

WHERE IS IT ALL GOING TO COME FROM? A LAYMAN'S ~~INTRODUCTION TO~~ PERSPECTIVE ON THE GEOPOLITICS OF RENEWABLE ENERGY IN THE 21ST CENTURY.

HARVARD ENERGY JOURNAL CLUB

03/27/17

FELIX BARBER

WHAT EFFECT CAN RENEWABLES HAVE?

Displacing existing fossil fuel supply-demand chains.

Emergence of new powers as primary developers of necessary technology.

Monopolies on scarce resources (e.g. rare earth metals in China).

Changes to power distribution.

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Influence of intermediaries on energy transfer.

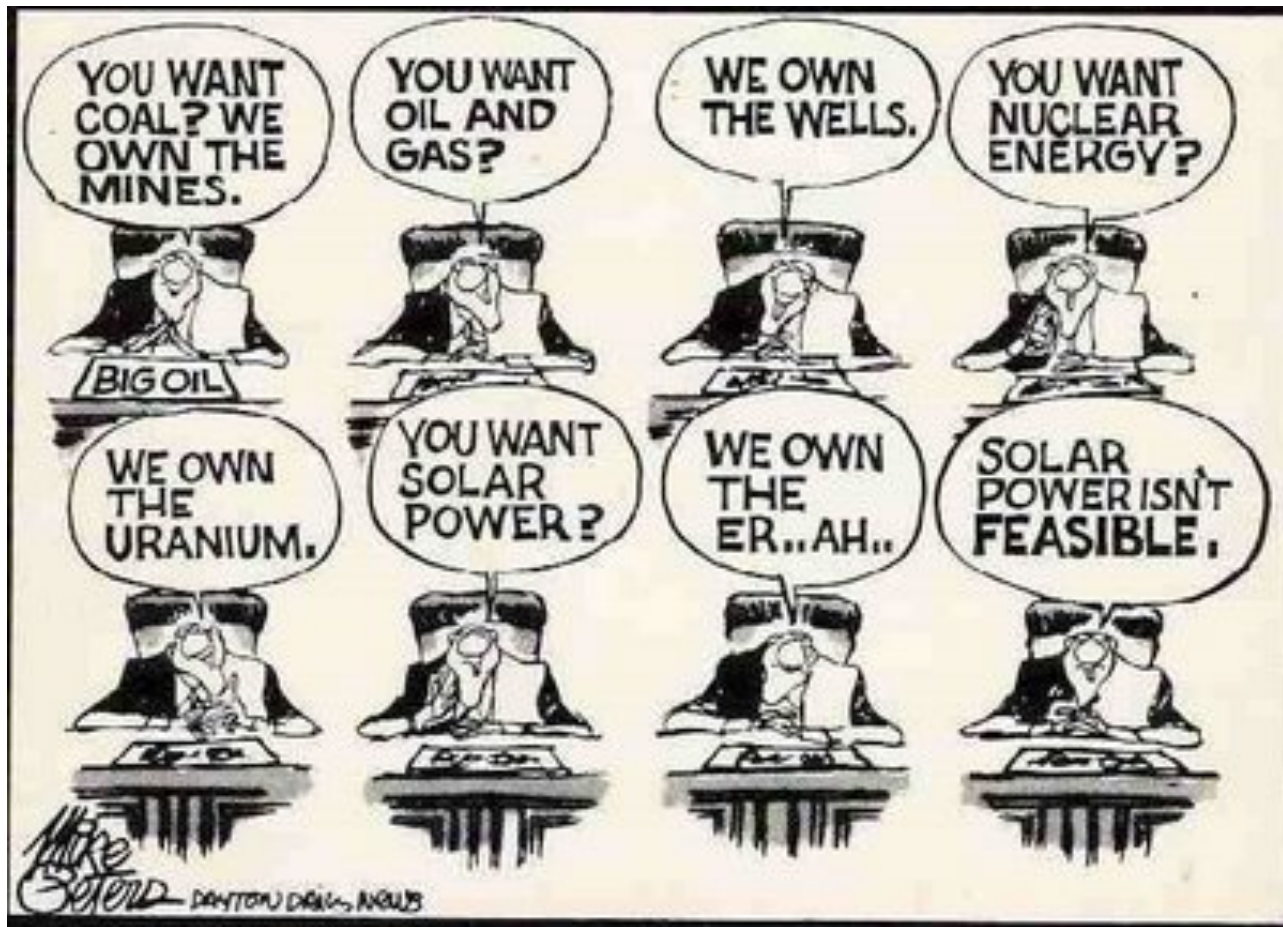
OUTLINE

Energy consumption and production: Past and present.

What's different about renewables?

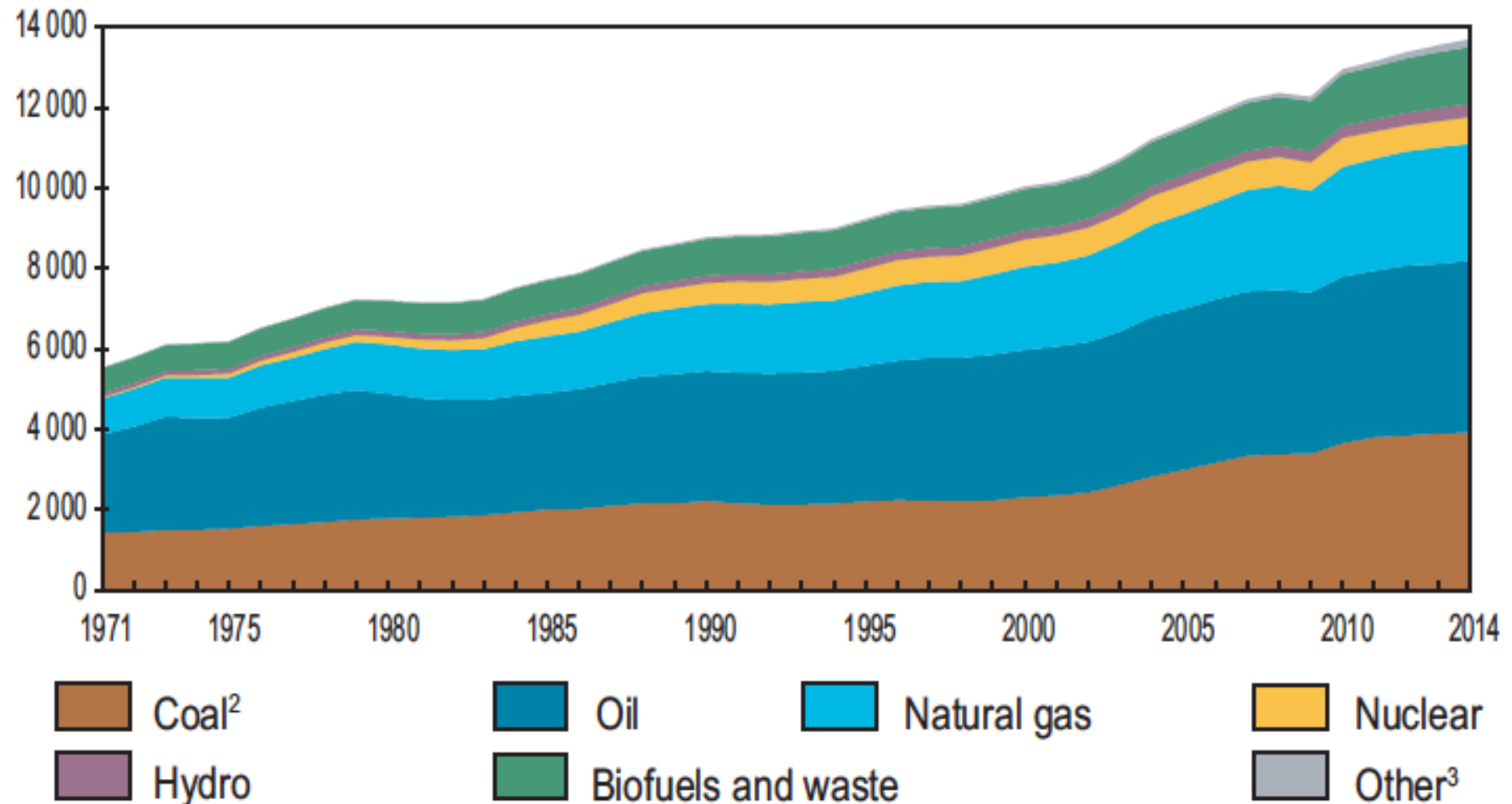
Global investment in renewables.

Projected population and energy demand estimates.



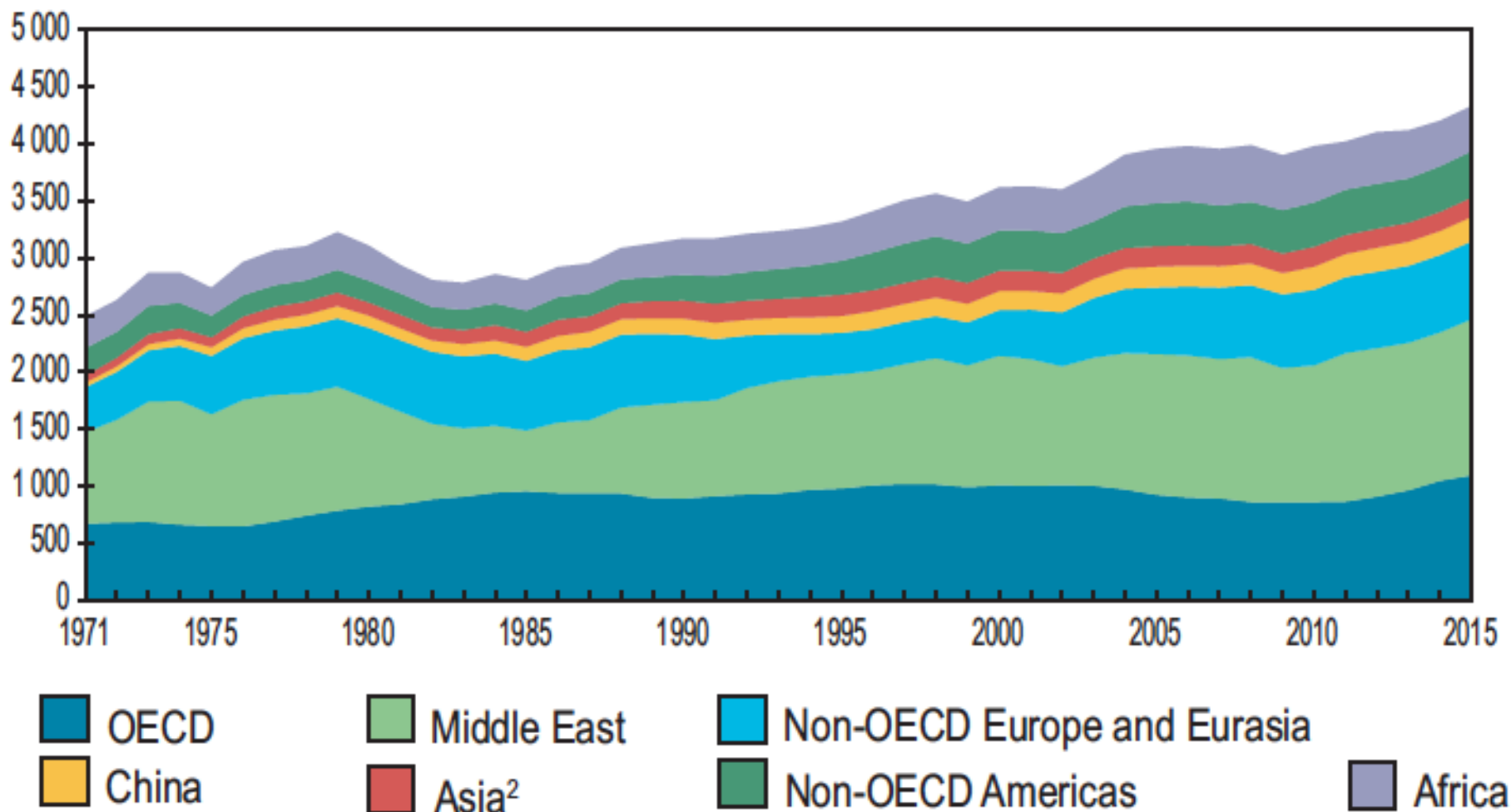
ENERGY CONSUMPTION AND PRODUCTION: PAST AND PRESENT.

WORLD TOTAL PRIMARY ENERGY SUPPLY BY FUEL: 1971 – 2014 (MTOE)



Mtoe = Million tons of oil equivalent. Other = Wind, solar, geothermal etc.
Source: International Energy Agency (IEA) Key world energy statistics 2016.

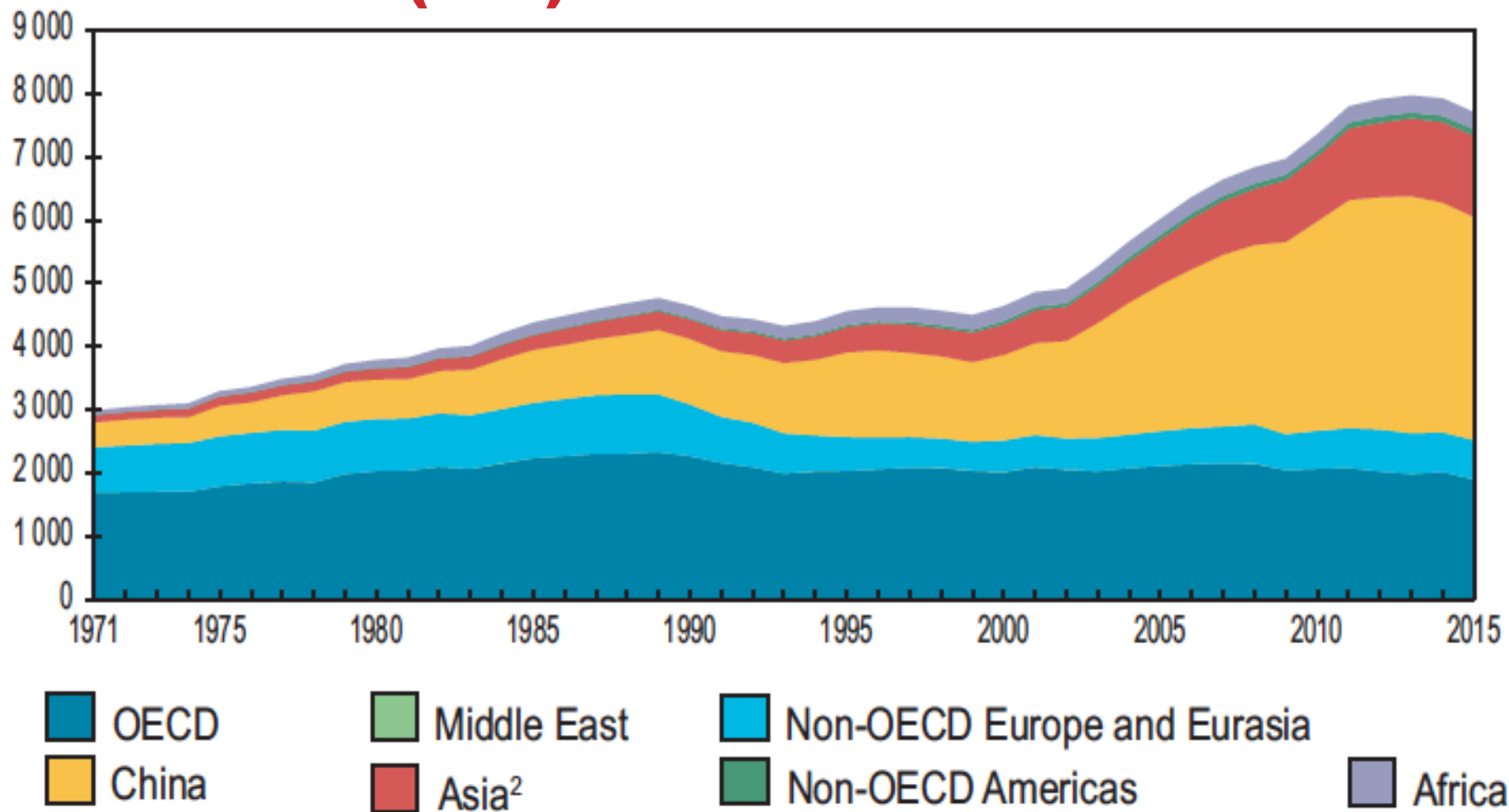
CRUDE OIL PRODUCTION FROM 1971 TO 2015 BY REGION (MTOE)



Mtoe = Million tons of oil equivalent.

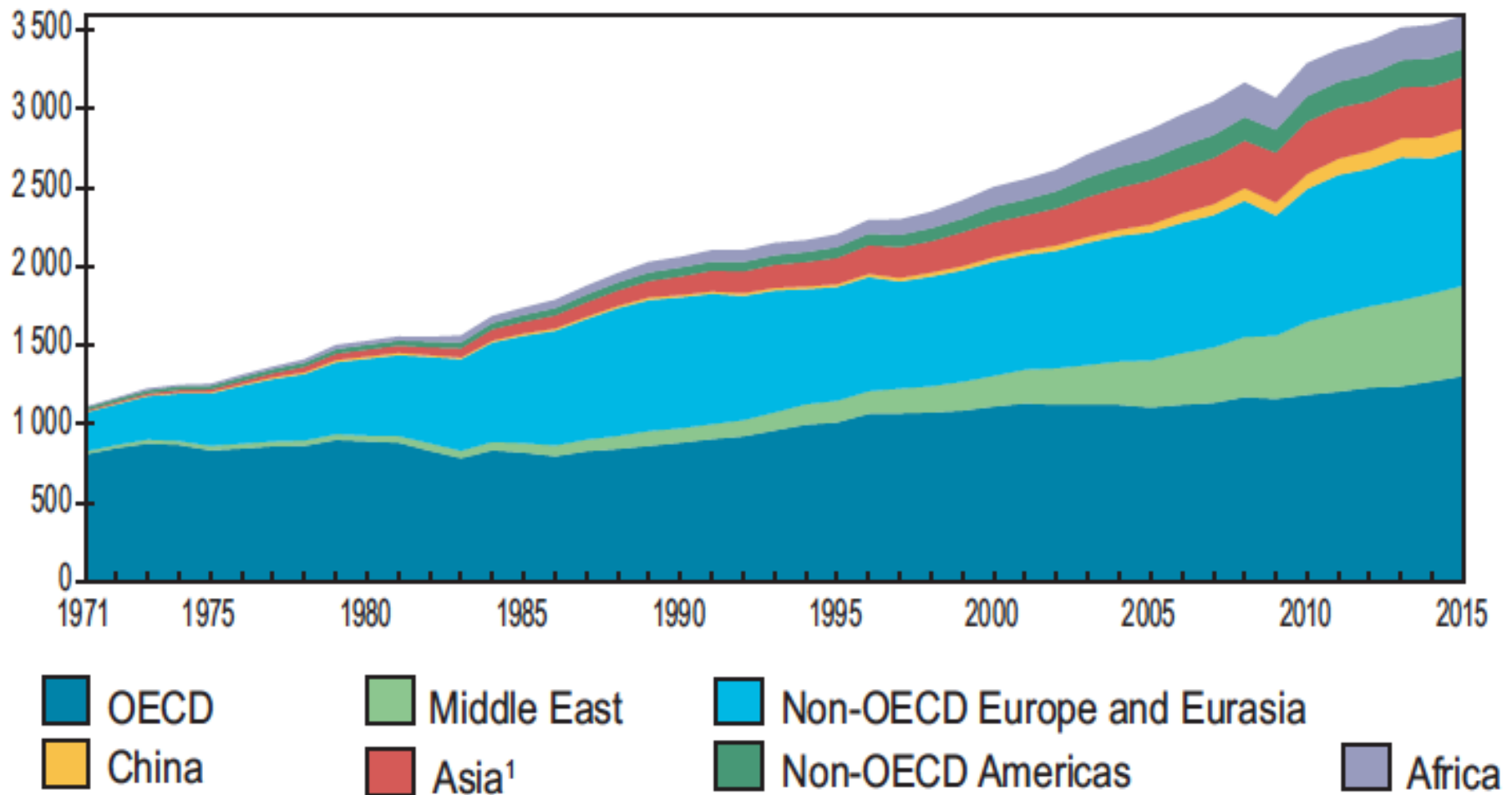
Source: International Energy Agency (IEA) Key world energy statistics 2016.

COAL PRODUCTION FROM 1971-2015 BY REGION (MT)



Source: International Energy Agency (IEA) Key world energy statistics 2016.

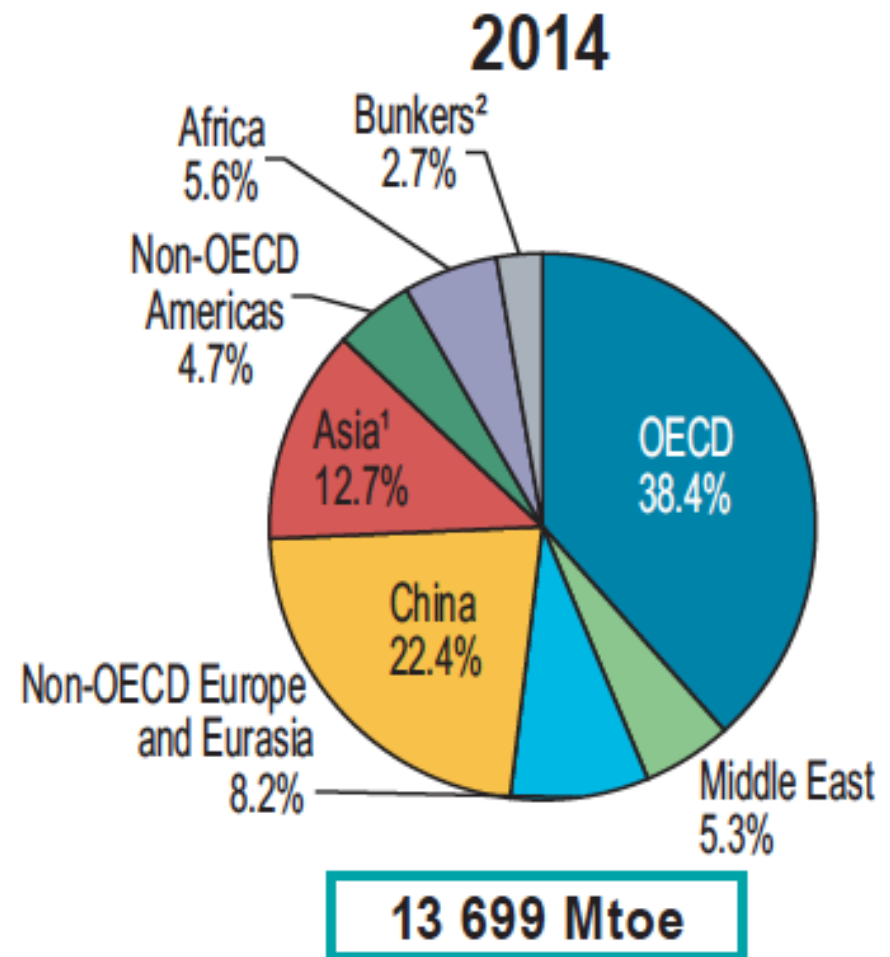
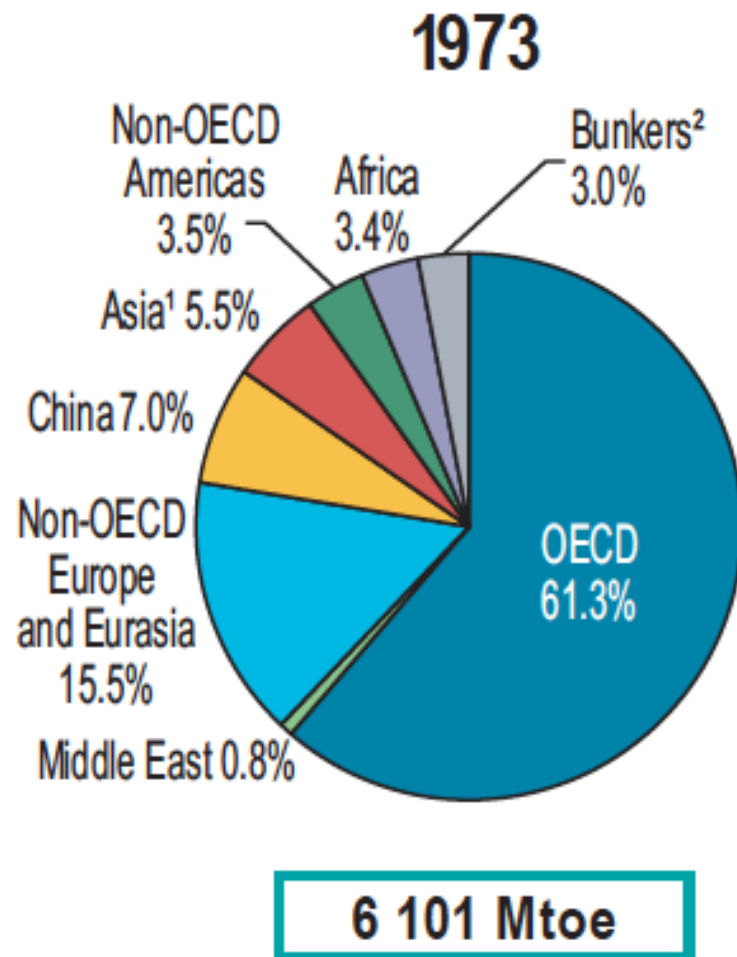
PRODUCTION FROM 1971-2015 BY REGION (BCM)



bcm = Billion cubic metres

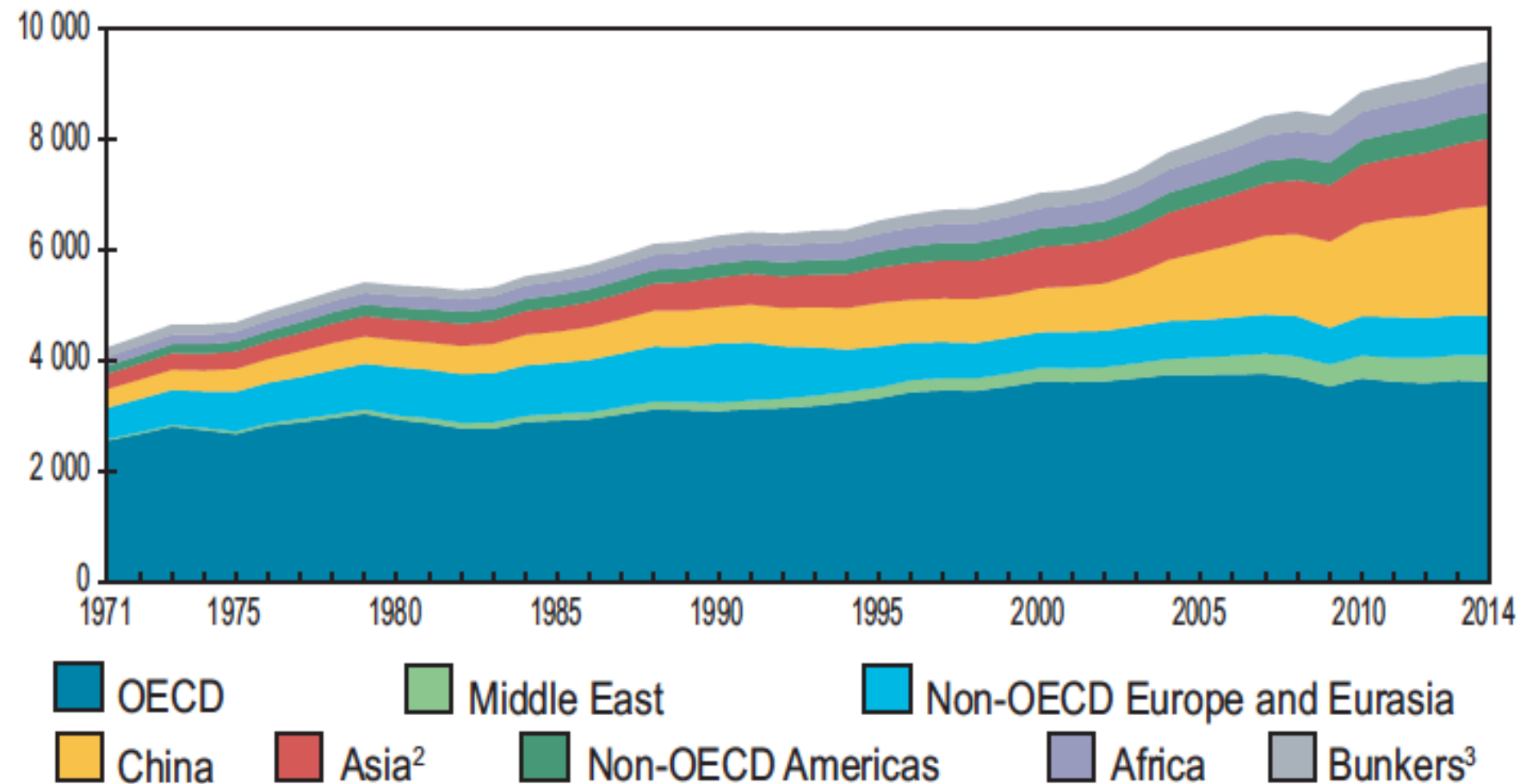
Source: International Energy Agency (IEA) Key world energy statistics 2016.

WORLD TOTAL PRIMARY ENERGY SUPPLY BY REGION

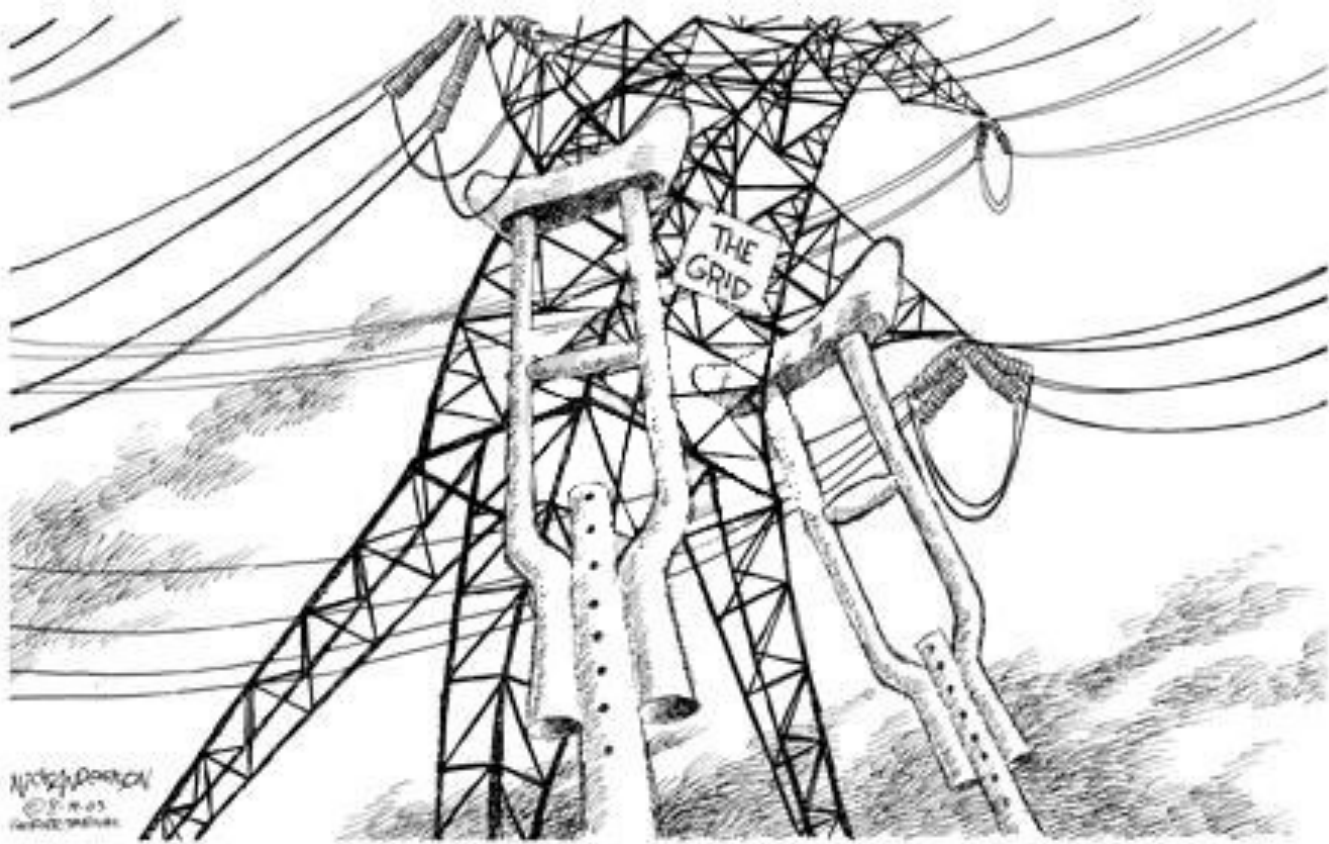


Source: International Energy Agency (IEA) Key world energy statistics 2016.

WORLD TOTAL PRIMARY ENERGY CONSUMPTION BY REGION: 1971 - 2014



Source: International Energy Agency (IEA) Key world energy statistics 2016.



WHAT'S DIFFERENT ABOUT RENEWABLES?

WHAT CHANGES FOR RENEWABLES?

Focus shift from getting resources to managing infrastructure effectively.

- Distributed generation – challenges control of extant companies.
- Sale of excess electricity between countries necessitates transmission lines, gives power to intermediaries.
- Challenges of an dominant but intermittent power source – large backup required.

Access to key metals comes from limited world regions (e.g. rare earth metals in China, and Lithium from Chile).

Greater leverage for countries which produce necessary generation or storage technology.

E.G. EU anti-dumping and anti-subsidy duties on solar cell and panel imports from China from December 2013-present.

Most countries generating some of their own power likely to reduce imports, and subsequently reduce geopolitical tensions.

**Q: WHAT DOES
ACCESS LOOK
LIKE FOR
RENEWABLES?**

**A: A LOT MORE
SPREAD OUT.**

SOME BRIEF NUMBERS ON RENEWABLES

Between 2005 to 2015 the US increased the share of wind and solar from 0.5% of total power generation to 5%.

In 2015 China became the country with the largest installed capacity of wind power (145GW) and solar power (45GW).

Boundary dam CCS project in Canada the result of effective policy: all coal-fired power plants that turn 40 years old either have to do a CCS retrofit or shut down + 240 million USD subsidy from Canadian government.

Sources:

Paltsev, Sergey. "The complicated geopolitics of renewable energy." *Bulletin of the Atomic Scientists* 72.6 (2016): 390-395.

Herzog, Howard. "CCS at a Crossroads." <https://sequestration.mit.edu/bibliography/ccs-crossroads.pdf>

MASSACHUSETTS OFFSHORE WIND AND HYDROELECTRIC

Distribution of resources gives countries possibility to either produce domestically or source from neighbors.

Example: H.4377 bill (August 2016)

- Requires Massachusetts utilities to pursue long-term contracts to supply up to 1,200 MW of hydro and 1,200 MW of offshore wind power by 2027.
- Hydro likely to be sourced from Canadian companies. Also gives bargaining power to states north of MA in which transmission lines would need to be built.

Transmission lines connecting neighbors can pose serious threat to energy security.

Example: Crimea.

- During Russia and Ukraine standoff, Ukraine destroyed transmission lines to Crimea, necessitating rapid building of new lines from Russia.

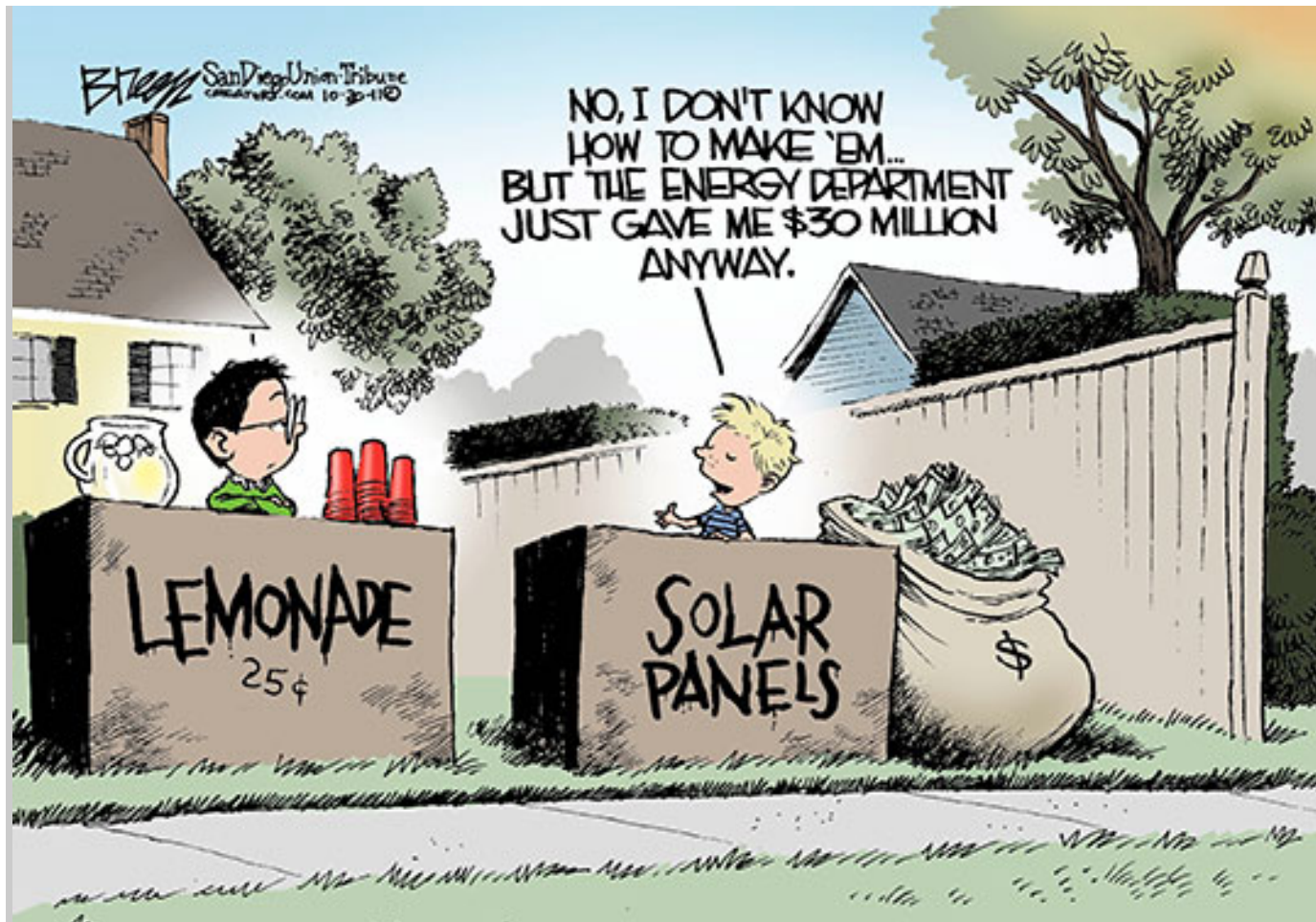
MATERIAL DISTRIBUTION

Necessary materials for RE tech: neodymium, indium, gallium, germanium, silicon.

In 2007 almost 90% of U.S. rare earth imports came from China.

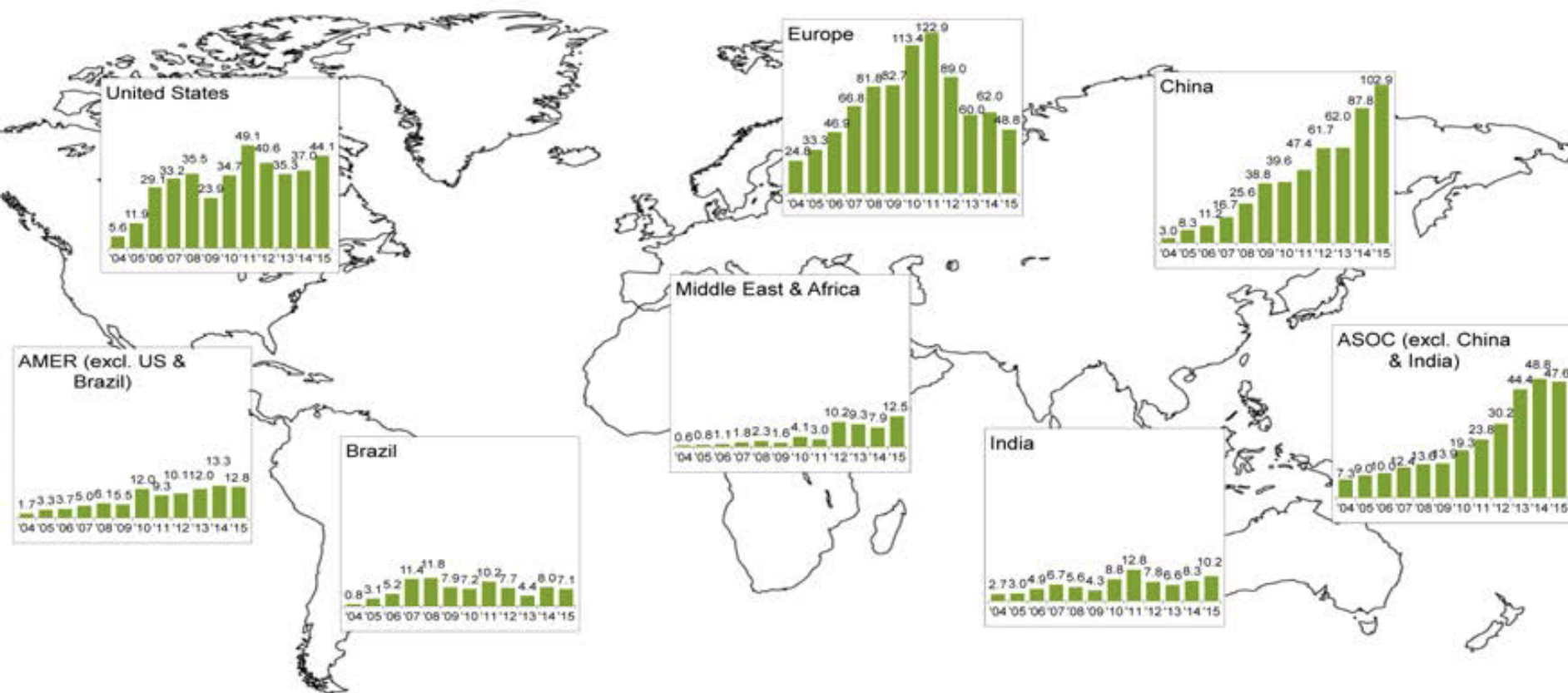
Localization of resources may lead to significant strategic power.

Spot prices for Lithium (essential for batteries) increased from \$7000 per metric ton (or tonne) in 2015 to \$20,000 per tonne in early 2016.

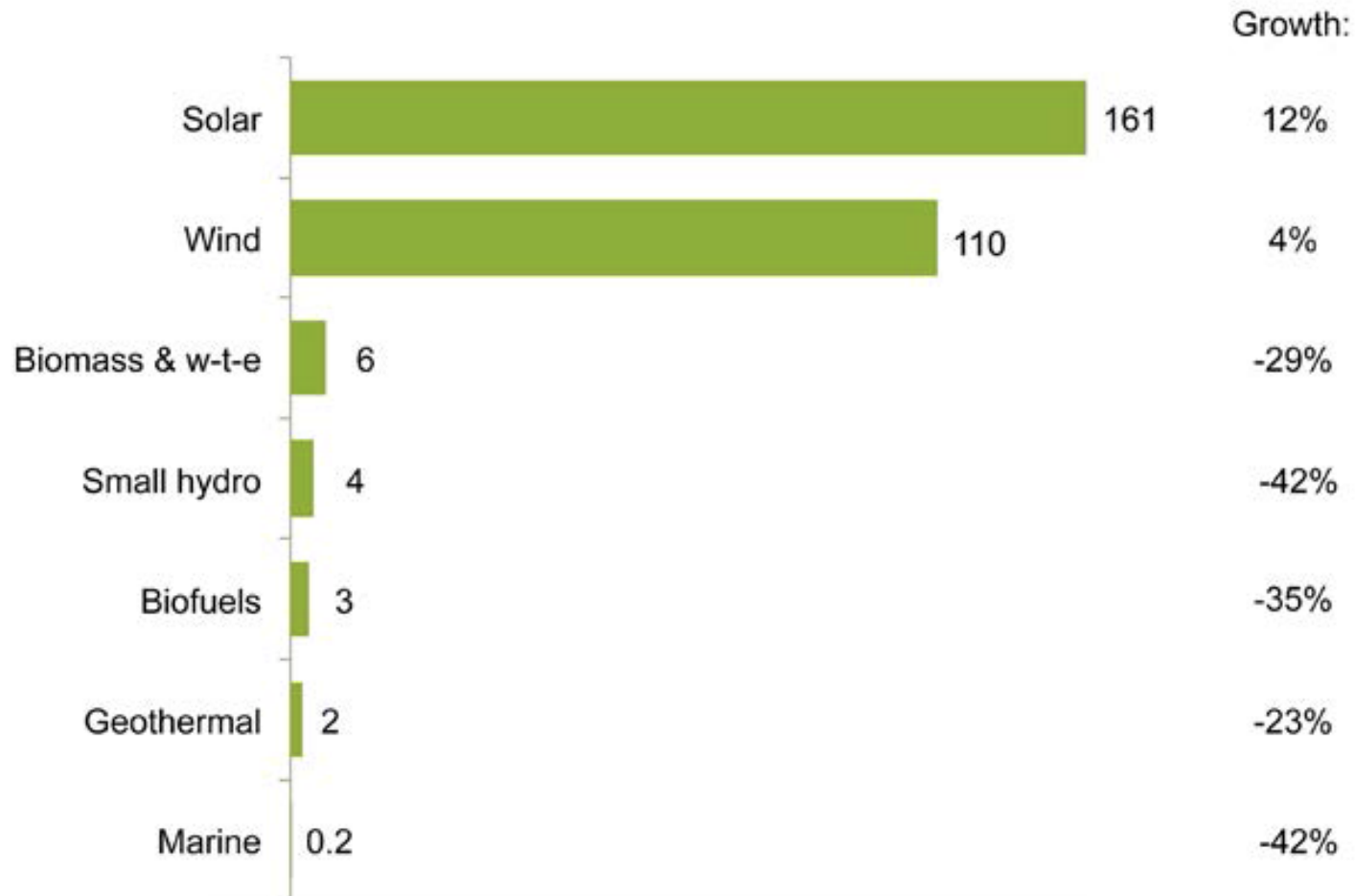


INVESTMENT IN RENEWABLES

GLOBAL NEW INVESTMENT IN RENEWABLE ENERGY BY REGION, 2004-2015, \$BN



GLOBAL NEW INVESTMENT IN RENEWABLE ENERGY BY SECTOR, 2015, AND GROWTH ON 2014, \$BN



WHERE WE ARE AT RIGHT NOW

**[https://www.bnef.com/dataview/clean-energy-investment/
index.html](https://www.bnef.com/dataview/clean-energy-investment/index.html)**

THIS SEEMS ENCOURAGING, BUT THERE'S A PROBLEM

Overwhelming majority of funding is for deployment of existing technologies, not R&D.

“From 2007 to 2014, even as global financial flows to deploy mature clean energy doubled to \$288 billion, private investment in early stage companies sank by nearly 50 percent, to less than \$2.6 billion”

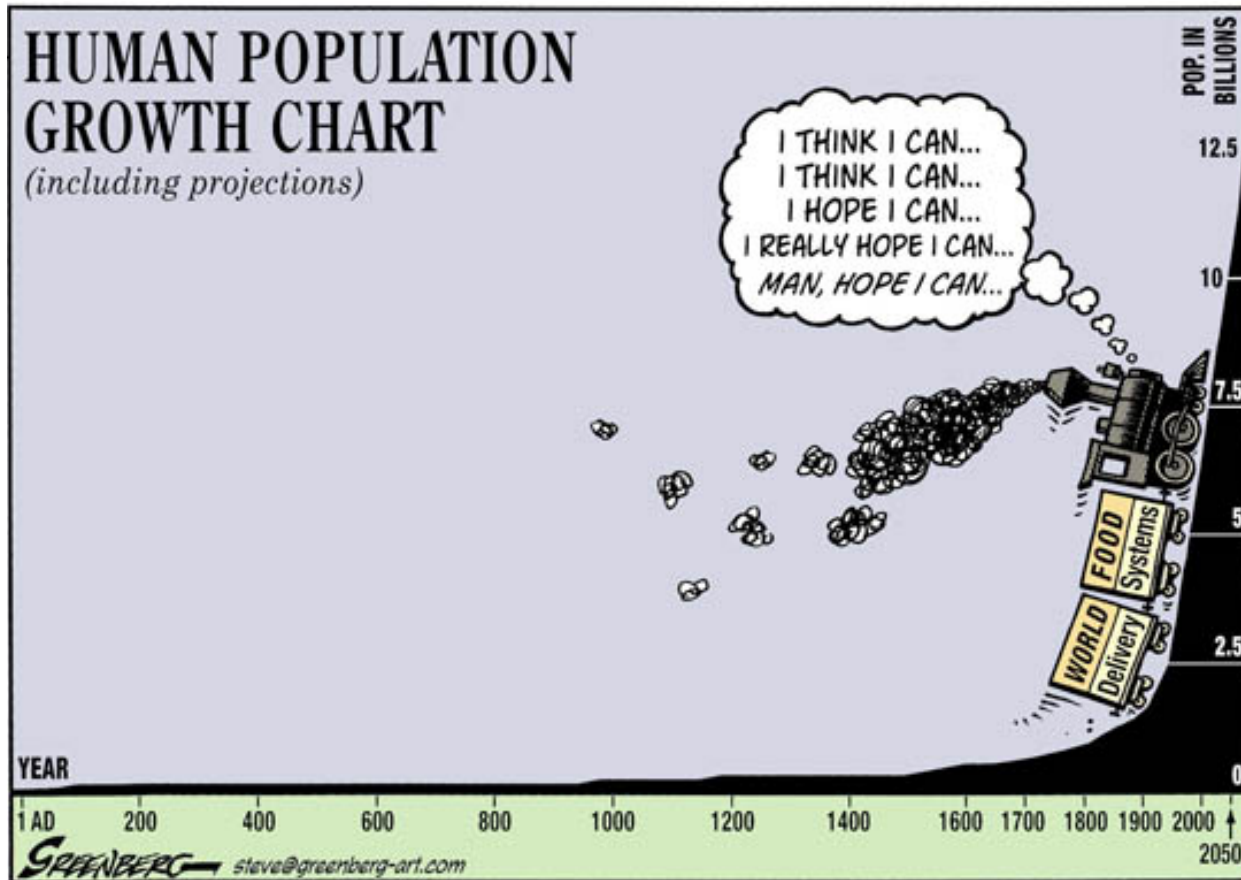
In US, clean energy R&D budget is \$6.4 billion, compared with \$78 billion on defense.

Necessitates intergovernmental cooperation.

MISSION INNOVATION

“Each of the 22 participating countries and the European Union—which represent more than 80 percent of global clean energy R&D budgets—plans to double its governmental and/or state-directed clean energy R&D investment over five years, reaching around a combined USD \$30 billion per year in 2021.”

Sounds great, but unfortunately over 1/3 of this comes from doubling the current value of US \$6.4 billion.



**PROJECTED POPULATION
AND ENERGY DEMAND
ESTIMATES.**

WHERE ARE WE HEADED?

TABLE 1. POPULATION OF THE WORLD AND MAJOR AREAS, 2015, 2030, 2050 AND 2100, ACCORDING TO THE MEDIUM-VARIANT PROJECTION

<i>Major area</i>	<i>Population (millions)</i>			
	<i>2015</i>	<i>2030</i>	<i>2050</i>	<i>2100</i>
World	7 349	8 501	9 725	11 213
Africa	1 186	1 679	2 478	4 387
Asia	4 393	4 923	5 267	4 889
Europe	738	734	707	646
Latin America and the Caribbean	634	721	784	721
Northern America	358	396	433	500
Oceania	39	47	57	71

Source: United Nations, Department of Economic and Social Affairs, Population Division (2015). *World Population Prospects: The 2015 Revision*. New York: United Nations.

World energy consumption

Figure ES-1. World energy consumption by country grouping, 2012–40 (quadrillion Btu)

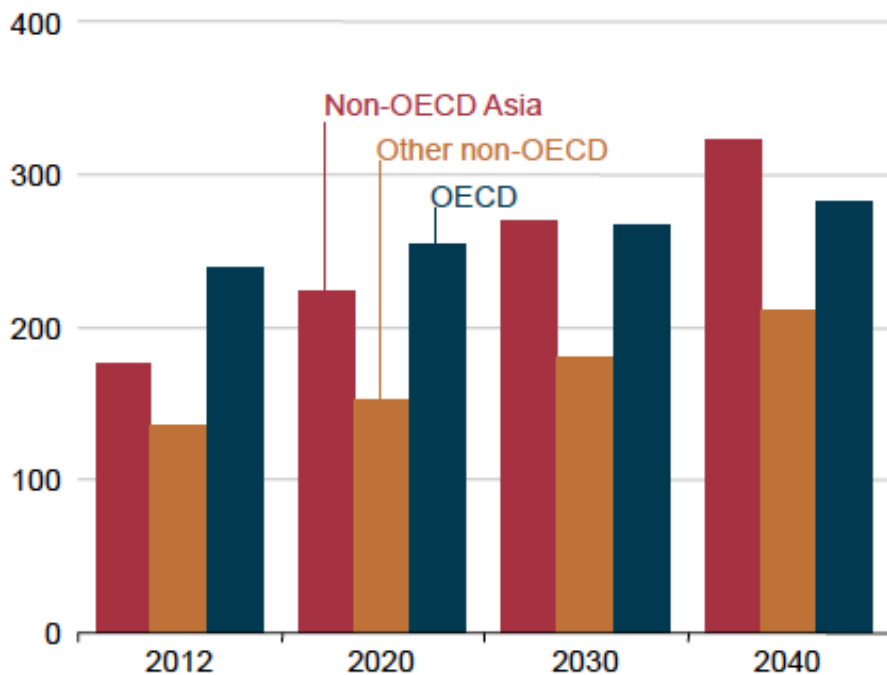
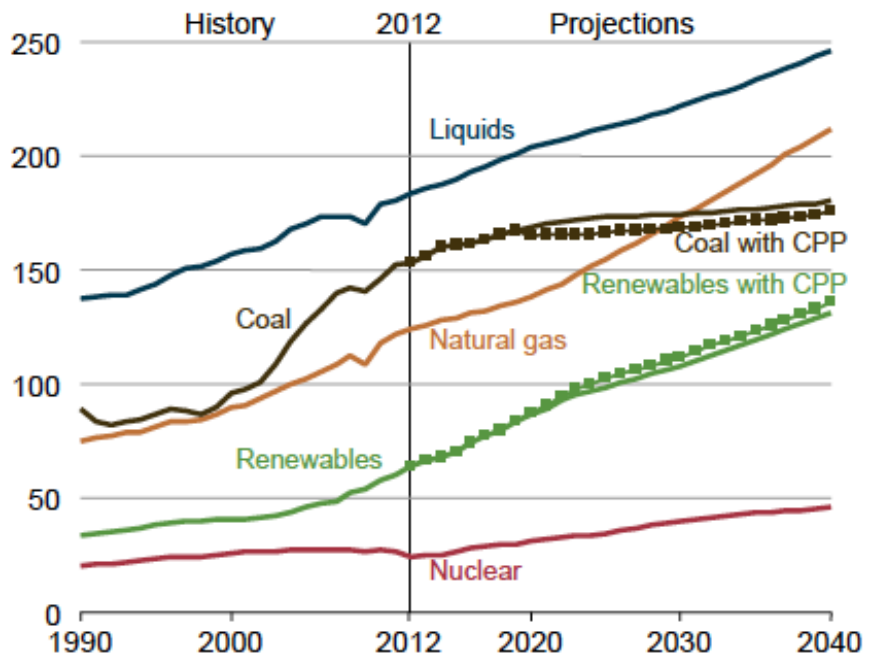


Figure 1-5. World energy consumption by energy source, 1990–2040 (quadrillion Btu)



Note: Dotted lines for coal and renewables show projected effects of the U.S. Clean Power Plan.

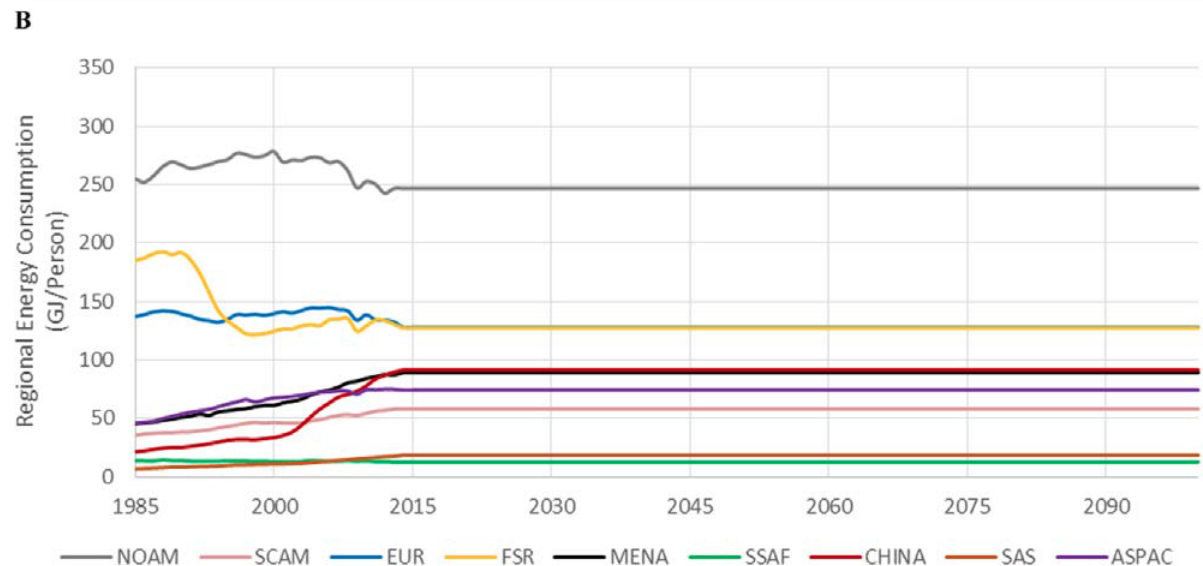
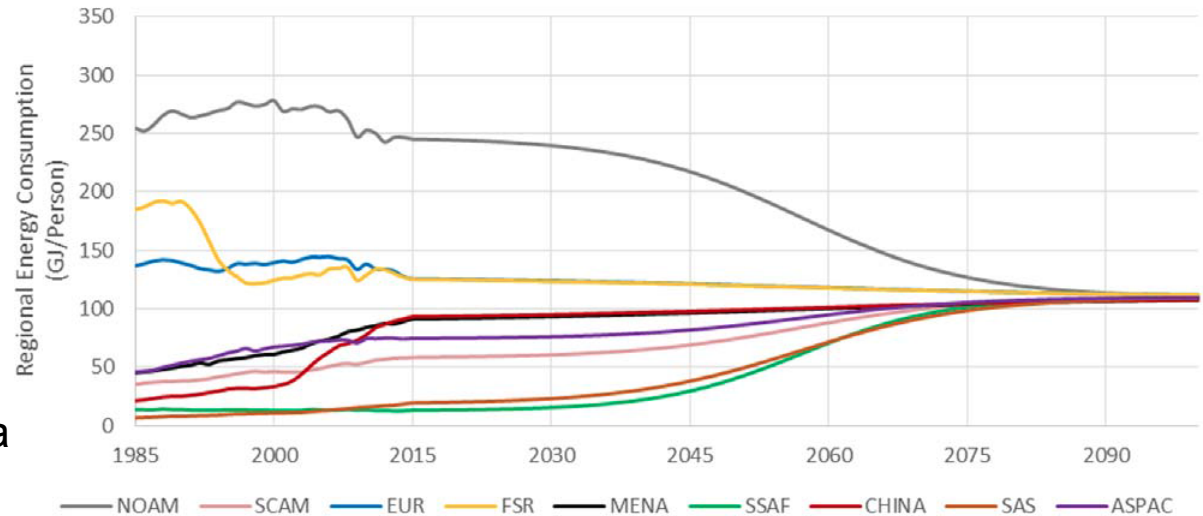
1 Btu ~ 1kJ. Quadrillion = 1×10^{15}

Source: US Energy Information Administration (EIA) International Energy Outlook 2016

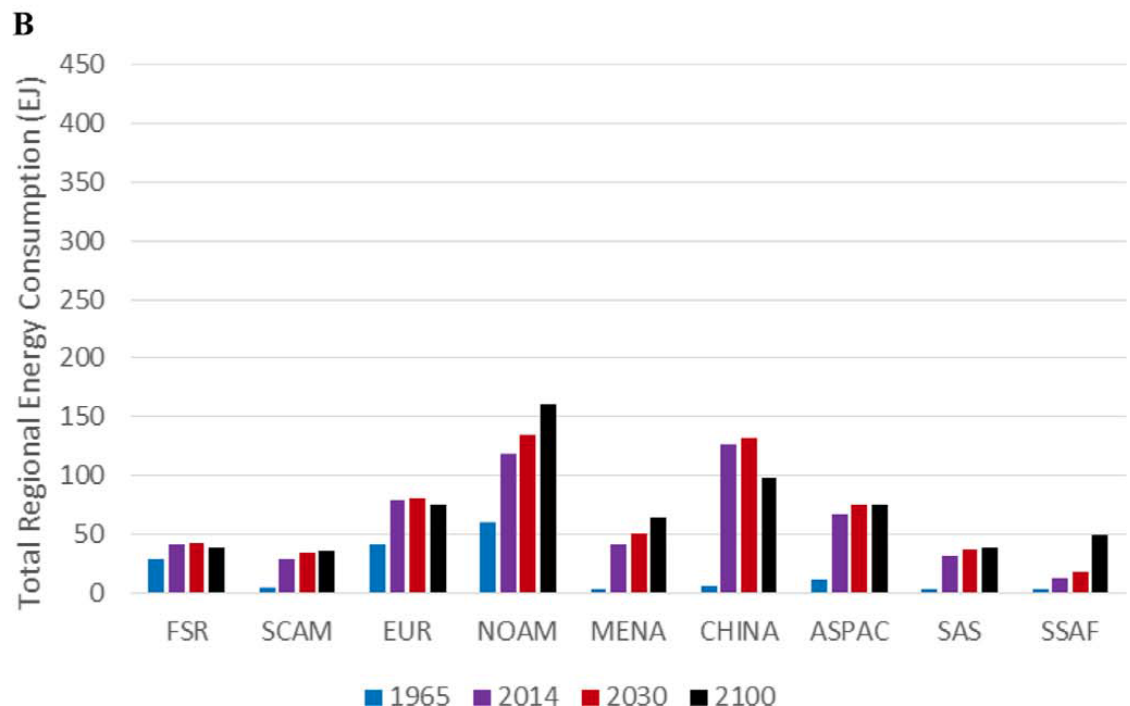
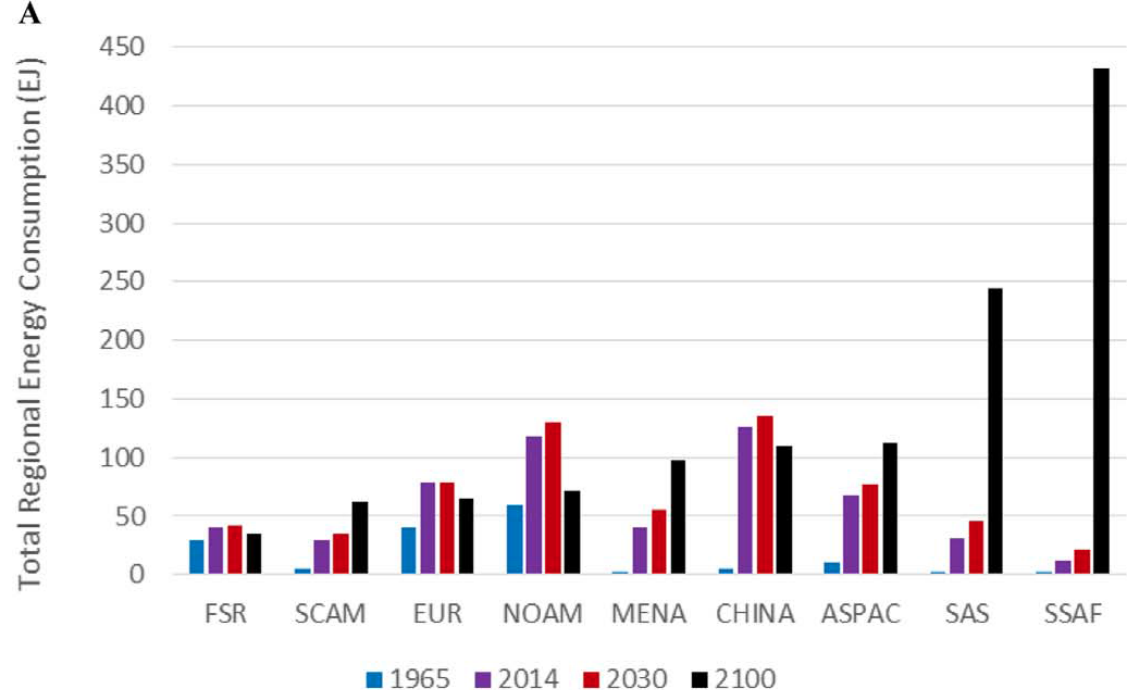
A POPULATION-INDUCED RENEWABLE ENERGY TIMELINE IN NINE WORLD REGIONS

NOAM – North America
 SCAM– South & Central America
 EUR – Europe
 FSR – Former Soviet Republics
 MENA – Middle East & North Africa
 SSAF–Sub-Saharan Africa,
 CHINA–China
 SAS – South Asia
 ASPAC–Asia Pacific

Warner, Kevin J., and Glenn A. Jones. "A population-induced renewable energy timeline in nine world regions." *Energy Policy* 101 (2017): 65-76.

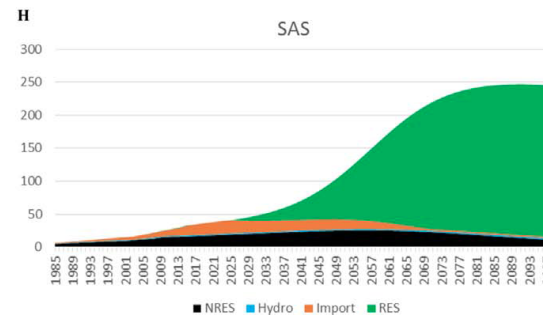
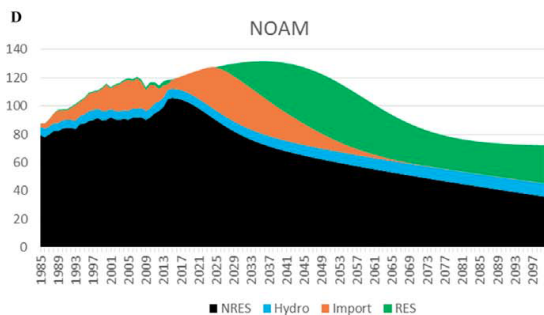
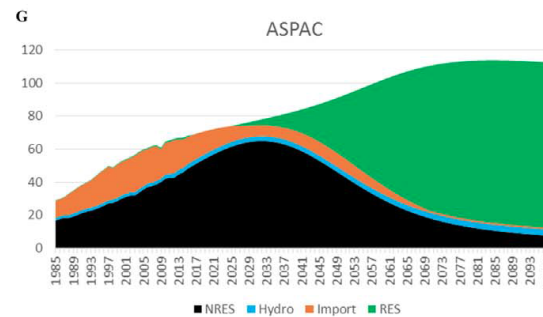
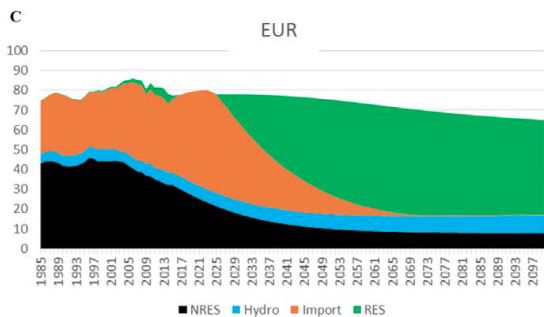
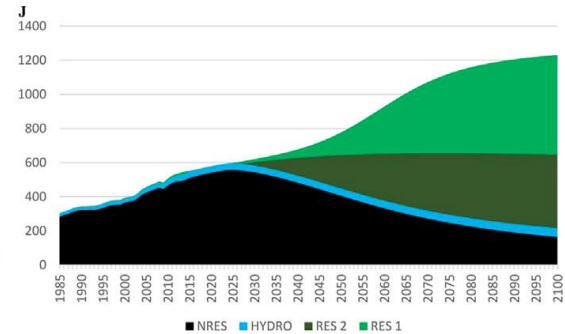
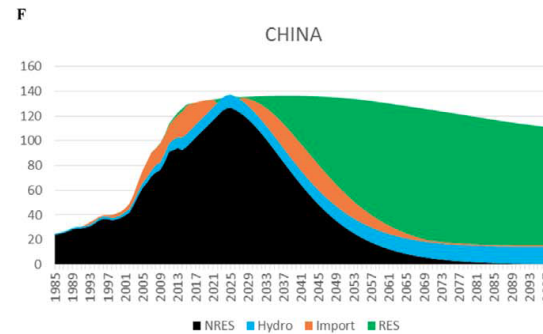
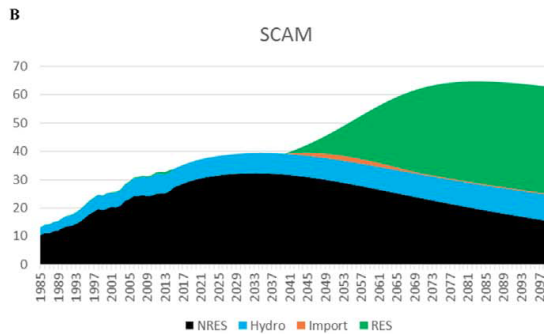
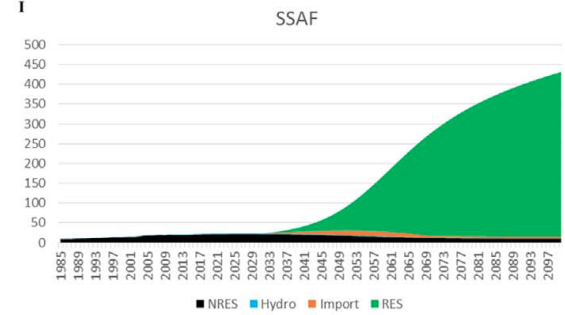
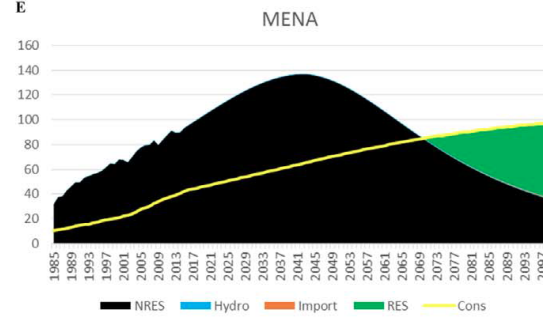
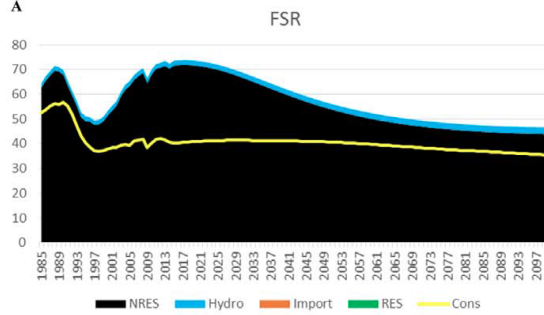


- Assumptions about energy trade and specific use are not realistic.
- Results are incongruous with world bank's sustainable energy for all initiative which hopes to have universal energy access by 2030.
- Fossil fuel consumption projected to peak in mid-21st century



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CONCLUSIONS

Renewables challenge existing supply-demand chains (both domestically and internationally).

Likely power shift from being primarily resource driven to infrastructure and technology development driven.

Despite increasing renewable investment internationally, investment in R&D has stagnated.

Energy consumption growth models depend largely on energy access and consumption profiles.

Policy adoption influences all of the above hugely, adding uncertainty. Watch this space.

EXTRA SLIDES

COMPARATIVE COST OF RENEWABLES

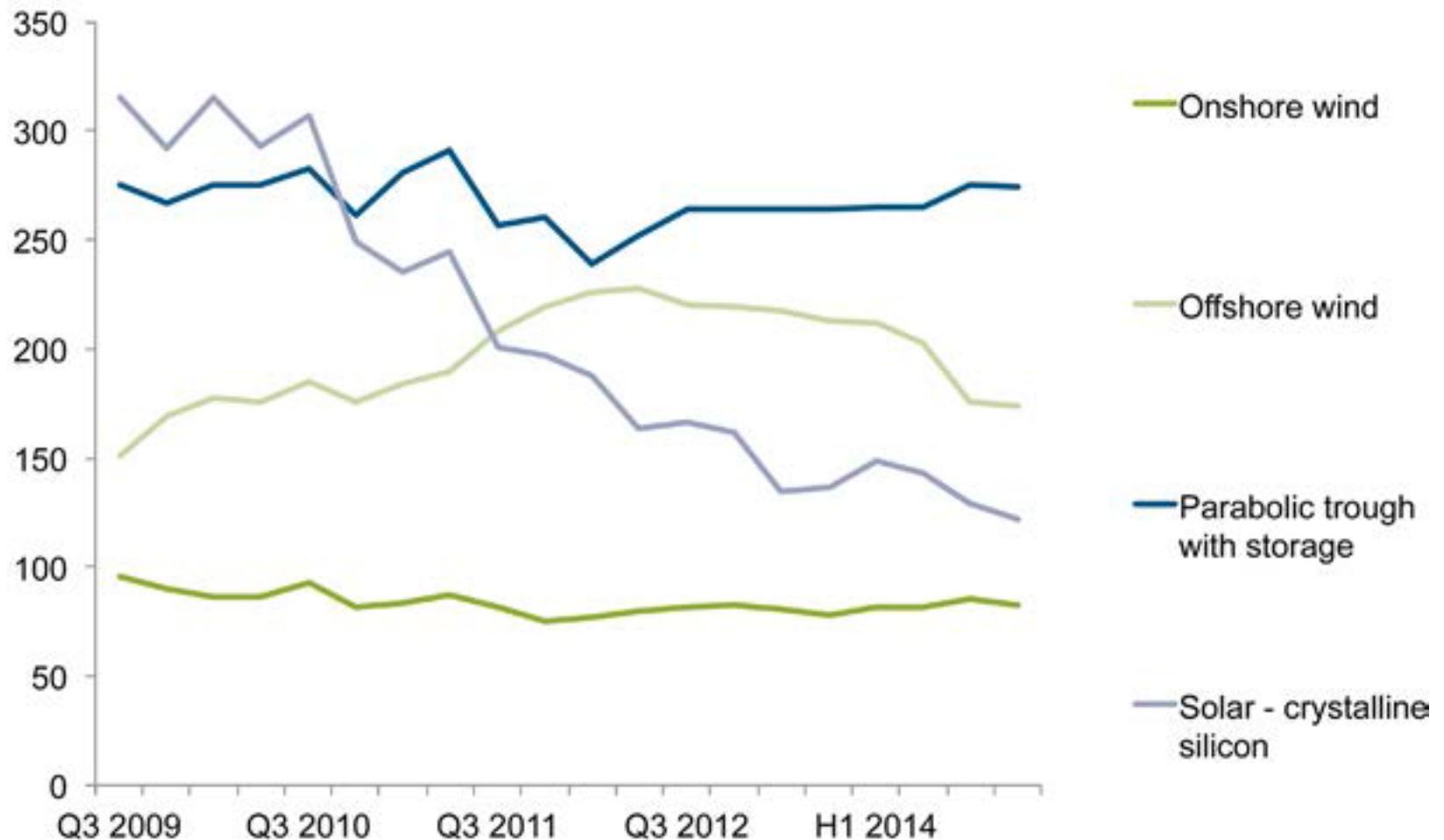
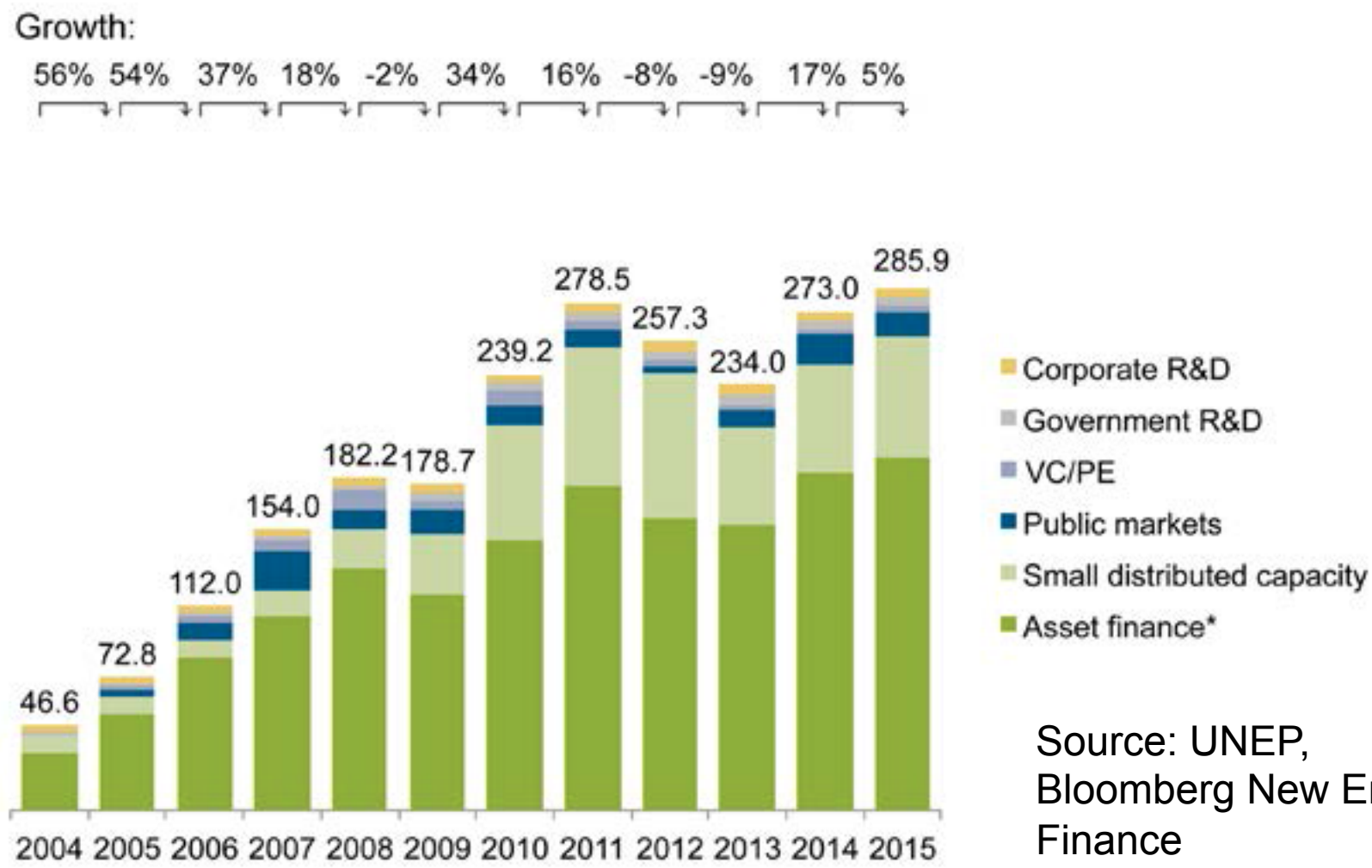


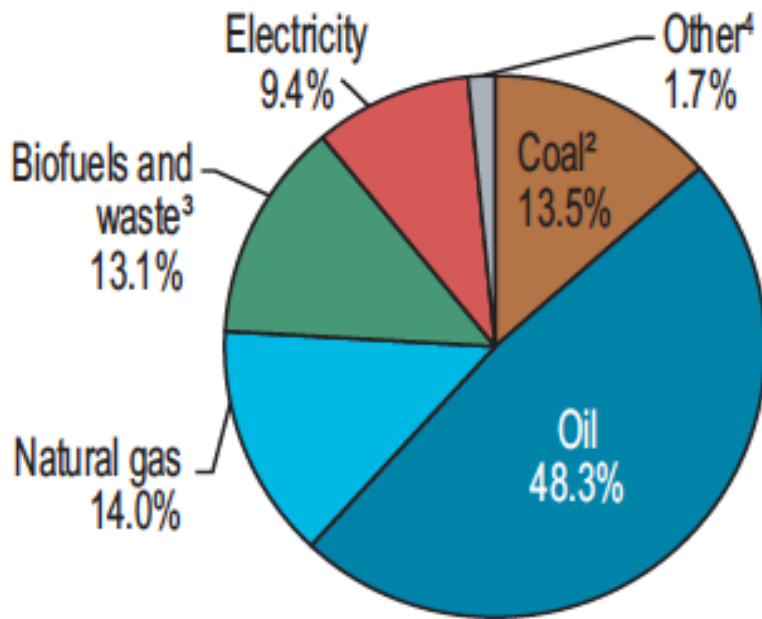
FIGURE 1. GLOBAL NEW INVESTMENT IN RENEWABLE ENERGY BY ASSET CLASS



Source: UNEP,
Bloomberg New Energy
Finance

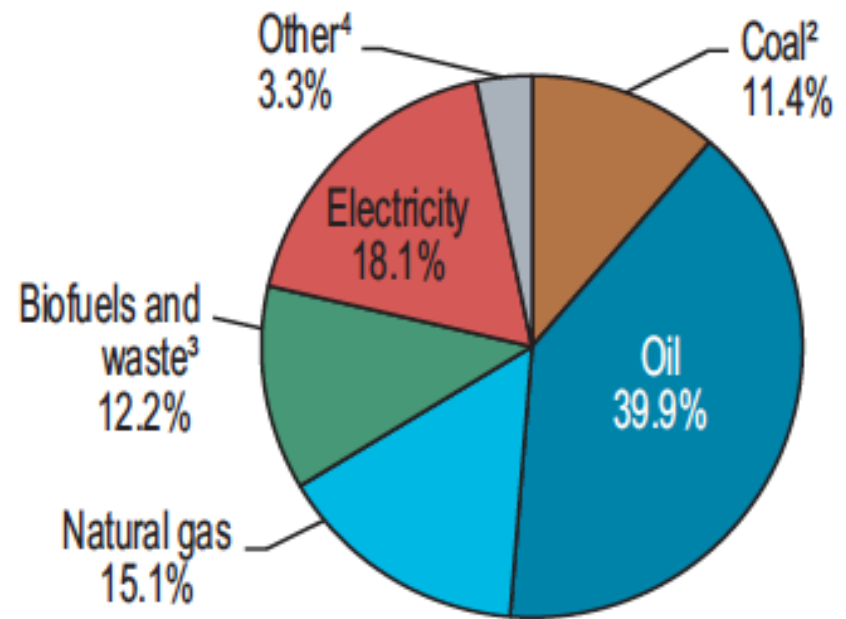
WORLD TOTAL PRIMARY ENERGY CONSUMPTION BY FUEL: NOW VS. THEN

1973



4 661 Mtoe

2014



9 425 Mtoe

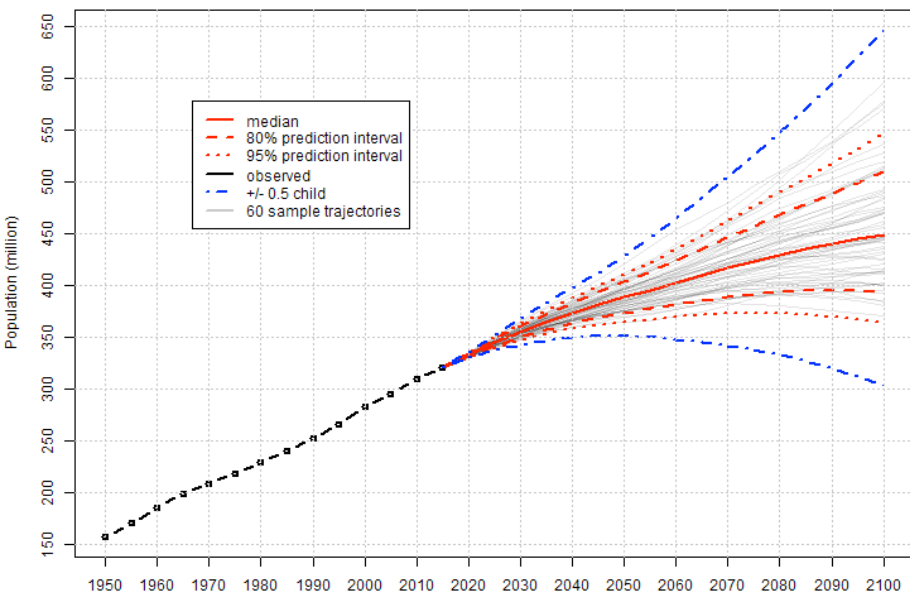
Mtoe = Million tons of oil equivalent. Other = Wind, solar, geothermal etc.
Source: International Energy Agency (IEA) Key world energy statistics 2016.

KEY QUESTION: WHERE CAN RENEWABLES FIT IN?

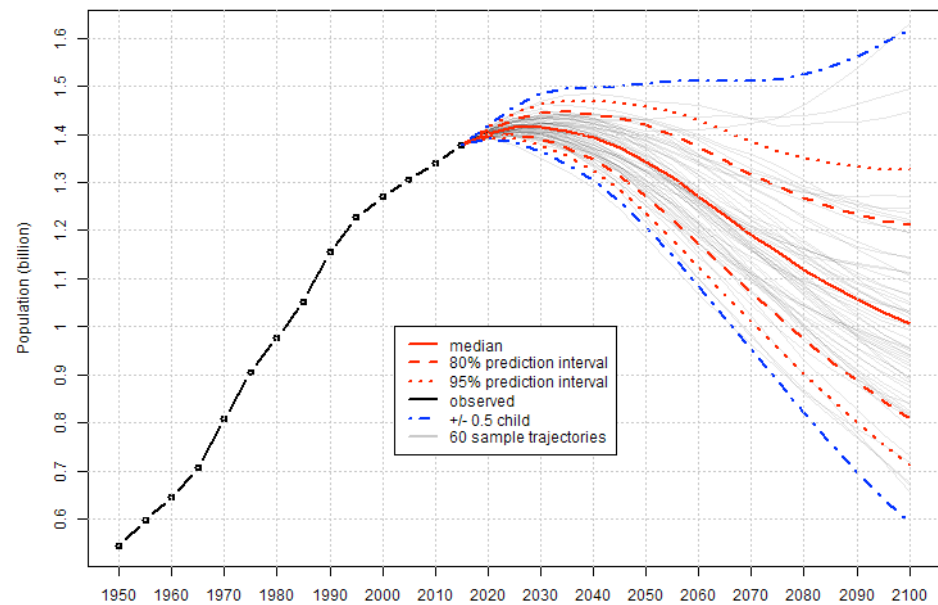
Electricity generation. Solar, wind, hydro.

Biofuels for petrochemical industry and transportation – but suffer from food vs. power debate, and not competitive in price.

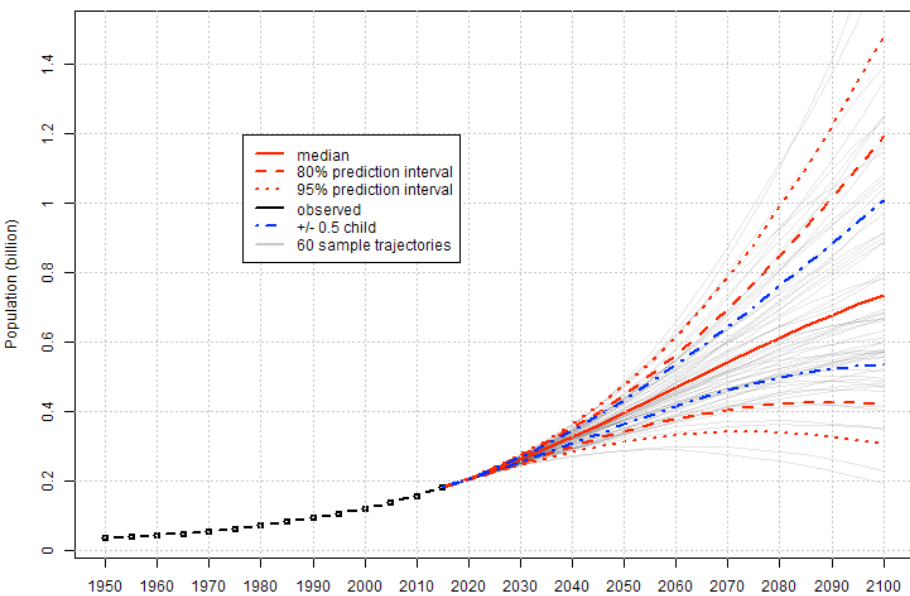
United States of America: Total Population



China: Total Population



Nigeria: Total Population



India: Total Population

