

Energy Demand

What Energy Sources and How Much of Them Does the World Consume? Total Primary and Final Energy Consumption by Fuel, by Sector and by Region.

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Review: Primary, Secondary, Final Energy

- Primary energy includes things like coal, crude oil, natural gas, biomass, wood
- Secondary energy or “energy carriers” are products of refining or converting primary energy sources to convenient forms—liquid, solids, gases, and electricity
- Final energy or “energy services” are the things we want to do with energy—produce heat, light, mechanical energy, or power electrical devices.

Accounting for Energy in National Statistics

•Primary energy Equivalent

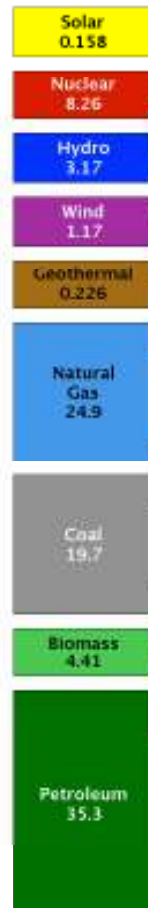
- Primary Energy Equivalent of Solar, Wind, Hydro, Nuclear is estimated as the amount of fossil fuel that would be needed to produce the same amount of electricity
- Biomass is estimated as the energy content of the wood or biomass.
- What about passive solar or the energy supplied using heat pumps, animal and human power, or the energy in the sunlight that falls on plants that are used for biomass energy?

•Energy Units

- BTU's, Joules, Watt-hours
- Tonnes of oil, coal equivalent, cubic meters (feet) of gas, barrels (gallons) of liquid fuel

US Example of Energy Flows

Estimated U.S. Energy Use in 2011: ~97.3 Quads



Source: LLNL 2012. Data is based on DOE/EIA-0384(2011), October, 2012. If this information or a reproduction of it is used, credit must be given to the Lawrence Livermore National Laboratory and the Department of Energy, under whose auspices the work was performed. Distributed electricity represents only retail electricity sales and does not include self-generation. EIA reports flows for non-thermal resources (i.e., hydro, wind and solar) in BTU-equivalent values by assuming a typical fossil fuel plant "heat rate." The efficiency of electricity production is calculated as the total retail electricity delivered divided by the primary energy input into electricity generation. End use efficiency is estimated as 80% for the residential, commercial and industrial sectors, and as 25% for the transportation sector. Totals may not equal sum of components due to independent rounding. LLNL-MI-410527

Energy Units (cont.)

- BTUs, Joules and Watts are very small units

Latin Prefixes Often Attached

Deka = ten (10^1)

Hecto = hundred (10^2)

Kilo = thousand (10^3)

Mega = million (10^6)

Giga = billion (10^9)

Tera = trillion (10^{12})

Peta = quadrillion (10^{15})

Exa = quintillion (10^{18})

Many of the large central power stations are rated at around 1 Gigawatt capacity—1000 Megawatts. What does this mean?

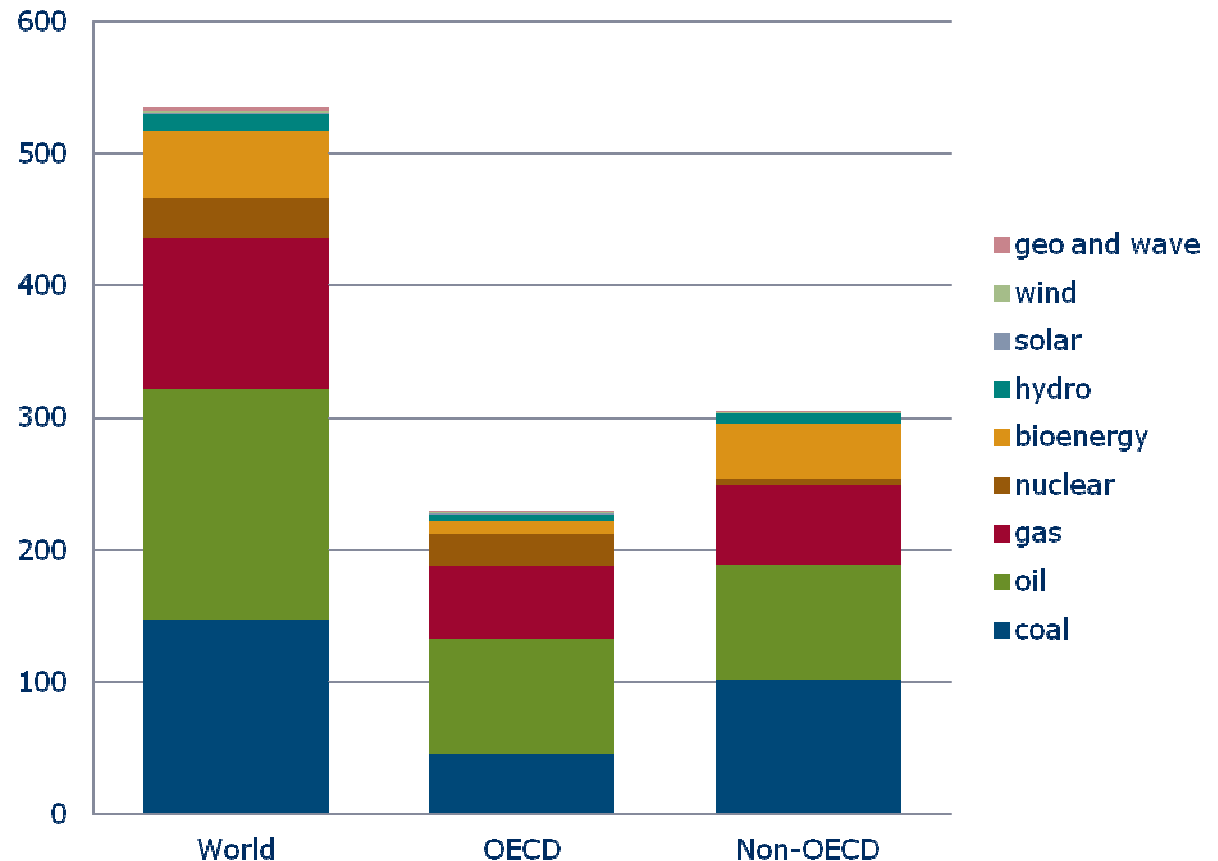
E.g. Exajoule, Terawatt hours. An exception— 10^{15} Btu's is a Quad)

Reference: Global Primary Energy Consumption is around 500 EJ, 500 Quads (1 BTU \approx 1 055 joules), 150,000 TWh (1 BTU/hr \approx 0.293 W)

World and Regional Primary Energy Consumption

- Worldwide, 82% of primary energy was fossil fuel (oil, gas, coal)
- Almost exactly the same shares in OECD and Non-OECD
- More nuclear in OECD
- More biomass in Non-OECD
- Coal is 33% in Non-OECD but just 20% in OECD

2010 Primary Energy Consumptions (EJ)

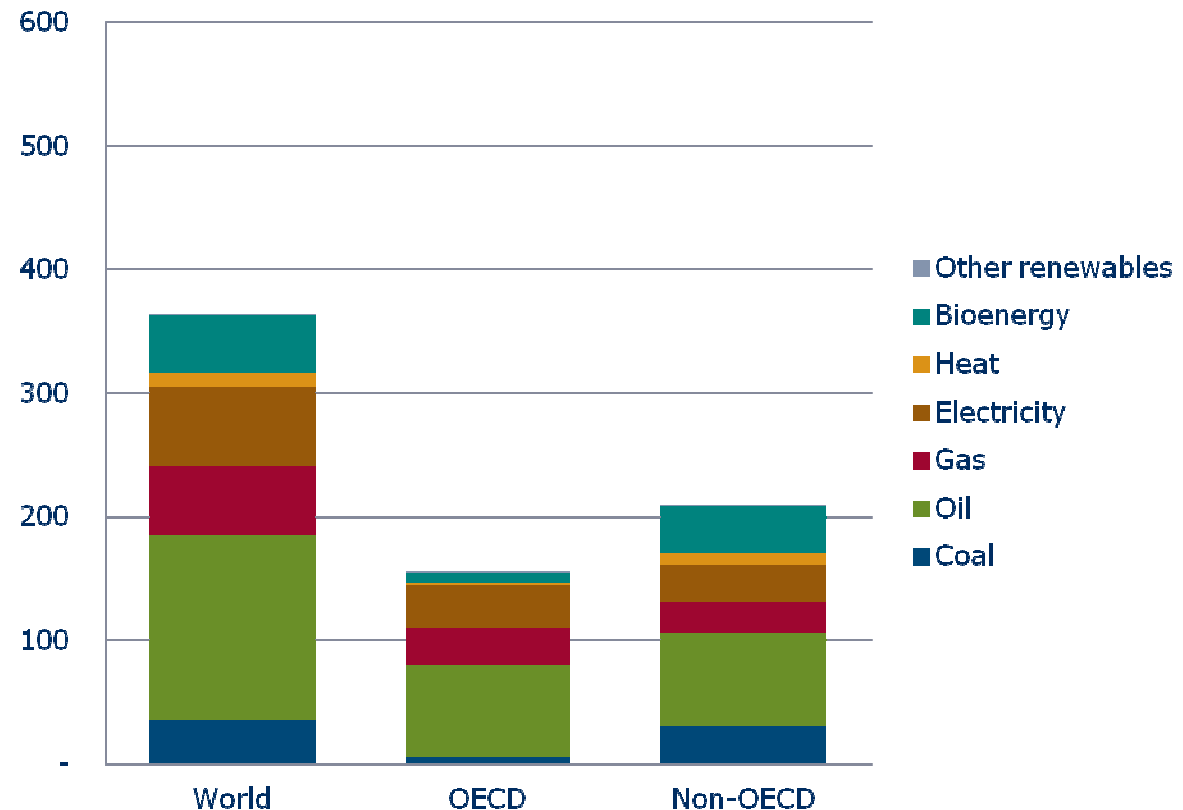


OECD is the Organization for Economic Cooperation and Development, a group of richer nations (Europe, US, Japan, Canada, Australia, New Zealand, now also Mexico, Korea, Chile, Israel, Turkey)

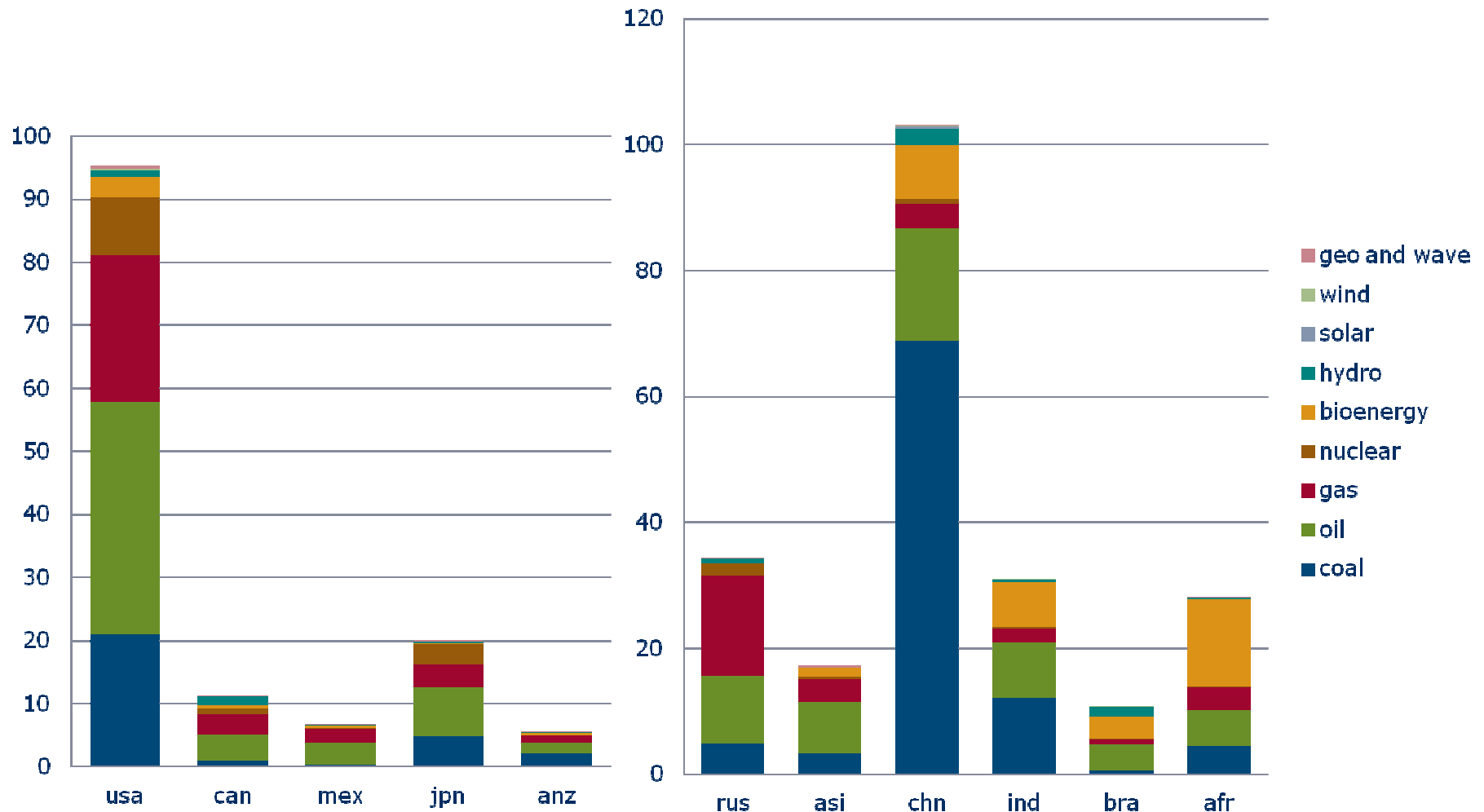
World and Regional Secondary Energy Consumption

- How different than Primary?
- $\approx 20\%$ less because losses in conversion are not accounted.
- Virtually no coal in OECD because almost all is used in power production.
- Coal is used in Non-OECD, mainly China, directly in industry.

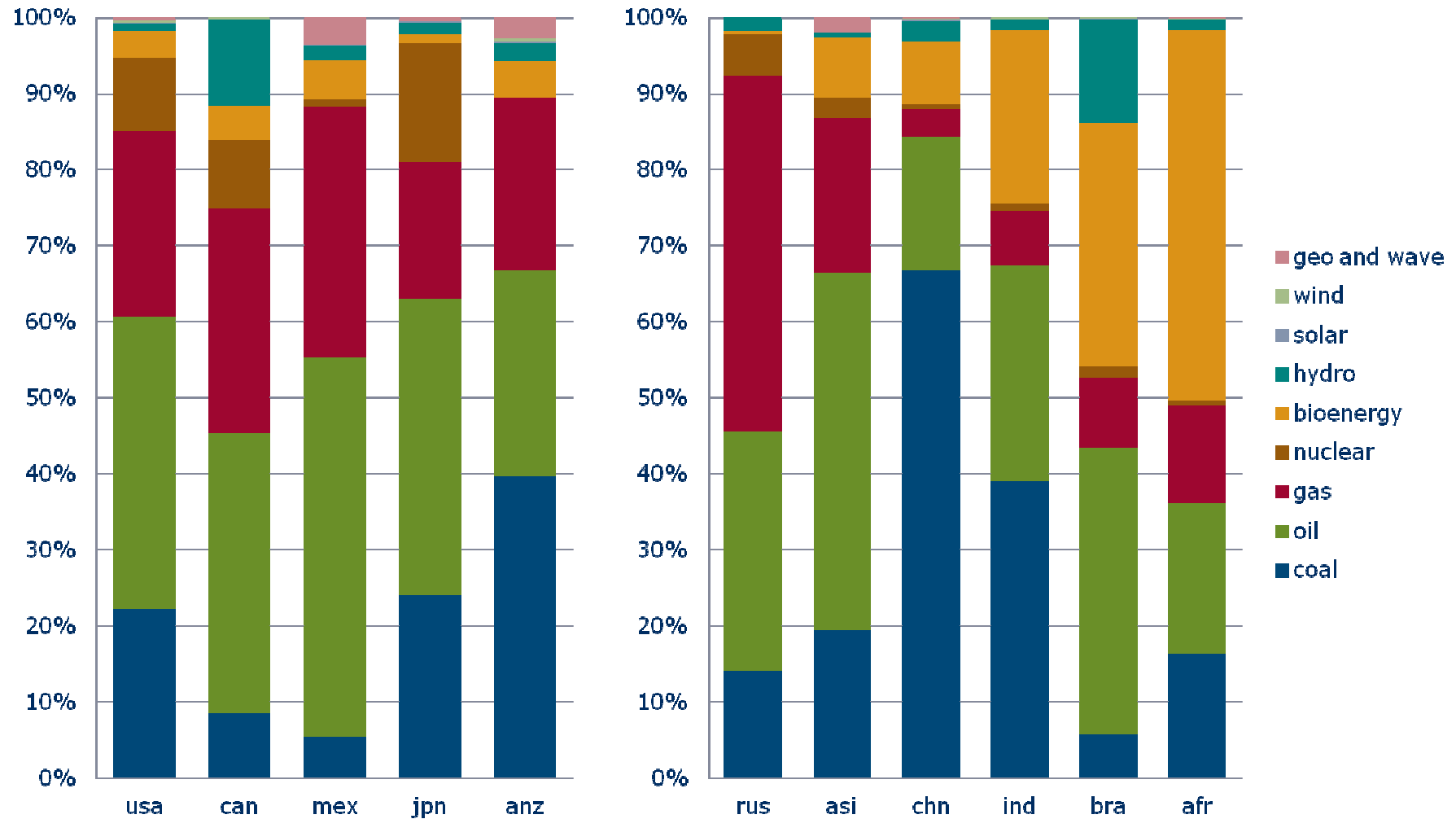
2010 Secondary Energy Consumptions (EJ)



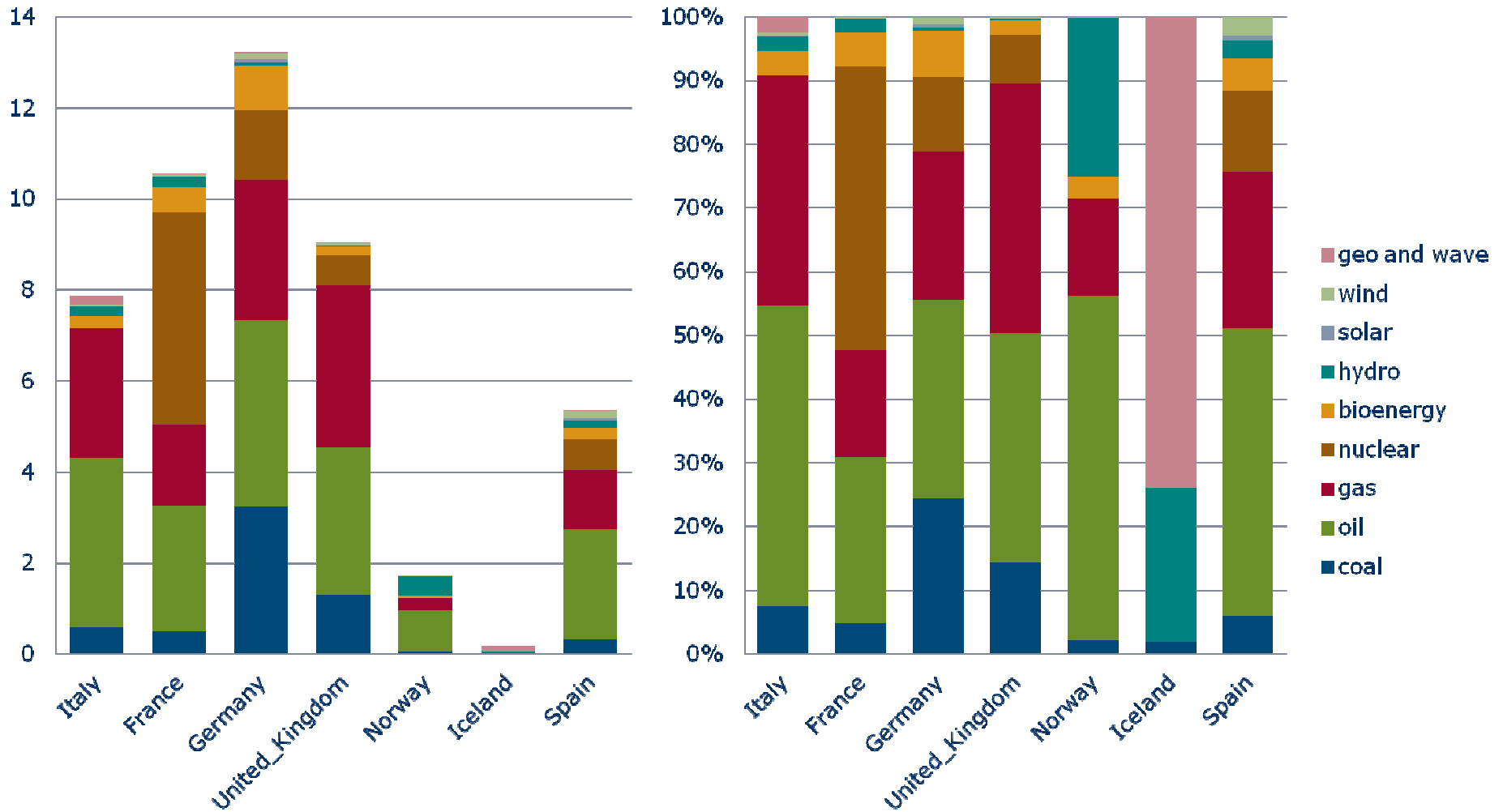
Primary Energy Use (EJ), Major Countries/Regions



Primary Energy Fuel Shares by Country/Region



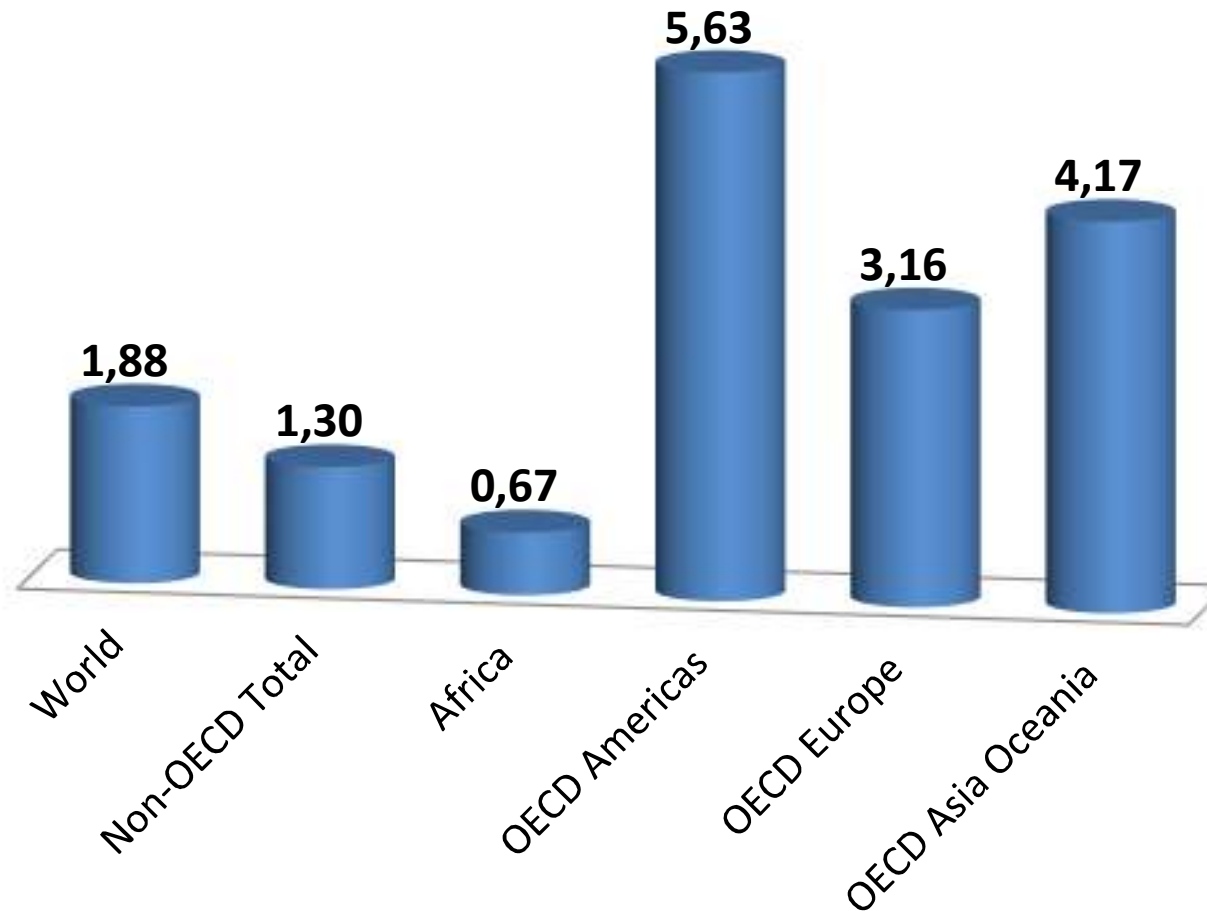
Primary Energy Fuel Use (EJ)/Shares in Europe



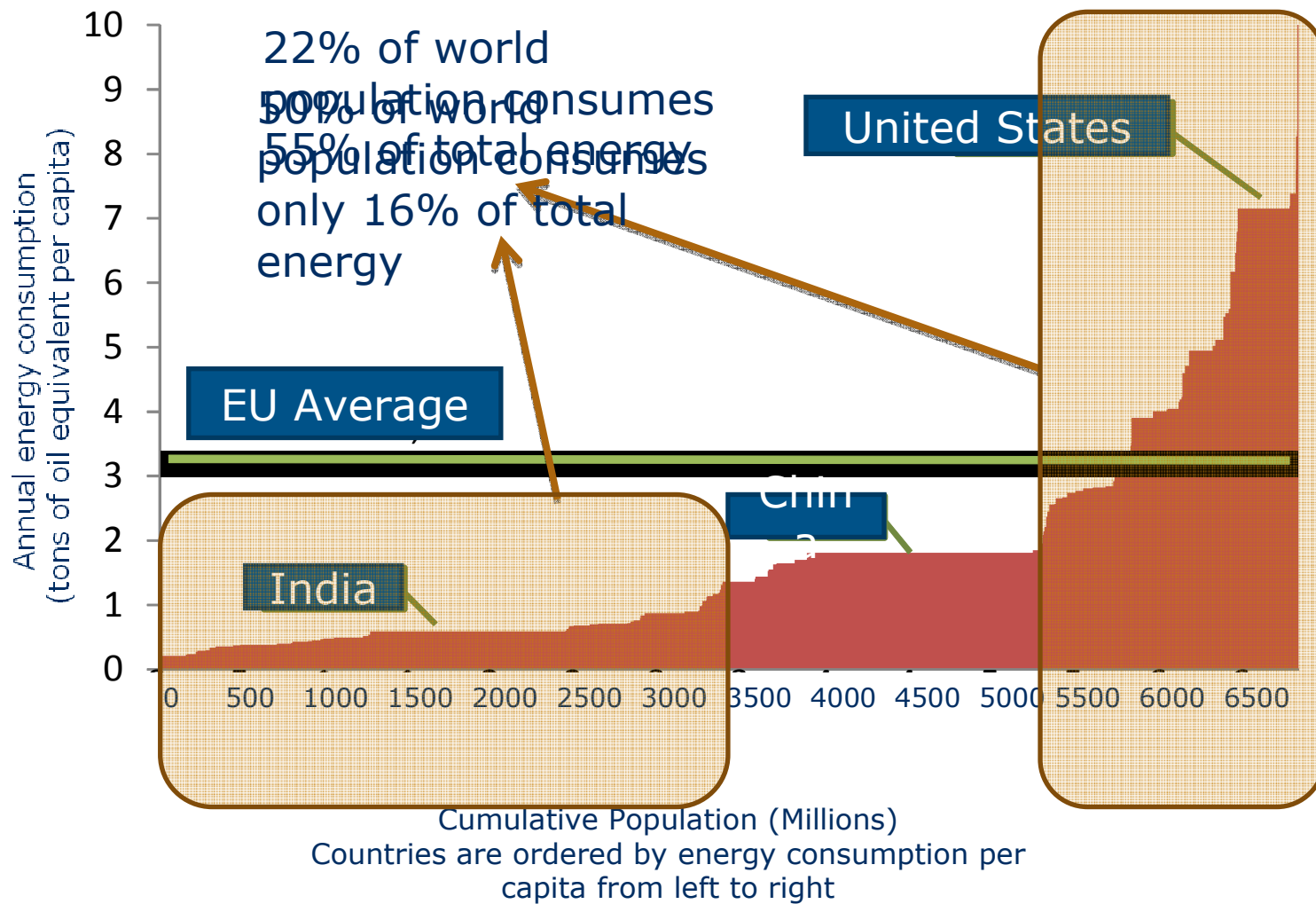
Primary Energy Consumption Per Capita

World and major regions

Energy consumption, Tons of oil equivalent per capita, annual



Primary Energy Consumption Per Capita (cont.)



Why do countries energy uses differ?

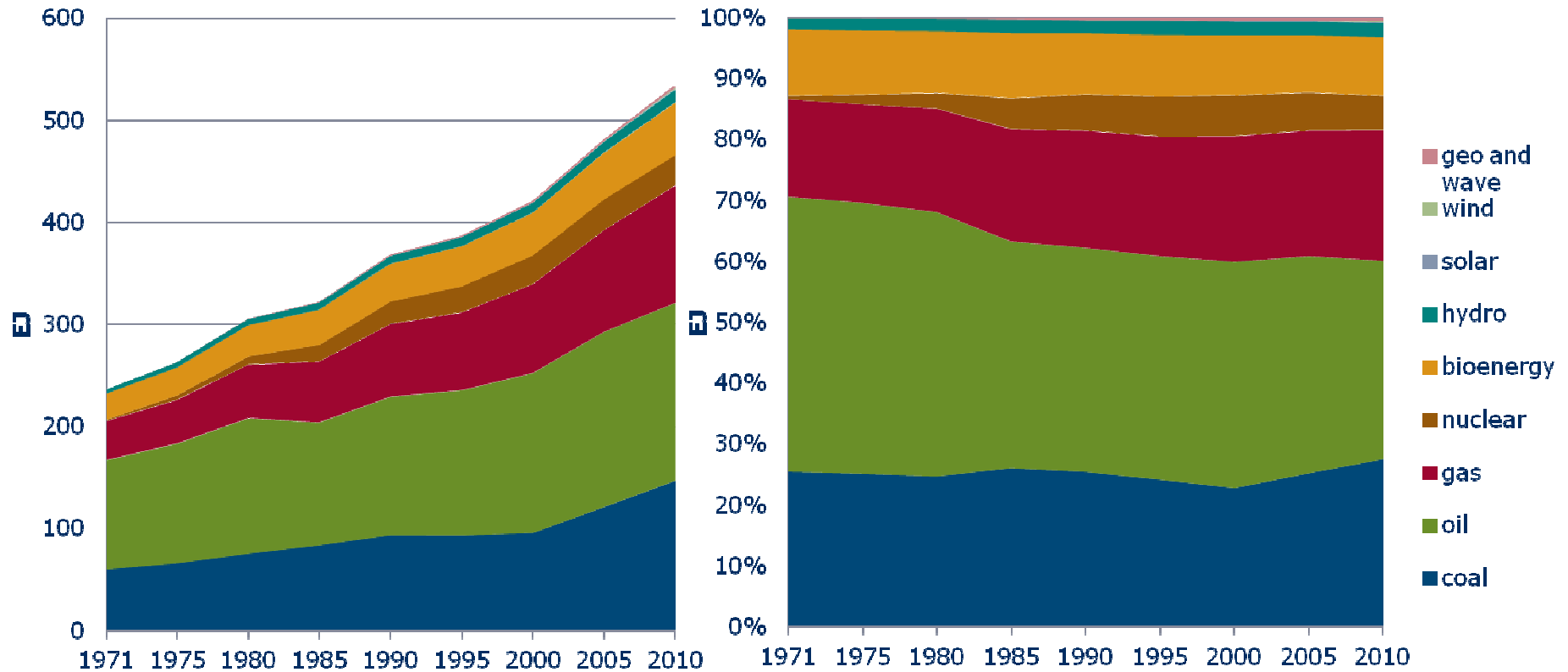
- Amount of Energy Use

- Population
- Size of the Economy
- Geographic size—longer transportation networks?
- Types of goods produced—Energy intensive compared with Services

- Shares of Different Fuels/Energy Sources

- Resource endowments: Iceland—geothermal; Norway—hydro; China--Coal.
- Average income levels:
 - E.g. Europe, US, Japan—lots of vehicles means lots of petroleum use.
 - Poorer countries use more traditional biofuels for cooking or heating
 - Higher income countries use more electrical appliances
- Climate—need for heating or air conditioning or both
- History—Cities developed earlier are denser and less able to handle vehicle traffic than cities developed later when road networks were planned as part of the development.
- Policy—fuel taxation (Europe vs. US; Specific Technology—e.g. France/Nuclear; Concern about reliance on external fuel sources.)

World Primary Energy Use Over Time, EJ



Since 1970, world energy use has more than doubled but the share of fossil fuel has fallen only slightly largely due to nuclear penetration through 1990.

Why does energy and fuel use change over time?

- Amount of Energy Use

- Population growth
- Economic Growth
- Changes in the types of goods consumed either due to changing technology or different needs at different income levels.
- Changes in policy

- Shares of Different Fuels/Energy Sources

- Changing resource endowments: new discoveries of fuels or exhaustion of best deposits of fuels
- Changes in the types of goods consumed
- Changing technology: invention of new or better ways to access or use different types of fuels
- Changing policy: E.g. concerns over nuclear safety; concerns over oil supply disruption, or dependence on foreign sources of natural gas
- Any of these may then be reflected as changes in the relative prices of fuels/energy sources, or the cost relative to income.

Can we continue to Depend on Fossil Fuels?

	Coal		Oil		Gas	
	Reserves ¹	Resource ²	Reserves ¹	Resource ²	Reserves ¹	Resource ²
North America	5011	25620	1246	4486	409	1290
S. & Cent. America	272	1143	1864	8045	287	1419
Europe & Eurasia	5566	124403	808	9716	2974	7708
Middle East & Africa	919	5361	5313	11885	3574	6989
Asia Pacific	5952	22432	236	1096	634	1551
WORLD	17720	178959	9467	35226	7879	18956
Approx. Annual Consumption	145		180		110	
Years at current rate	120	1,200	50	200	70	170

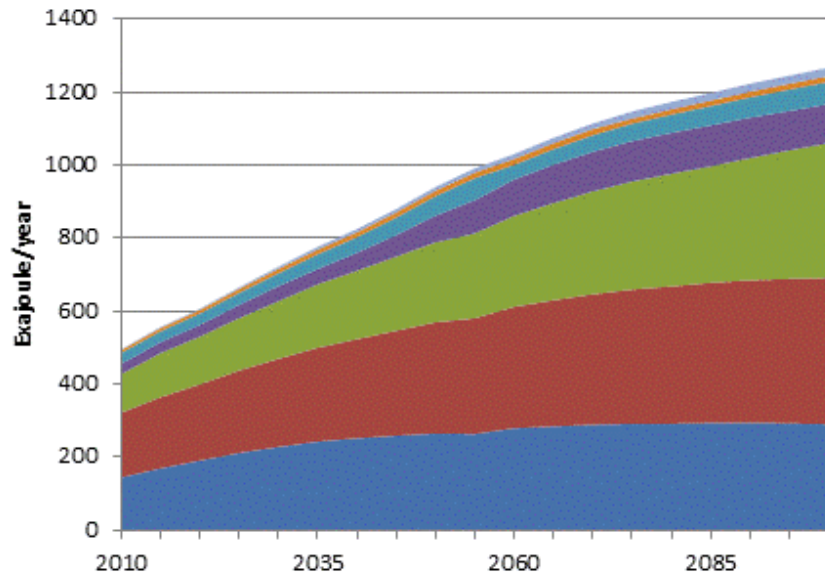
BP 2012 Statistical Review. Reserves are quantities that geological and engineering information indicates with reasonable certainty can be recovered in the future from known reservoirs under existing economic and operating conditions.

²Based on USGS/ (oil and gas) WEC (coal) technically recoverable resources (median estimate), with assumption that with future technology a larger share of resources estimated to be in place will be recovered.

Modest estimate of shale gas and oil—methane hydrates or oil shale could be as large or an order of magnitude larger.

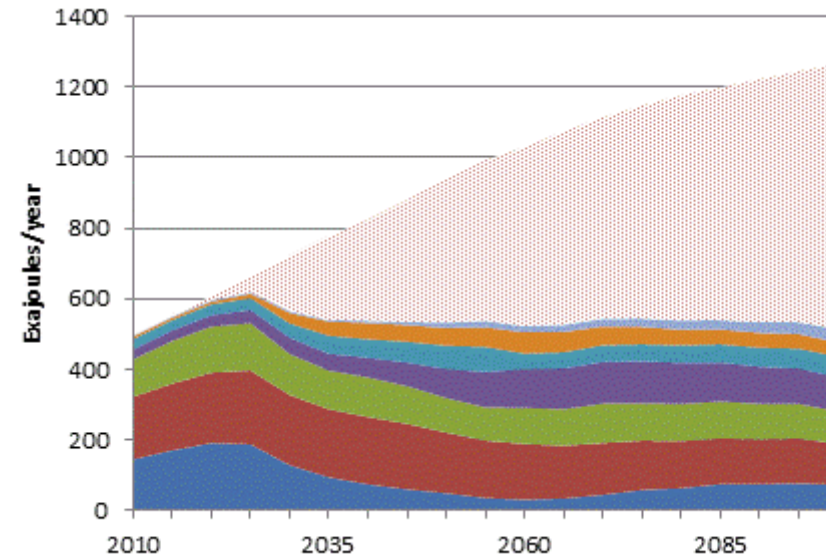
Issue: They contribute to pollution.

An Energy Choice: Sneak peak at final Lecture on Scenarios



■ coal ■ oil ■ gas ■ nuclear ■ hydro ■ renewables ■ biofuels ■ reduced use

Unconstrained



Stabilization of Radiative Forcing @ 4.5 W/m²