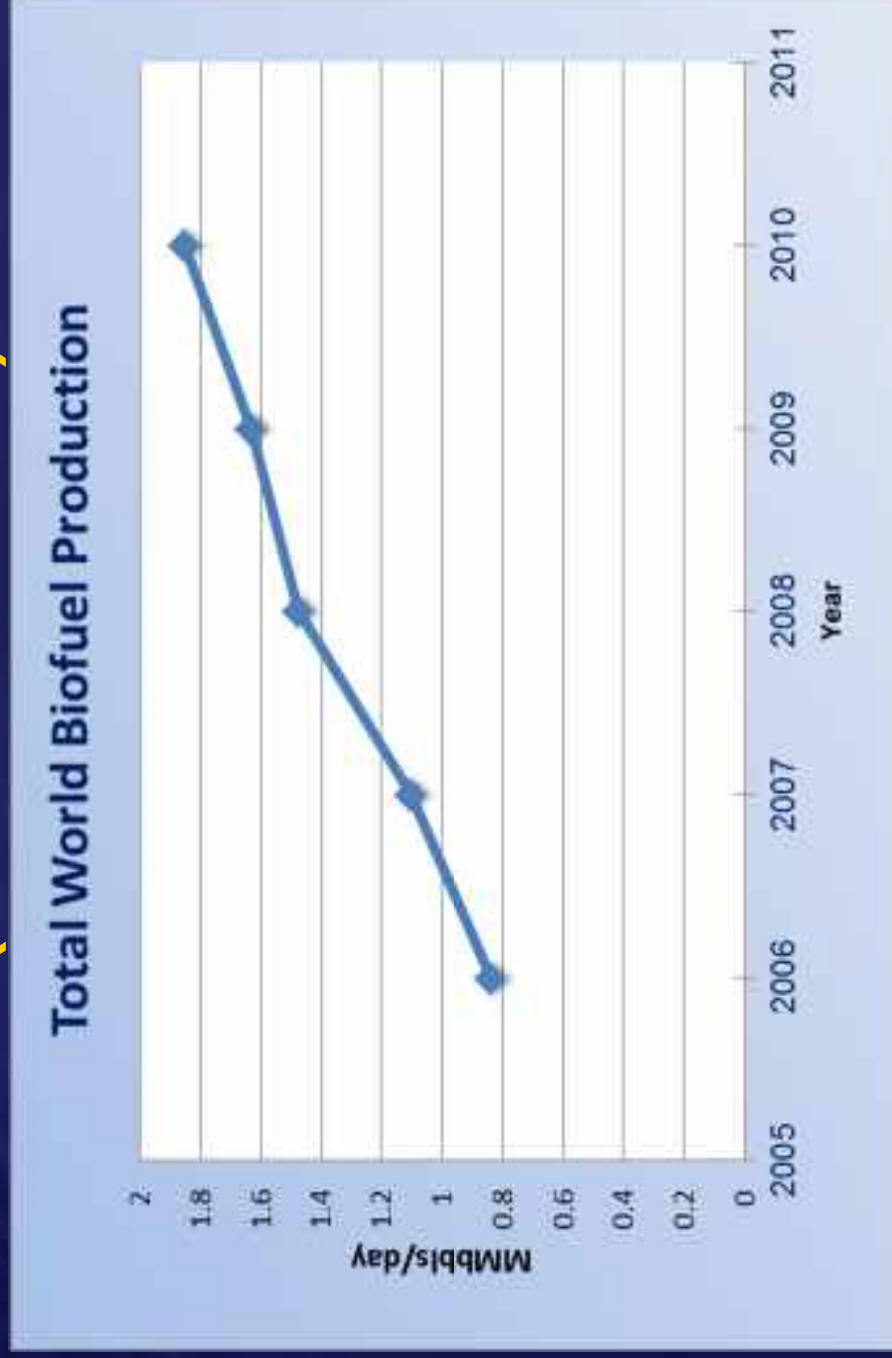
Source: EIA

Corn Ethanol – Not The Answer

- In 2010, The US Produced 13 Billion Gals Ethanol
- 13 Billion Gals Consumed 40% of US Corn Prodn
- That Corn Was Grown on 32 Million Acres of Land
- Entire Corn Crop = Only 18% of US Gasoline Needs
- Ethanol Prepared By Distillation Using Fossil Fuel
- Need Farm 1/3rd Area of US to Replace Gasoline
- Subsidy for Corn Ethanol in 2010 >\$5.68 Billion
- **Cellulosic Ethanol Still Not Commercially Viable**

Source: Scientific American, The Energy Imperative

Global Biofuel Production 2000-2010 (Ethanol+ Biodiesel)



Source: EIA

What About The Other 149,999?*



*Source: Virgin Airlines

Future Energy Trends

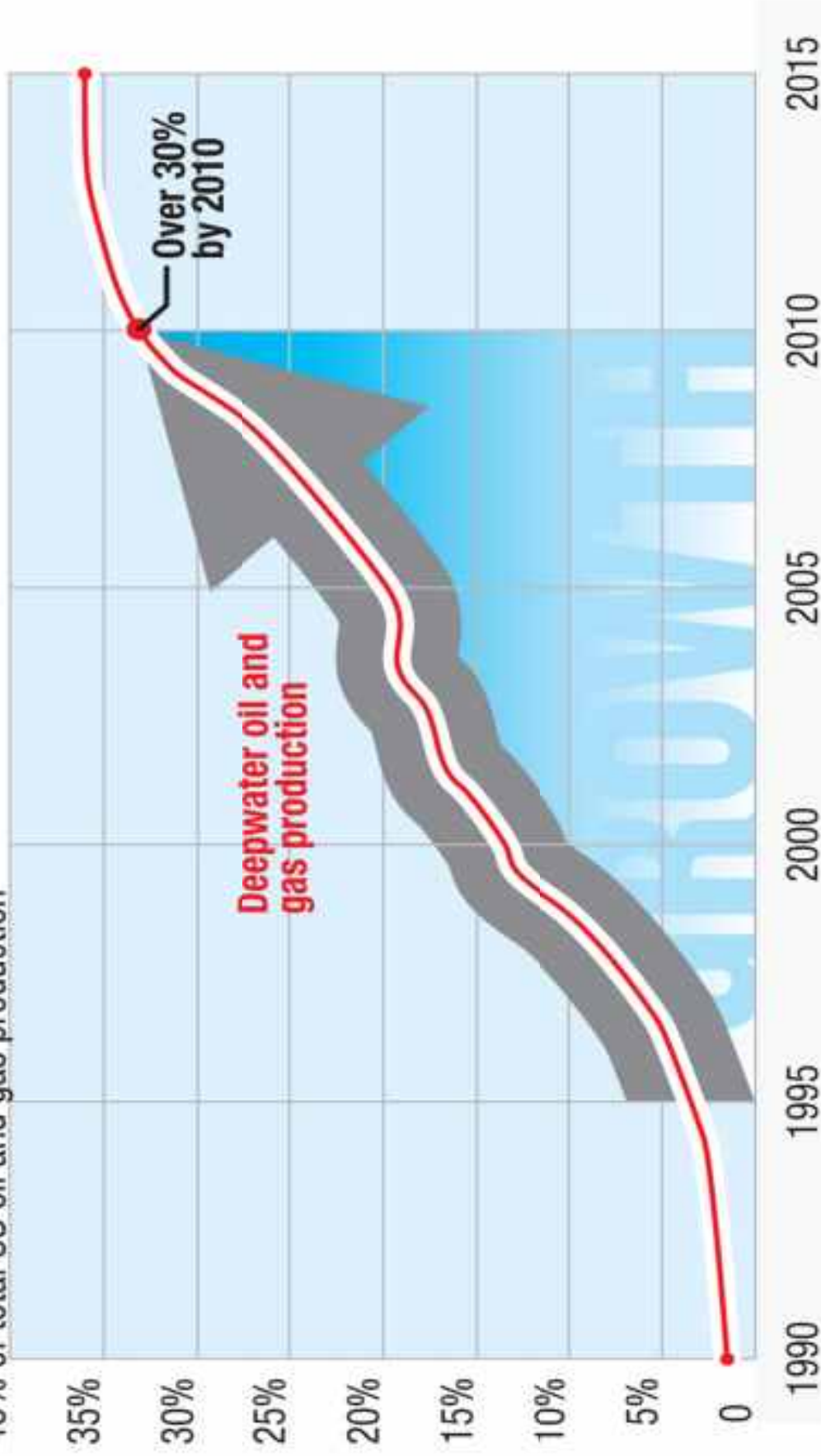
Oil/Gas Industry Statistics

- ~ 1 Million Wells Currently Worldwide
 - Those Wells Produce ~ 90 Million Bbls Oil/Day
 - ~3500 Drilling Rigs Operating Worldwide
 - 40,000 New Wells Drilled/Year Worldwide
 - Most Needed To Maintain Current Production
 - Many Major Oilfields in Decline
 - Drilling Alone Cannot Meet Future Oil Needs
- Technology Improvements Can Help

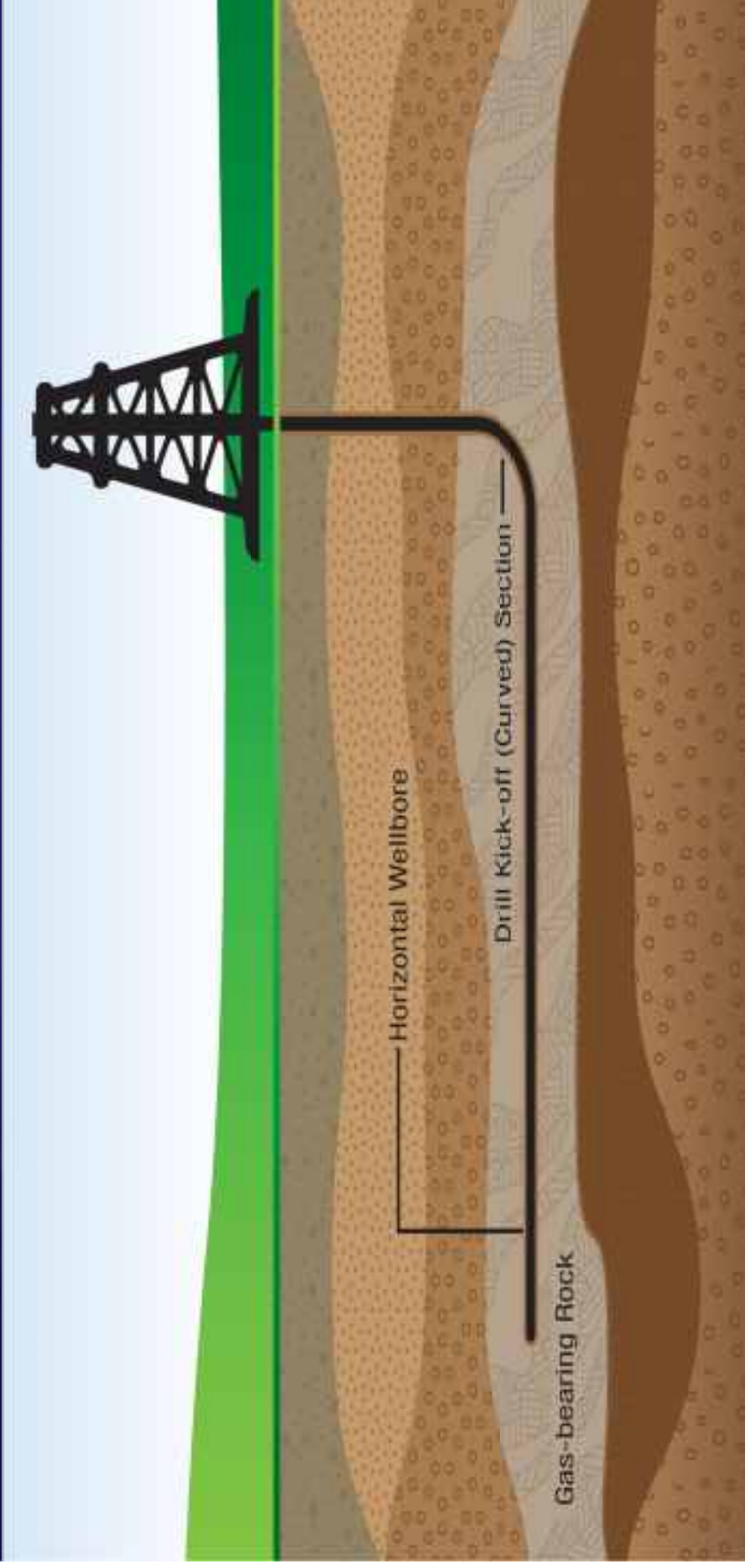
Examples of Improved Technology

- Deep Water Drilling & Production
- Extended Reach And Horizontal Drilling
- Hydraulic Fracturing

40% of total US oil and gas production

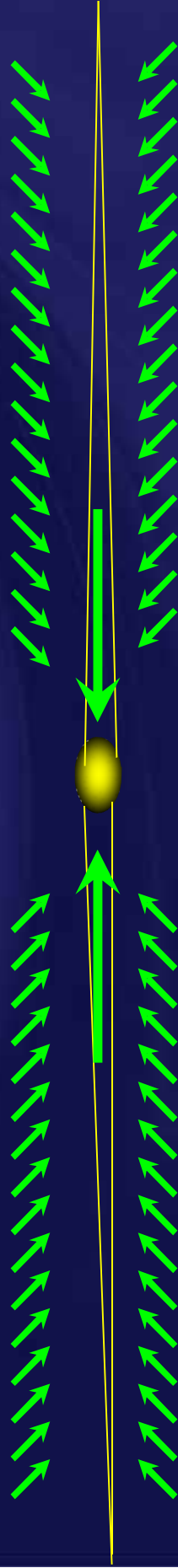


Horizontal Drilling



Hydraulic Fracturing

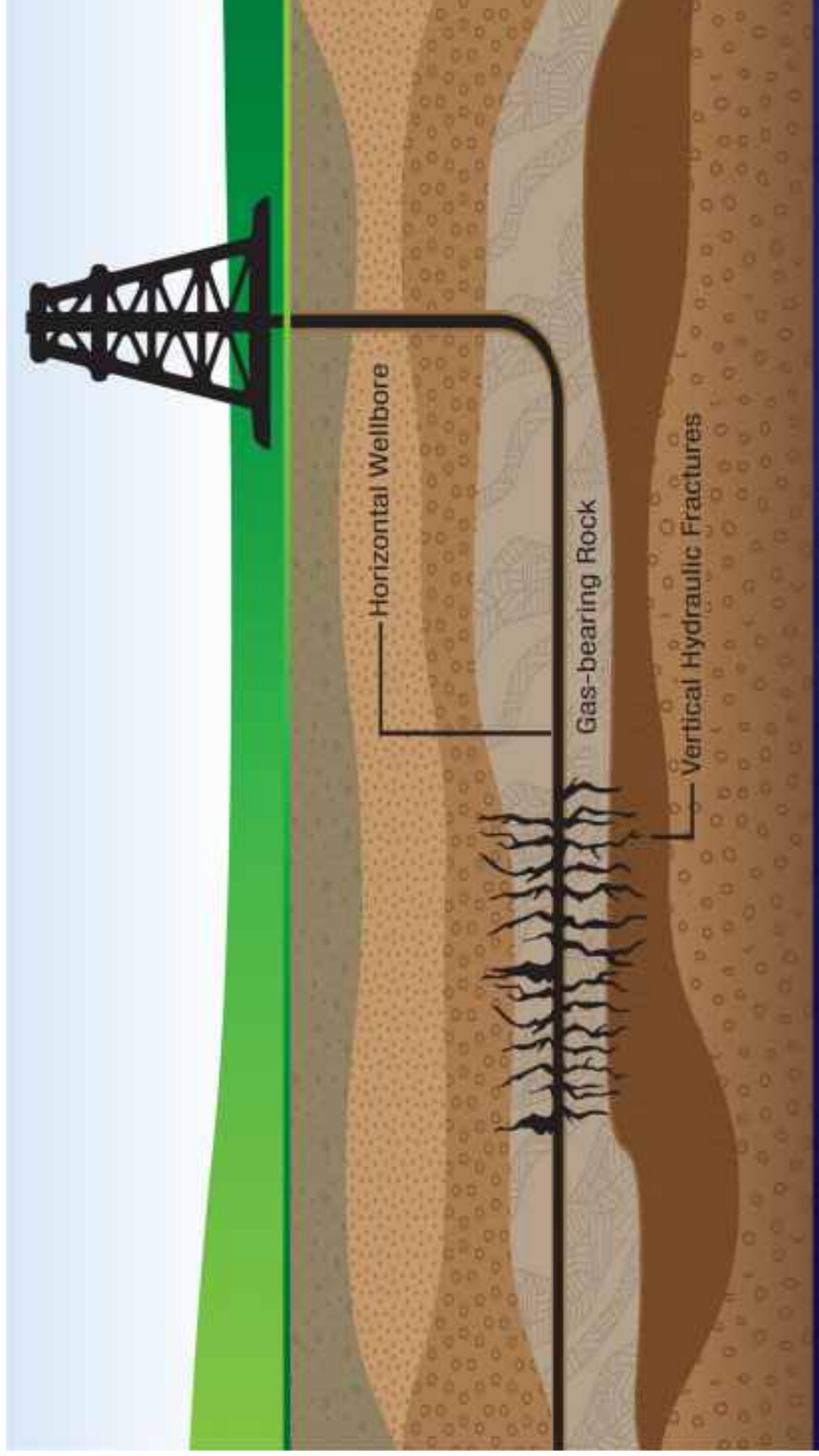
- Maximizes Contact Between Well and Reservoir
- Inflow Surface Increased By Factor of 10 – 1000x
- Fracture Provides Paths of Increased Conductivity
- Well Produces At Higher Rate ($\sim 2 - 10x$)
- Higher Ultimate Recovery From Fractured Wells
- Less Wells Needed To Drain A Reservoir



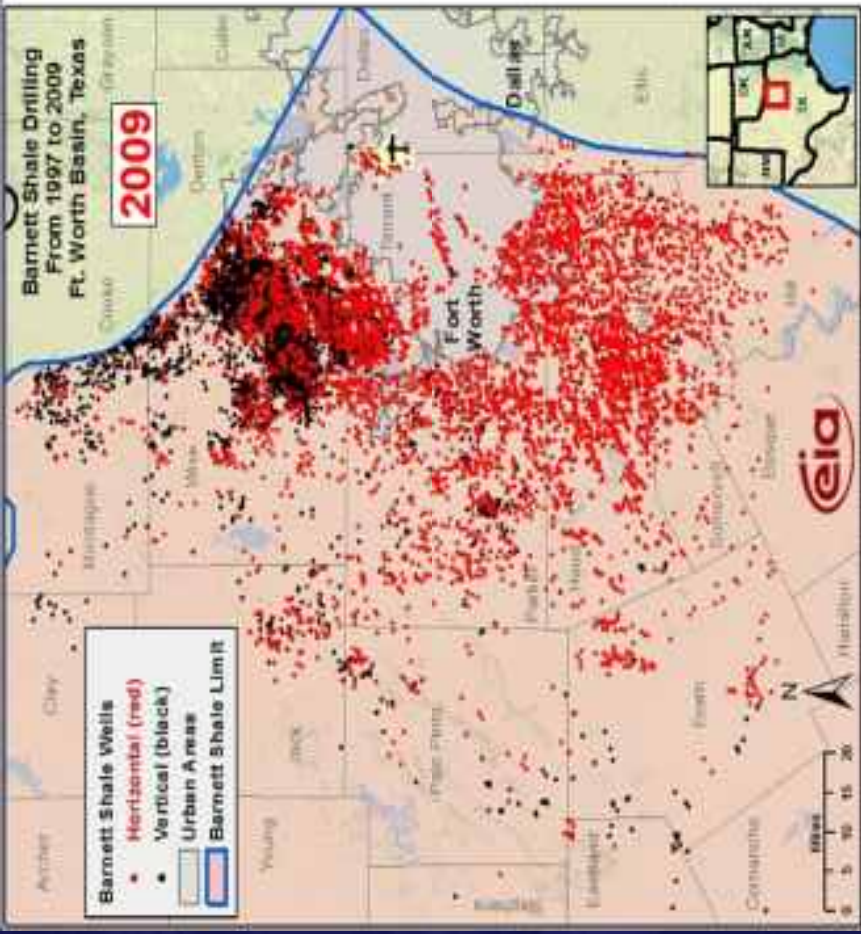
Importance of Hydraulic Fracturing

- > 9 Billion Bbls of Additional US Oil Production*
- > 700 Trillion Ft³ of Additional US Gas Production*
- Hydraulic Fracturing Has Now Changed The Game
 - Vastly Increased Estimated US Oil and Gas Recoverable Reserves
 - Significantly Increased US Domestic Gas Production
- US Built LNG Infrastructure To Import Gas
- Now Largest Global Producer of Natural Gas
- Could Become Net Gas Exporter In Future

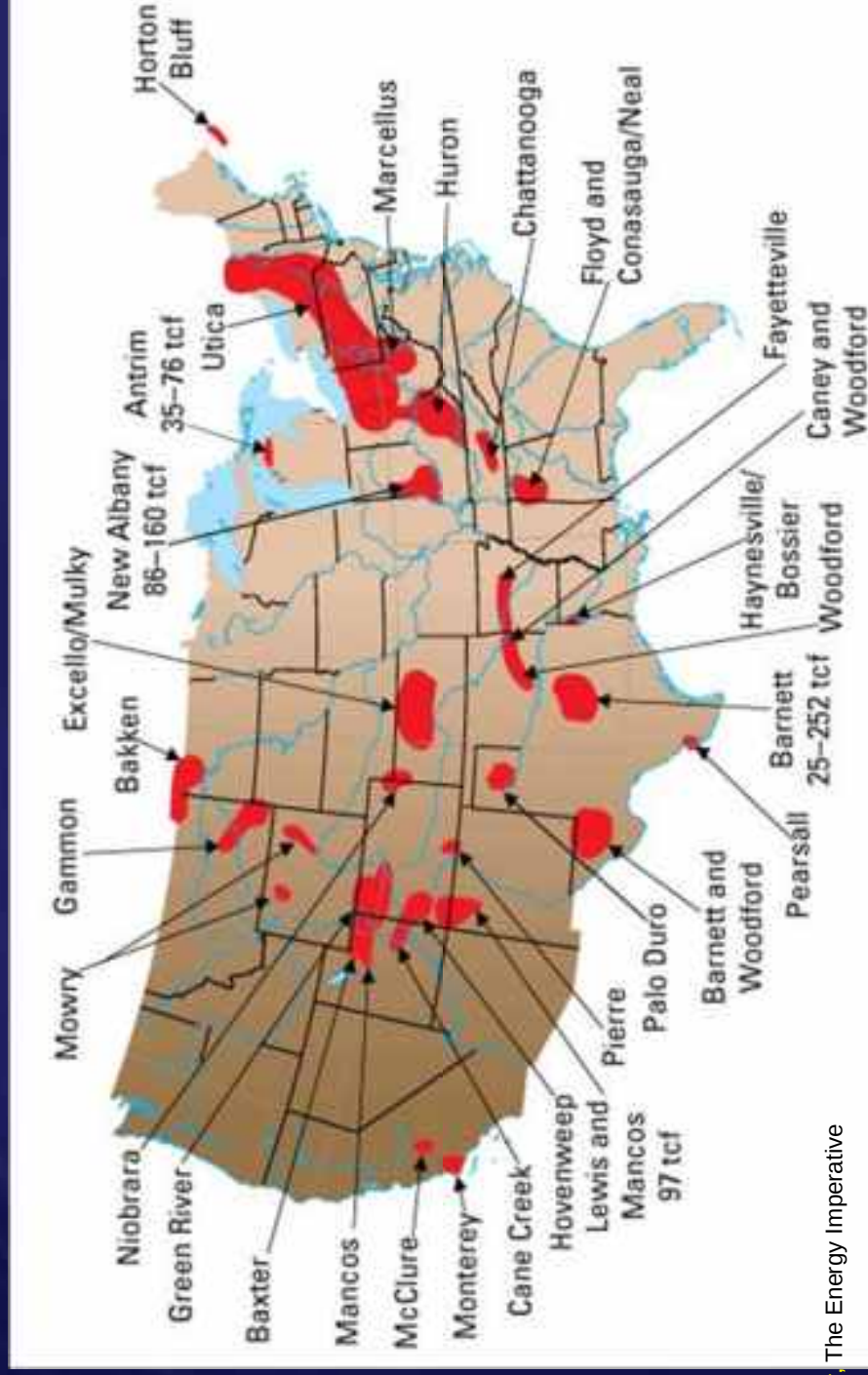
* Source: Journal of Petroleum Technology



Comparative Activity - Barnett Shale



Major US Shale Gas Basins



Source: Schlumberger, The Energy Imperative

Major European Shale Gas Basins



Source: The Economist

“Fracking” – New Word In The Green Lexicon

- **A New “Drilling Technology” That Must Be Stopped!**
- **“Poisonous Chemicals” Being Injected Into The Earth**
- **Pollution of Ground Water and Aquifers**
- **Gas Contamination of Drinking Water**
- **Causes Earthquakes**
- **Uses ~5 Million Gals of Water for Each Well**
- **Noisy Operation**
- **Thousands of Truck Journeys per Well (4000-6000)**

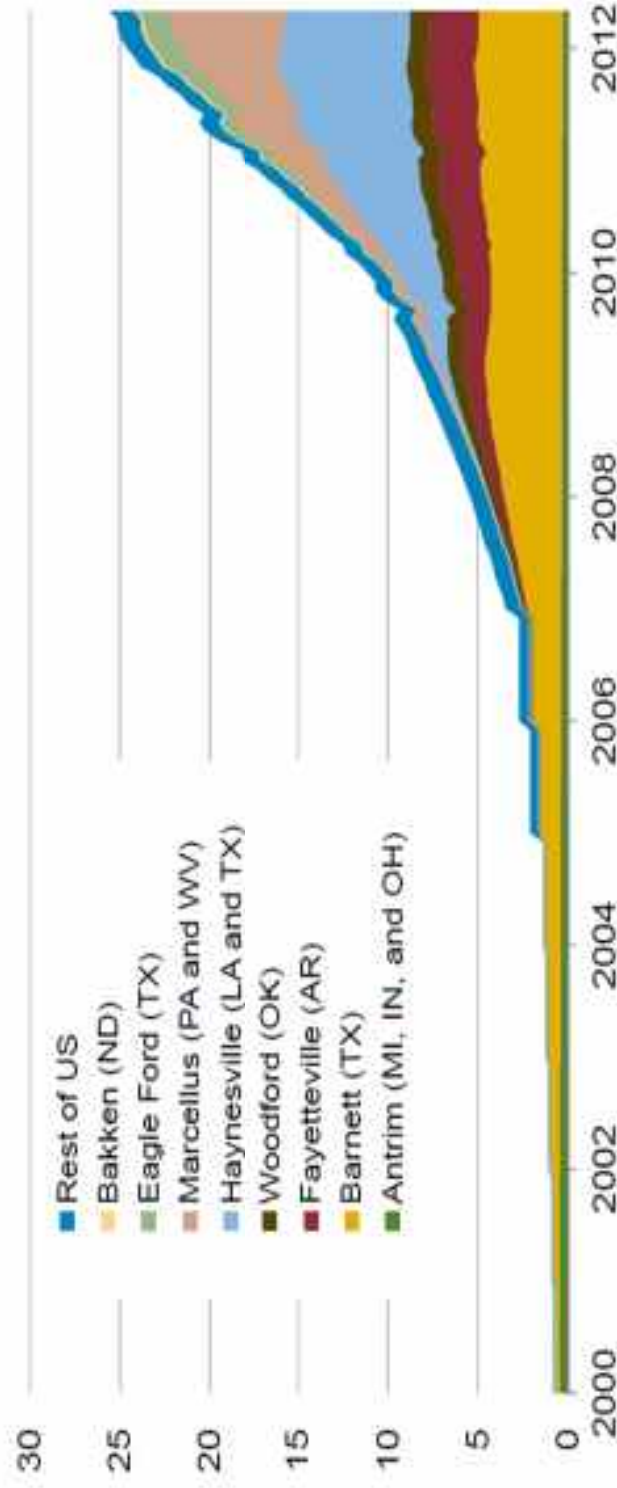
Hydraulic Fracturing - Sorting Frac from Fiction

- A 65 Year Old Technology
- Over 2.5 Million Frac Jobs Done To Date
- >80% of Conventional Oil and Gas Wells in US are Frac'd
- ~99.5% of Injected Fluid Is Water
- Common Food Additives Used in Fluid Formulations
- Target Zones Thousands of Feet Below Aquifers
- Very Minor Seismic Effects, If Any
- 5e⁶ Gals H₂O = 3 Weeks Requirement For A Florida Golf Course
- Noise Abatement Possible – Very Short Term Problem
- Average Shopping Mall = 15000-25000 Trucks/Year, Every Year

Sources: JPT, Scientific American, The Economist

The Impact of Shale Gas

U.S. shale gas production comprised over 30 percent of total U.S. dry production, in 2011

shale gas production (dry)
billion cubic feet per day

Sources: Lippman Consulting, Inc. gross withdrawal estimates as of May 2012 and converted to dry production estimates with EIA-calculated average gross-to-dry shrinkage factors by state and/or shale play.

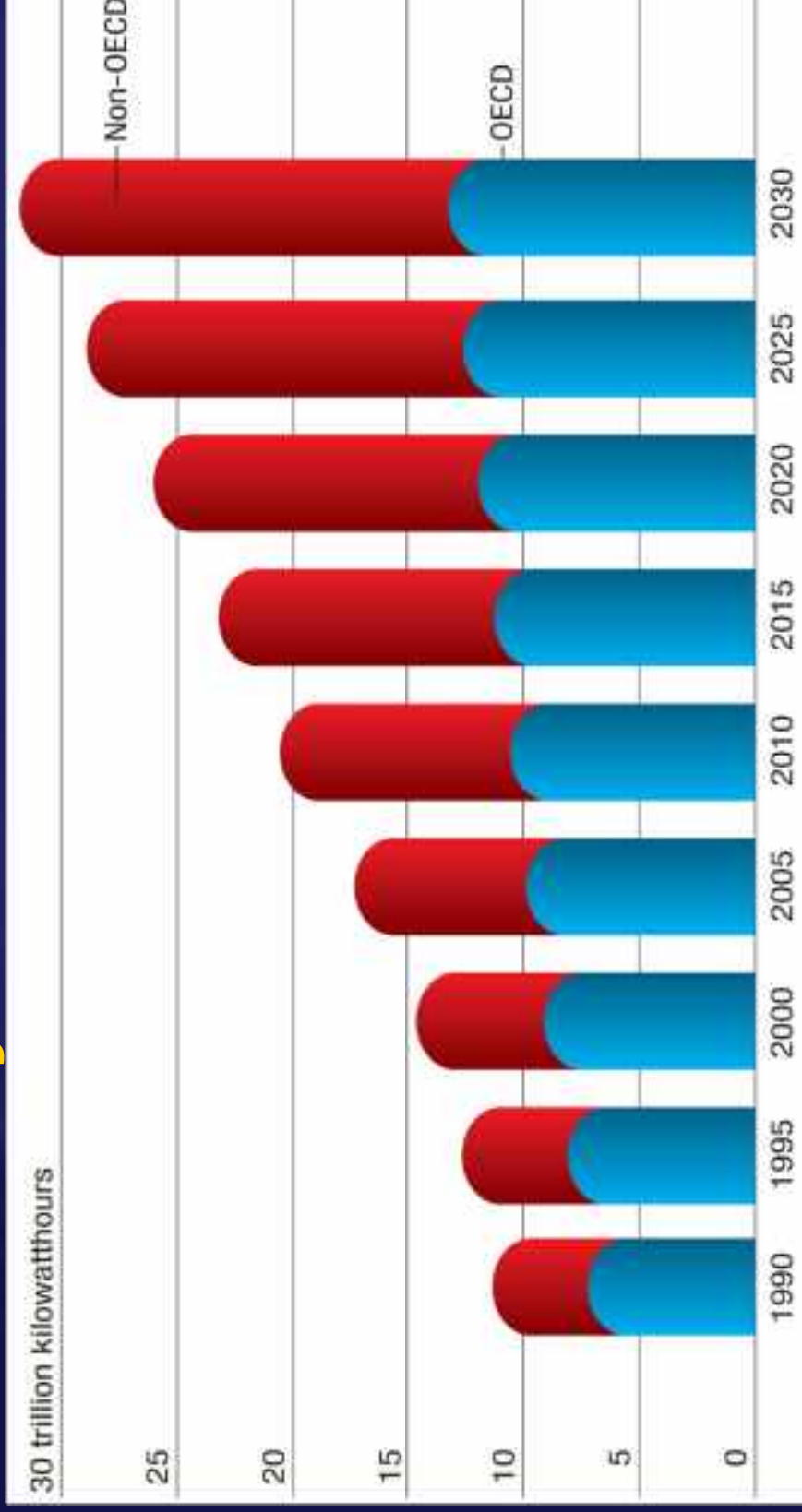
So What?

- We Have Huge Amounts of Natural Gas
- Technology Has Provided Access To New Sources
- USGS Estimate 2001 For Marcellus Shale – 1.9 tcf
- DOE Estimate 2009 For Marcellus Shale – 460 tcf
- IEA Estimates Global Gas Resources of 30,000 tcf
- At Current Consumption = ~300 Years Supply
- Likely To Increase Further
- Deep Sea Gas Hydrate Deposits Even Bigger

And.....

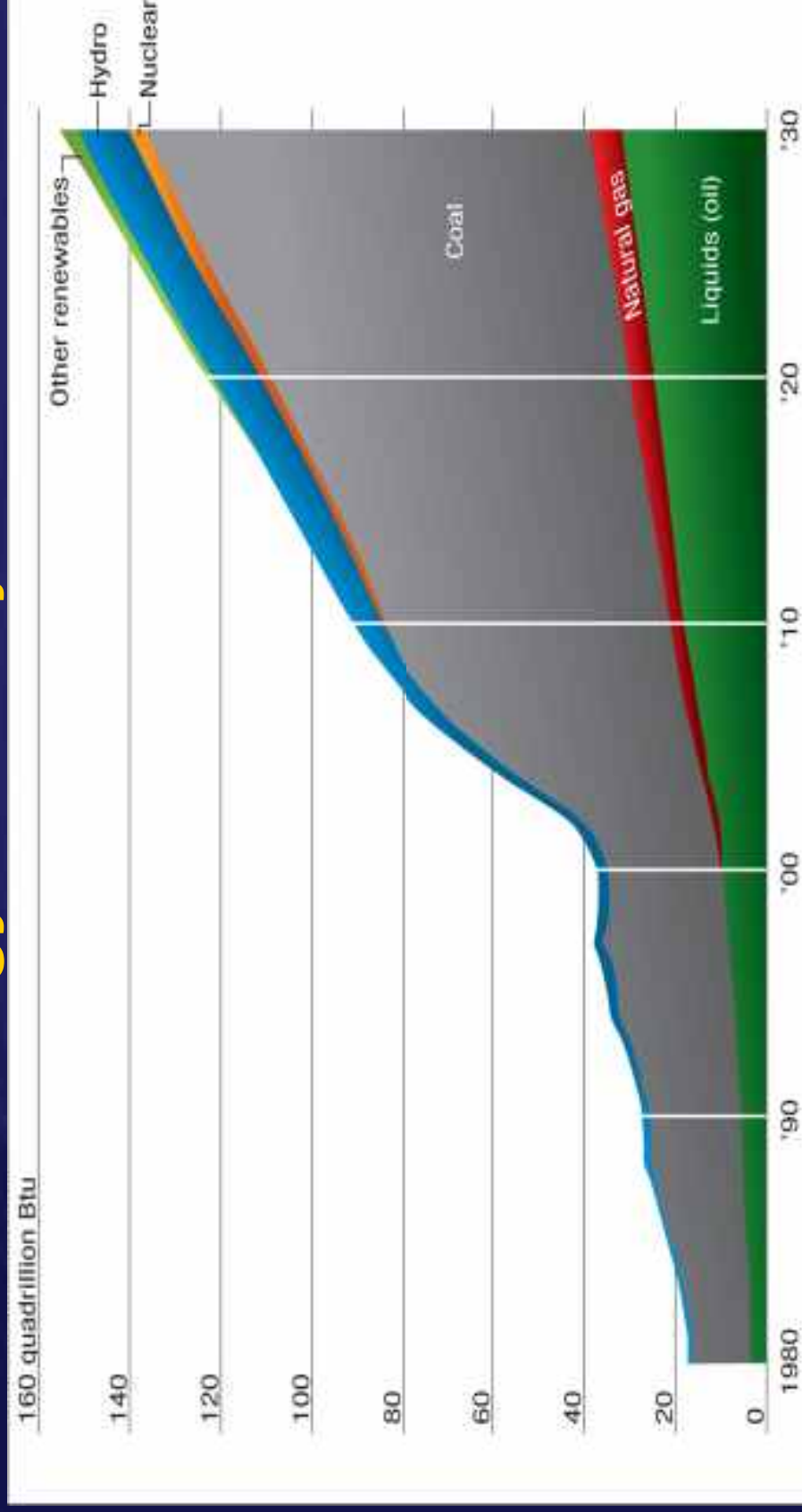
- Gas Is The Cleanest of The Hydrocarbon Fuels
- Gas = 25-50% Less CO₂ per Unit of Energy Yielded
- Gas Could Replace Coal for Power Generation
- Gas Could Replace Liquid Fuels for Transportation
- Gas Is Now A Globally Traded Commodity
- Pipeline/LNG/Re-Gas Infrastructure Widespread
- New Storage Technologies Emerging, Also
- Gas Offers Solutions To Many Current Problems

Why Does This Matter?



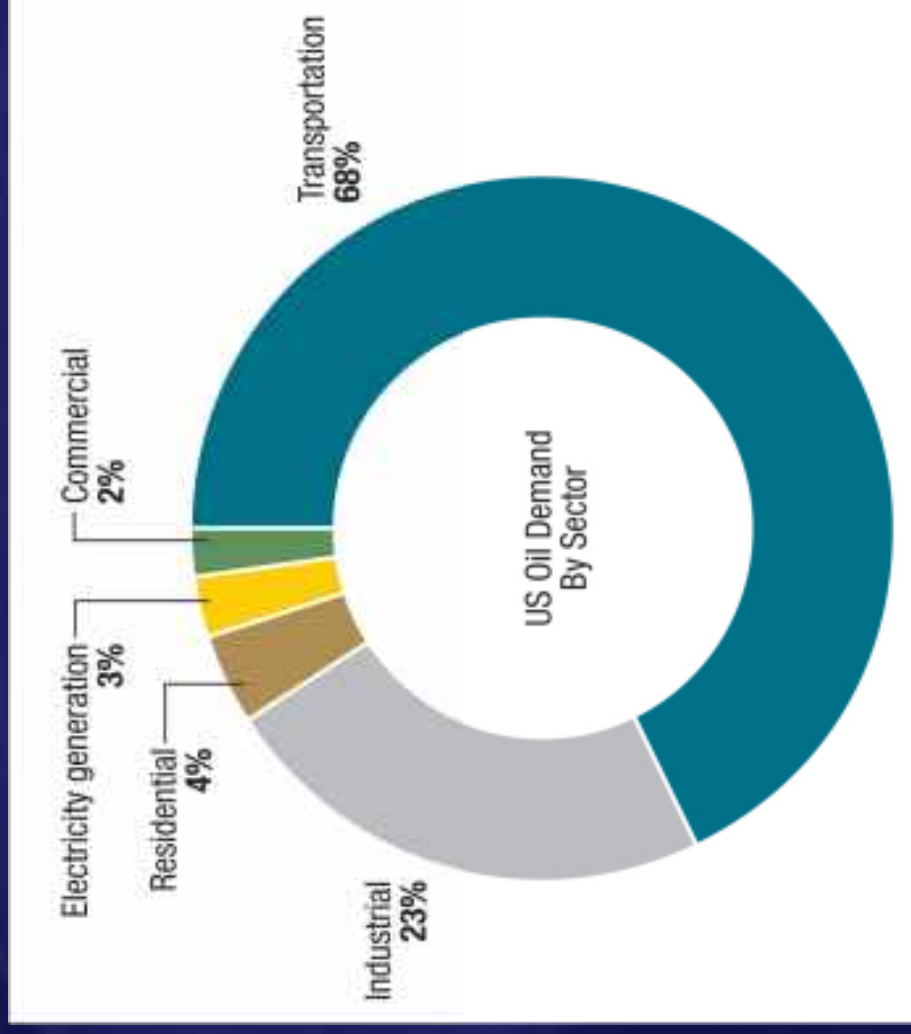
Source – IEA, EIA, The Energy Imperative

China's Energy Mix Projection in 2010



Source – DOE/EIA, China Academy of Sciences, The Energy Imperative

Transportation Opportunity?



Source: EIA

Gas As A Transportation Fuel

- Simple To Implement With Existing Engines
- Already Used For Fleet Vehicles, Taxis, etc
- Cheaper Than Gasoline (= Oil at \$15 – \$30/bbl)
- Energy Independence Achievable With Gas
- Reduce US Oil Imports of 7-10 Million BOPD
- Reduce US Trade Deficit Significantly
- Cleaner Air
- Fewer Pollutants
- Sensible Transition Step to EVs, PIHs, etc

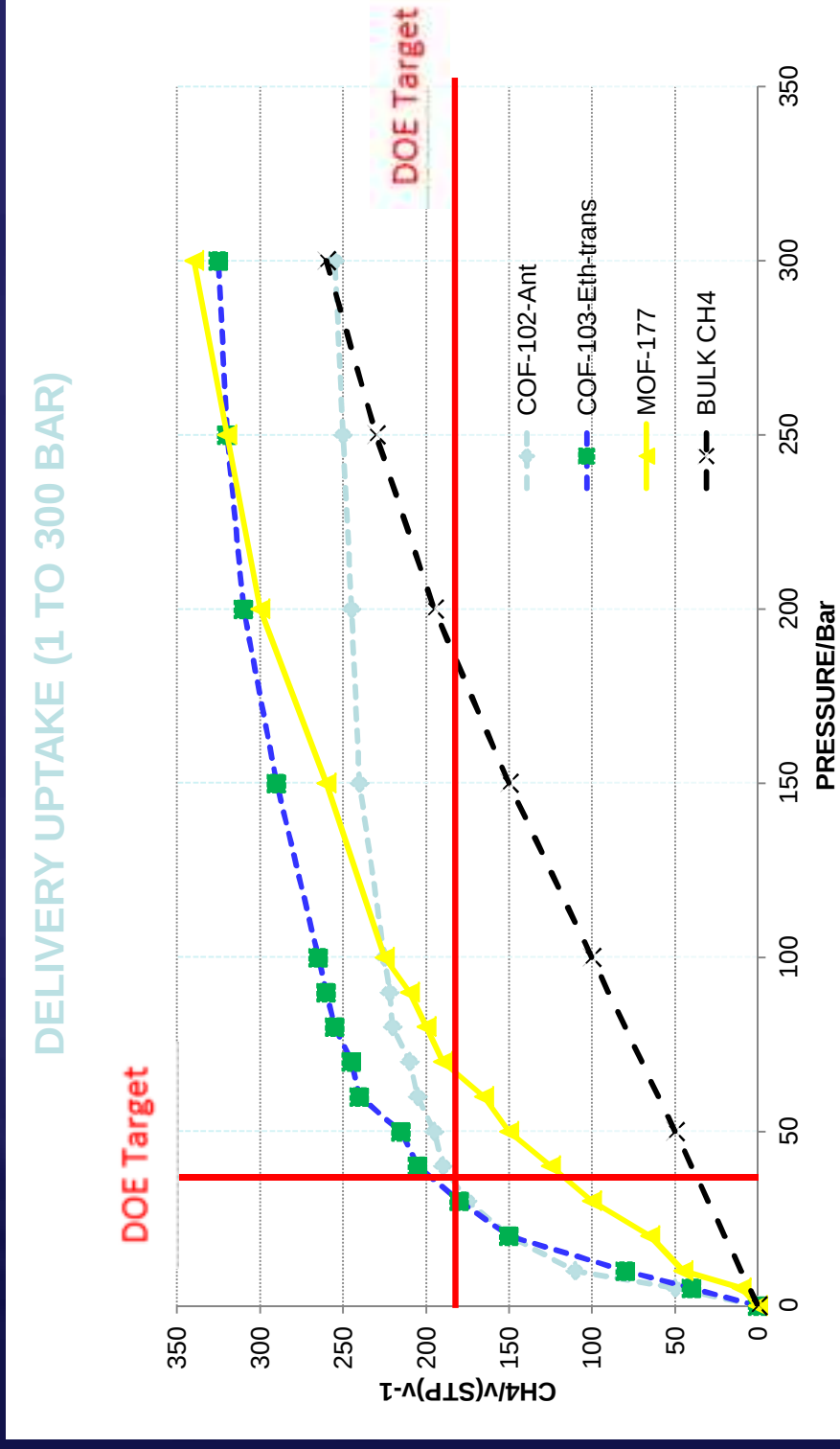
What The Future Holds? Part 1



Current Storage Issues for CNG Vehicles

- ~45 Gal HP Steel Tank Required for Equivalent Mileage
- Composite Tanks Reduce Weight BUT Still High Pressure
- New Sorbents Allow High Volume Storage at Low Pressure
- Act Like A Sponge To Soak Up and Hold Natural Gas
- DOE Requirement – 180 v/v at 35 Bar
- Experimental Materials Capable of >200 v/v at 35 Bar
- Allow Use of Lighter, Distributed Fuel Tank
- Some Believe 400 v/v at 35 Bar is Feasible

More Room In The Trunk, Perhaps?



EPA Fuel Economy and Environmental Comparisons

Electric Vehicle

99

combined city/hwy

MPGequivalent

106

city

92

highway

34 kW-hrs per 100 miles

Charge & Range

7 hours

at 240V

0 7 14 21 28 35 42 49 56 63 73 miles

73 miles

Annual Electric Cost

\$561

How This Vehicle Compares

Among all vehicles and within midsize car

Worst 9

MPG

99 Best

MPGe

Environment

Greenhouse Gases (CO₂ grams, tailpipe only)

Other Air Pollutants

98/7 Worst Best

1 Worst Best

Your actual mileage and costs will vary with electricity cost, temperature, driving conditions, and how you drive and maintain your vehicle. Cost estimates are based on 15,000 miles per year at 12 cents per kW-hr. MPGe equivalent: 32.7 kW-hrs = 1 gallon gasoline energy.

See the **FREE Fuel Economy Guide** at dealers or www.fueleconomy.gov

Closing Remarks

- Hydrocarbons Have Provided Affordable Energy for The Past 250 Years and Will Probably Provide The Bulk Of It For The Next 100 Years
- That Affordable Energy Has Transformed The World and Allowed Unprecedented Improvements in Living Standards
- World Energy Demand Will Continue To Rise
- Unrealistic Constraints on Hydrocarbon Use Will Affect Many Countries, Impede Growth and Delay Development

Closing Remarks

- In The Short Term, Move Progressively to Plentiful Natural Gas for Power Generation....and For Transportation, Too!
- Continue To Diversify and De-Carbonize Our Energy Supply But Unrealistic Subsidies Can Be Dangerous, Too
- Increased Carbon Taxation In Some Form Is Inevitable but Care Must Be Taken To Minimise Speculation and “Gaming The System”
- Adaptation To Climate Change Is More Realistic and More Cost Effective Than Trying In Vain To Control It

That's All From Me!
Thank You All For Your Attention!
Any Questions?





Putting The Energy Industry In Perspective

Phil Rae
InTuition Energy Associates



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Lecturer Program

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Enter your section in the DL Evaluation Contest by
completing the evaluation form for this presentation :

Click on:

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