



NECST project, Lesson I

Energy: Scenario and Challenges

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Energy: definitions

Energy is a property of objects which can be transferred to other objects or converted into different forms, but cannot be created or destroyed.

(????)

More specifically, energy is the capacity of a system to perform work.

Great, then what is work?

In physics, a force is said to do work if, when acting on a body, there is a displacement of the point of application in the direction of the force.

OK, I haven't understood anything yet...

Energy: definitions



“It is important to understand that we have no exact idea of what energy is” (R. P. Feynman)

Fortunately, the common concept of energy that we have is more than sufficient for today’s lesson!

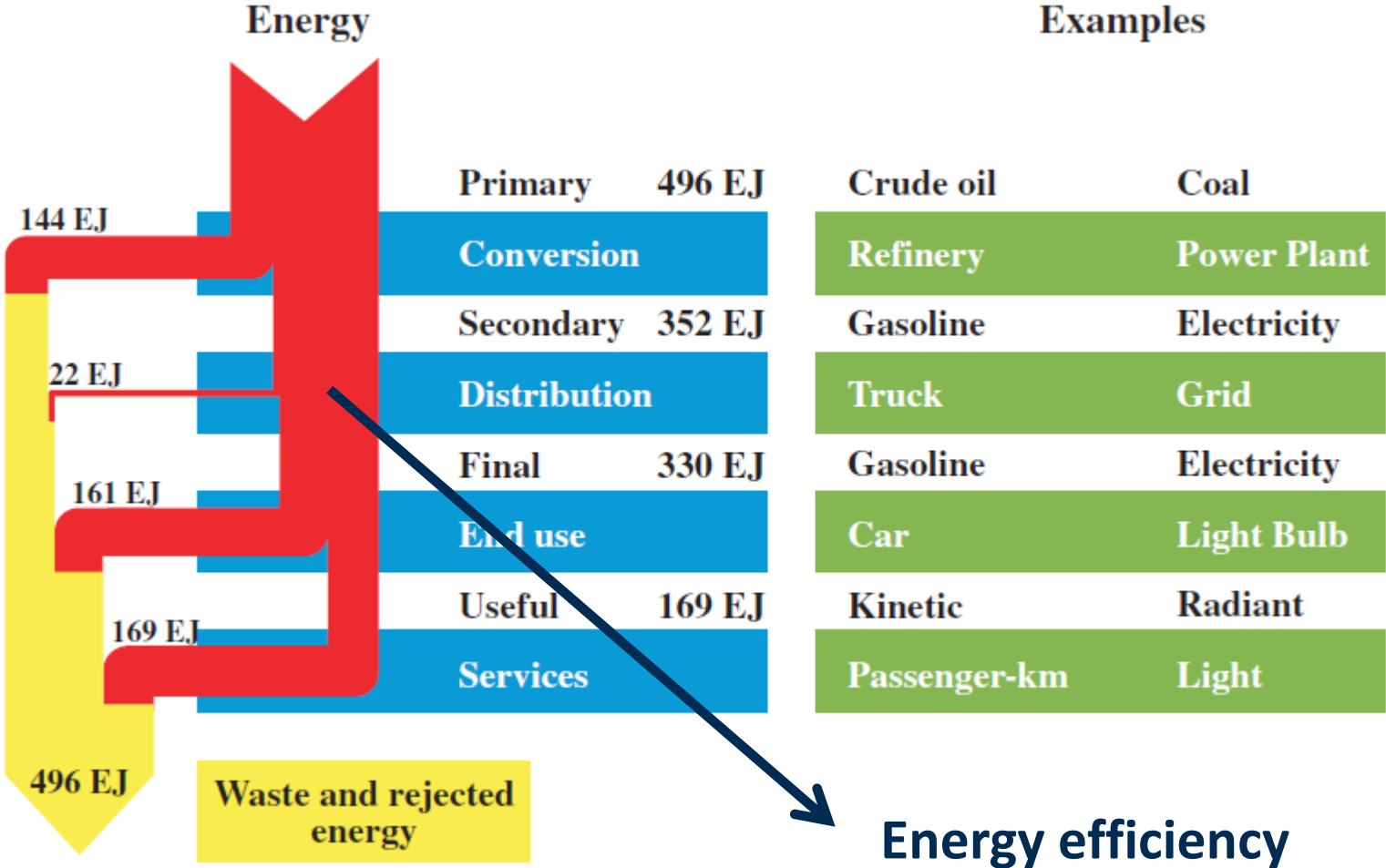
Energy: definitions

- **Primary energy** is the energy that is embodied in resources as they exist in nature.
 - Chemical energy embodied in fossil fuels (coal, oil, and natural gas) or biomass, the potential kinetic energy of water drawn from a reservoir, the electromagnetic energy of solar radiation, and the energy released in nuclear reactions.
- For the most part, primary energy is not used directly but is first converted and transformed into **secondary energy**.
 - Electricity, hydrogen and fuels such as gasoline, jet fuel, or heating oil which serve as energy carriers for subsequent energy conversions or market transactions.

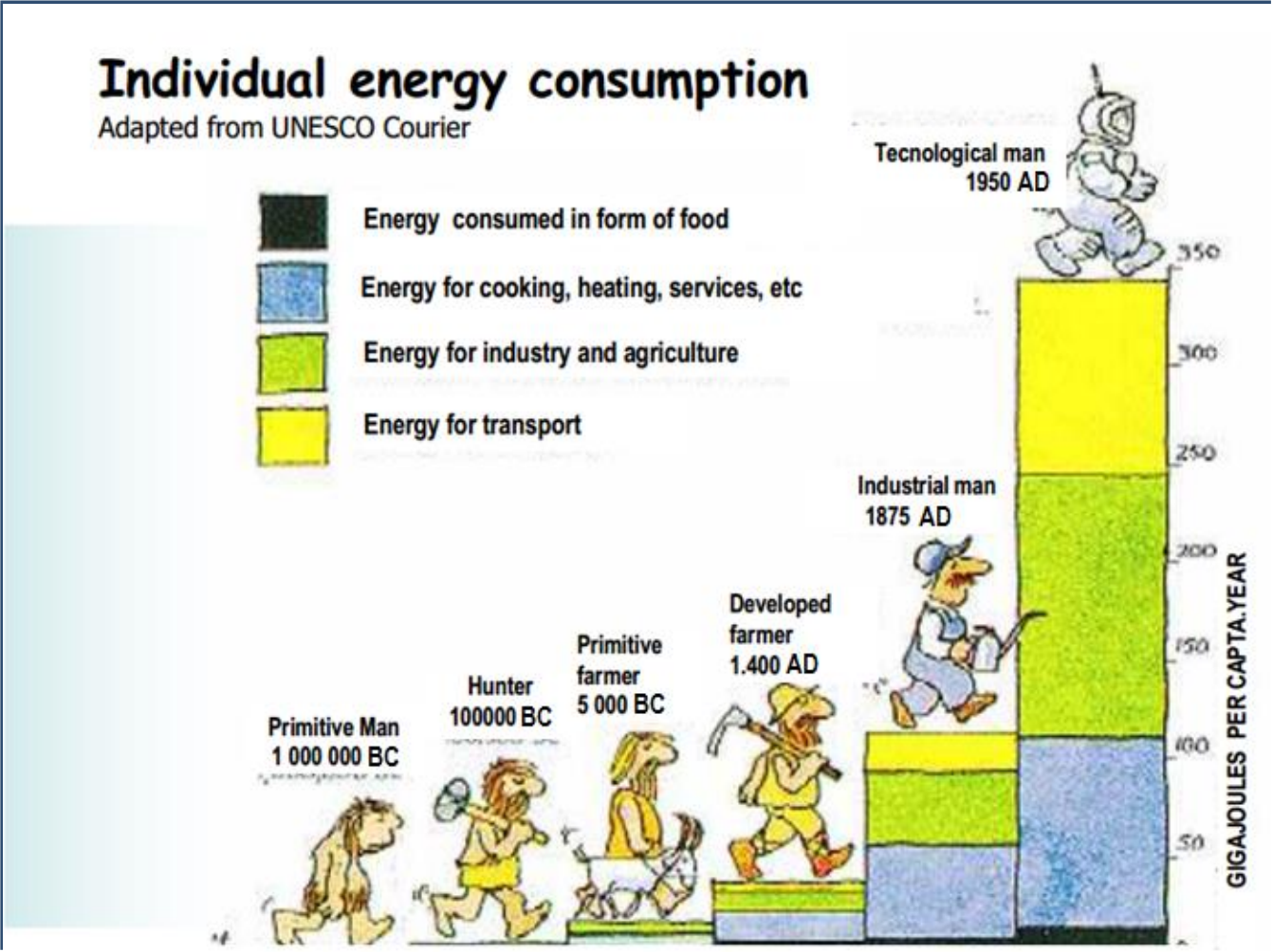
Energy: definitions

- **Final energy** (“delivered” energy) is the energy transported and distributed to the point of retail for delivery to final users (firms, individuals, or institutions).
- The next energy transformation is the conversion of final energy in end-use devices such as appliances, machines, and vehicles into **useful energy** such as the energy forms of kinetic energy or heat.
- The application of useful energy provides **energy services** such as a moving vehicle (mobility), a warm room (thermal comfort) process heat (for materials manufacturing), or light (illumination).

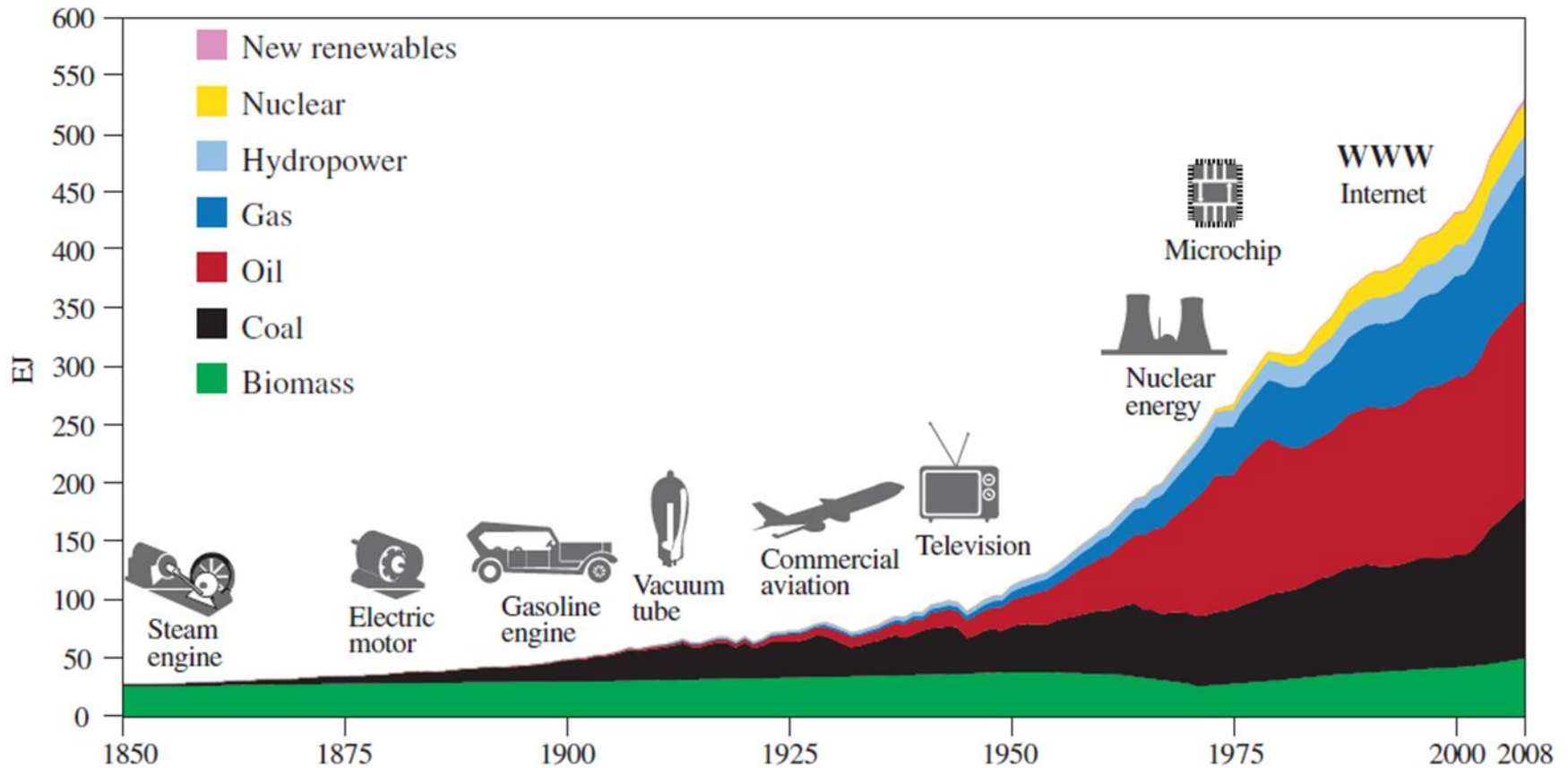
Global energy flows



Energy and development



History of world primary energy use

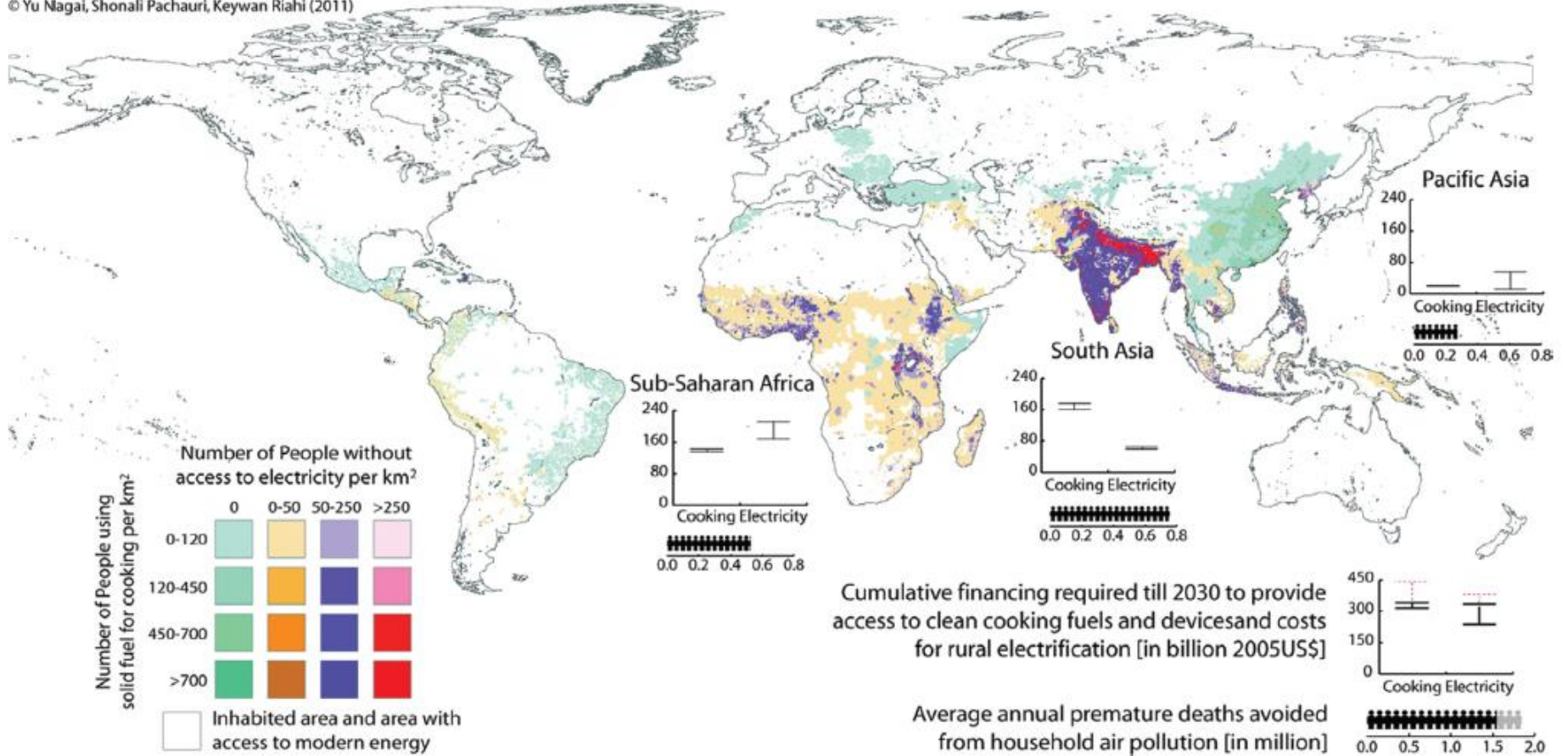


Share of the poor over total population

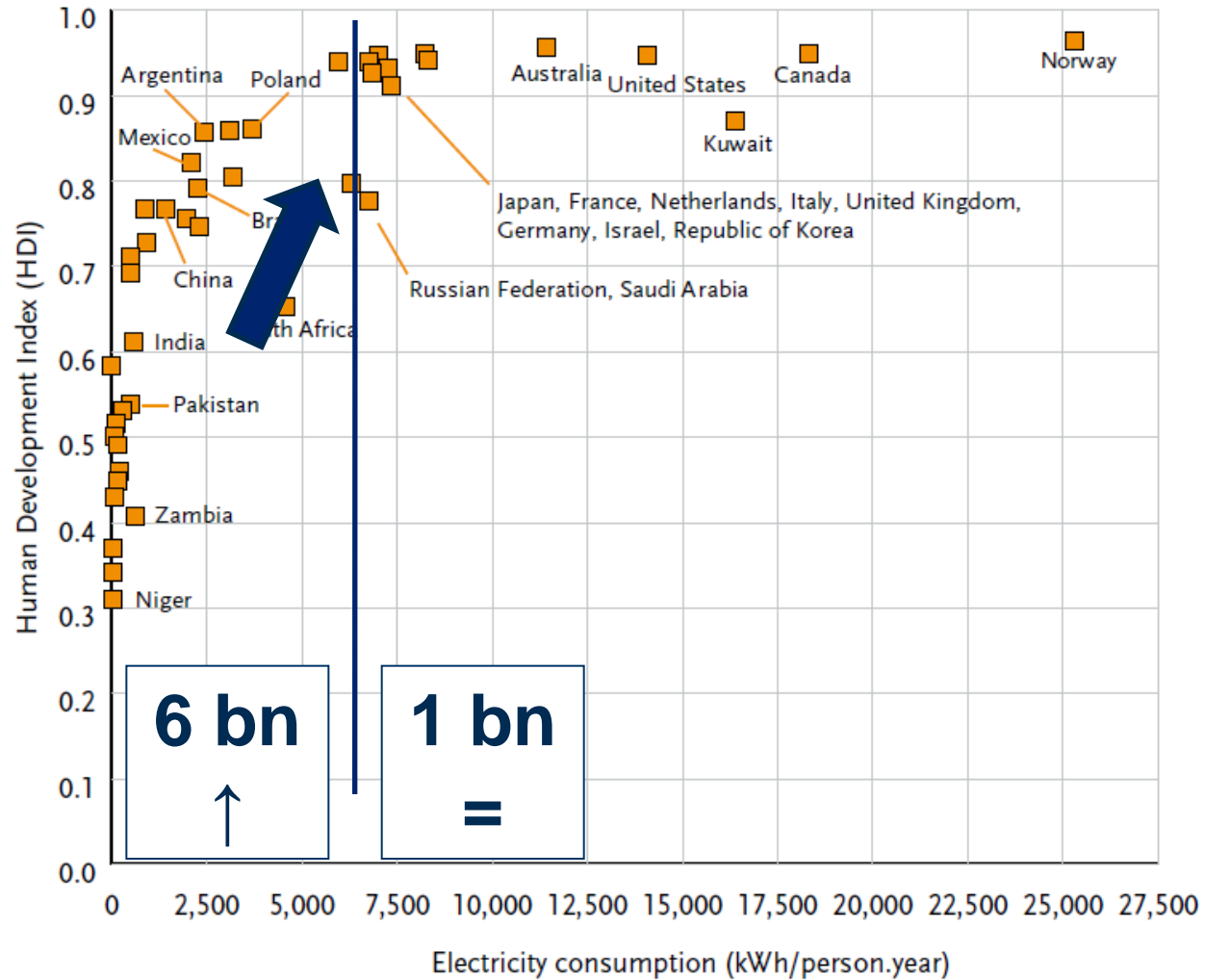
Region	Year		
	1999	2002	2005
Sub-Saharan Africa	58.4	55.0	50.9
South Asia	44.1	43.8	40.3
East Asia and Pacific	35.5	27.6	16.8
Latin America and Caribbean	11.0	10.7	8.1
Europe and Central Asia	5.1	4.6	3.7
Middle East and North Africa	4.2	3.6	3.6

Energy poverty worldwide

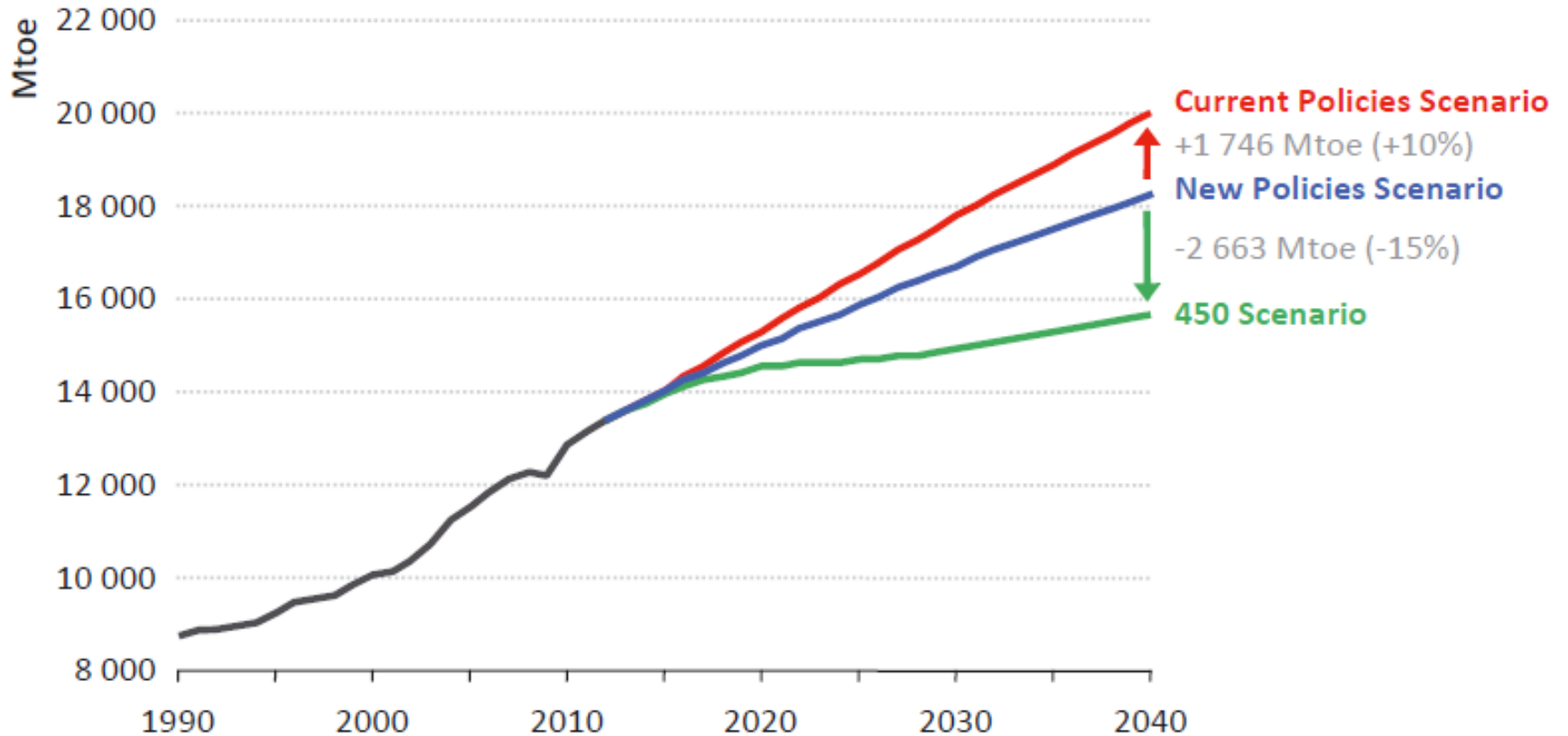
© Yu Nagai, Shonali Pachauri, Keywan Riahi (2011)



Electricity and development

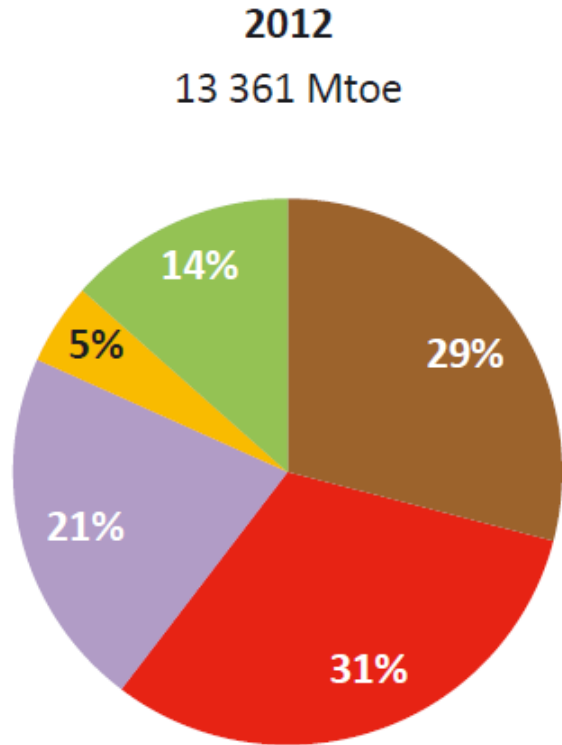


Energy demand: future trends

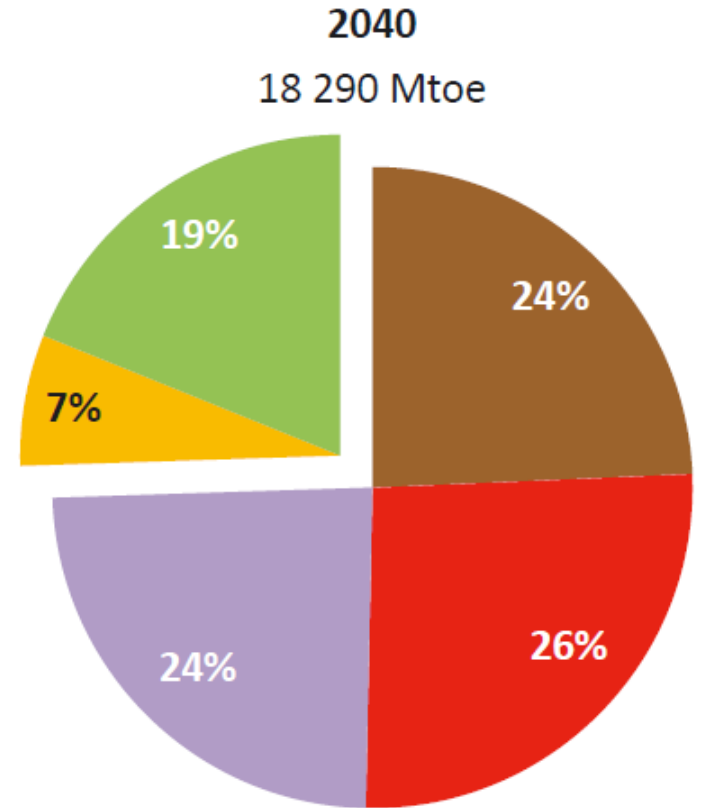


Rif. 2012: CPS +50%, NPS +37%, 450S +17%.

Primary energy share (New Policies Scenario)



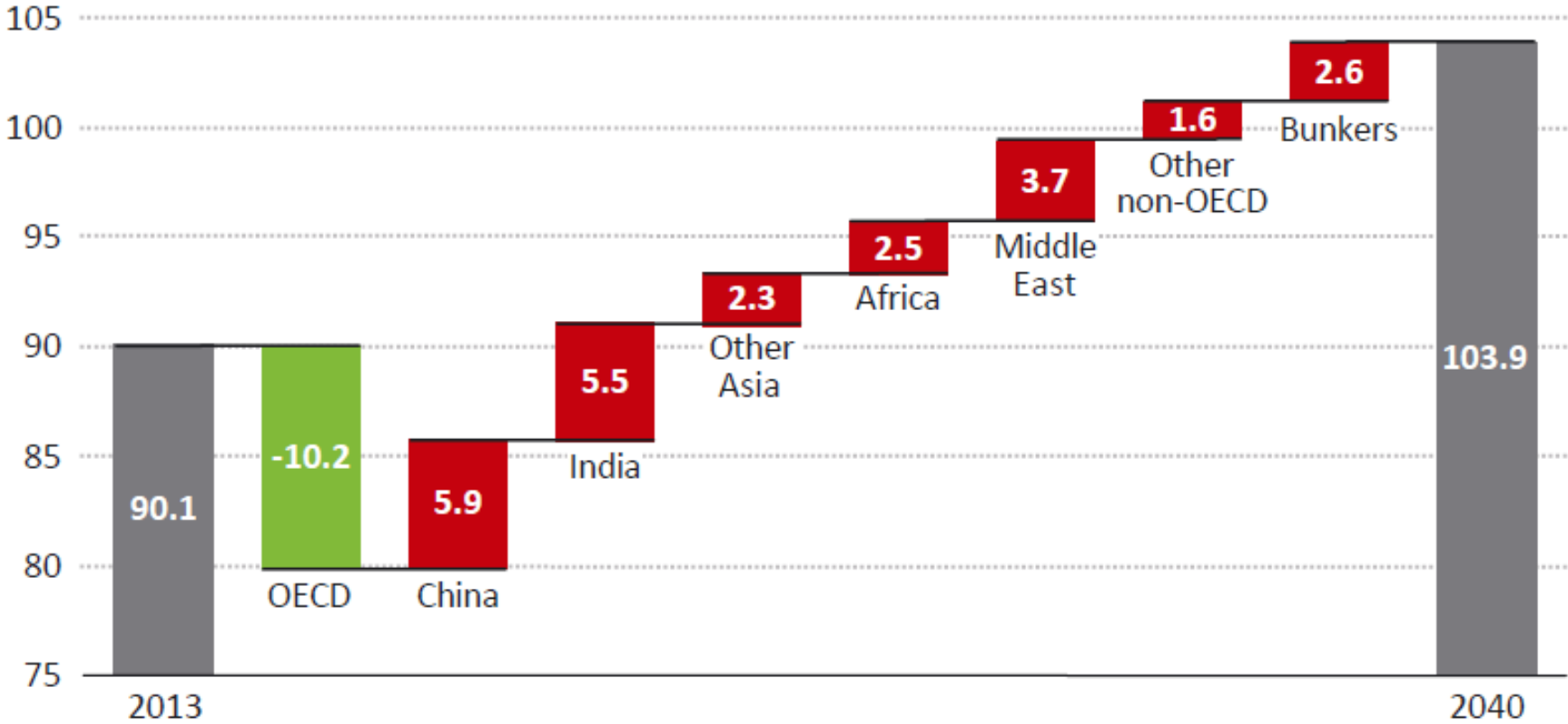
Fossils: 81%



Fossils: 74%

- Coal
- Oil
- Gas
- Nuclear
- Renewables

World oil demand (New Policies Scenario)



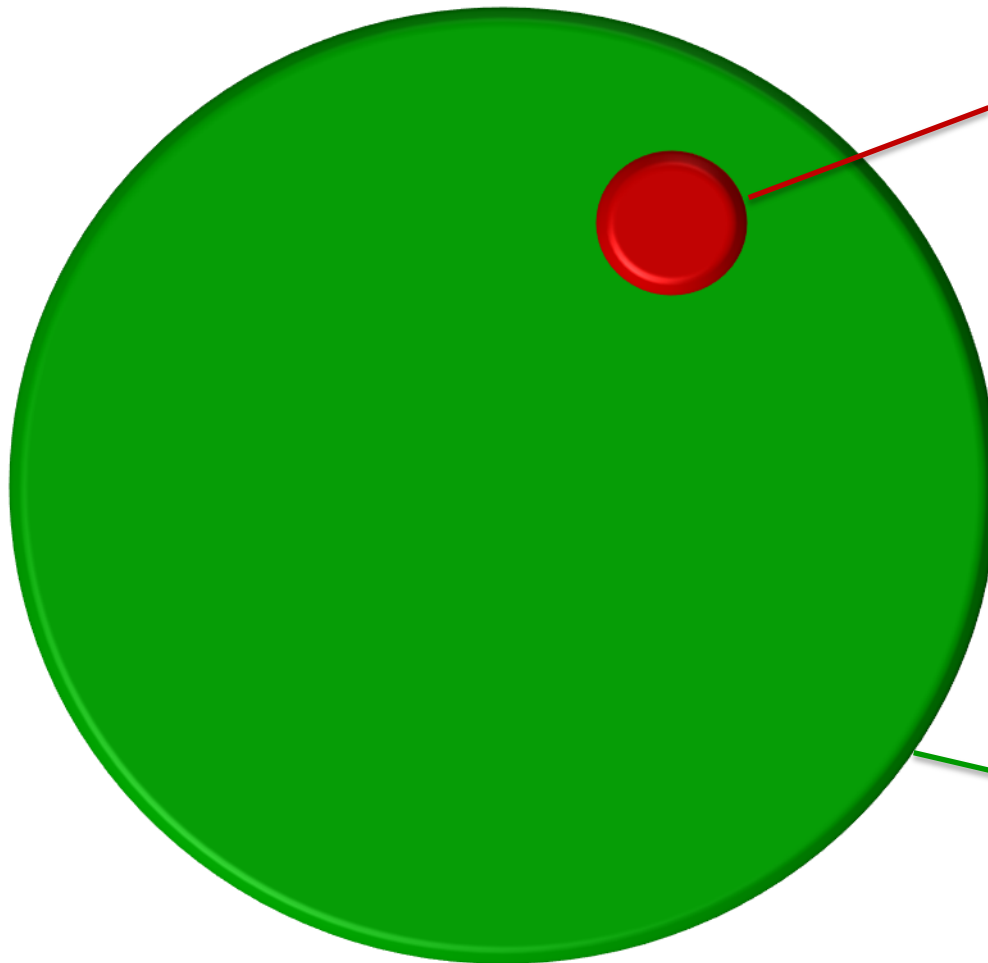
Million barrels per day.

Dominance of fossil fuels

Two main issues:

- Energy availability (and security)
- Sustainability and climate change

Reserve-to-production ratio: oil



Production:
33.3 billion barrels per year
(2003 → 2013: +14%)

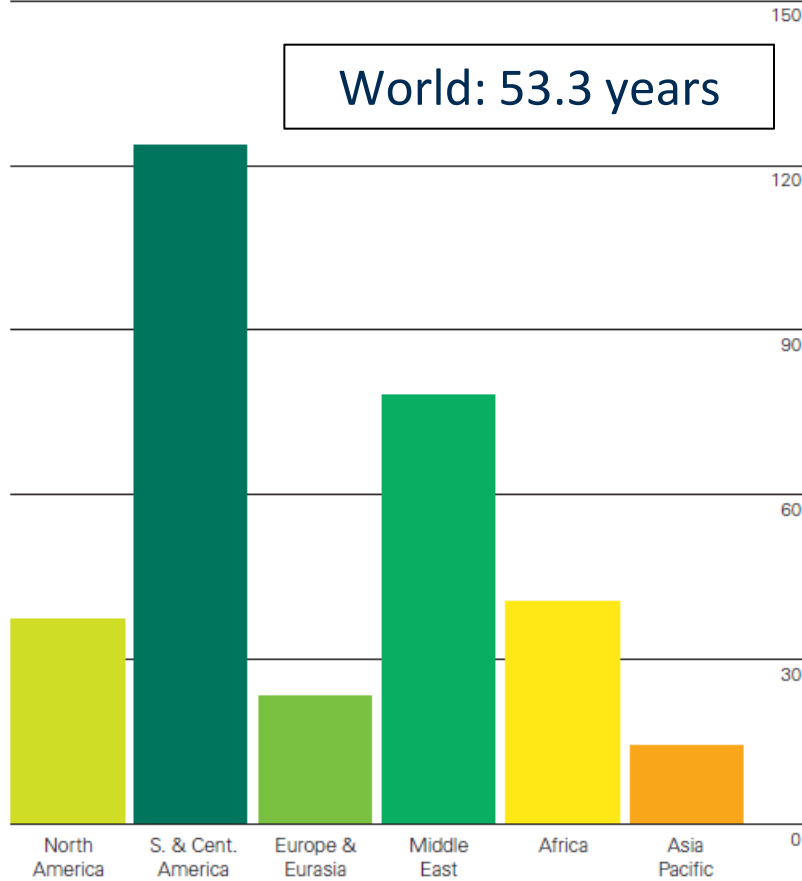
Reserves:
1688 billion barrels
(2003 → 2013: +27%)

Reserve-to-production ratio: oil

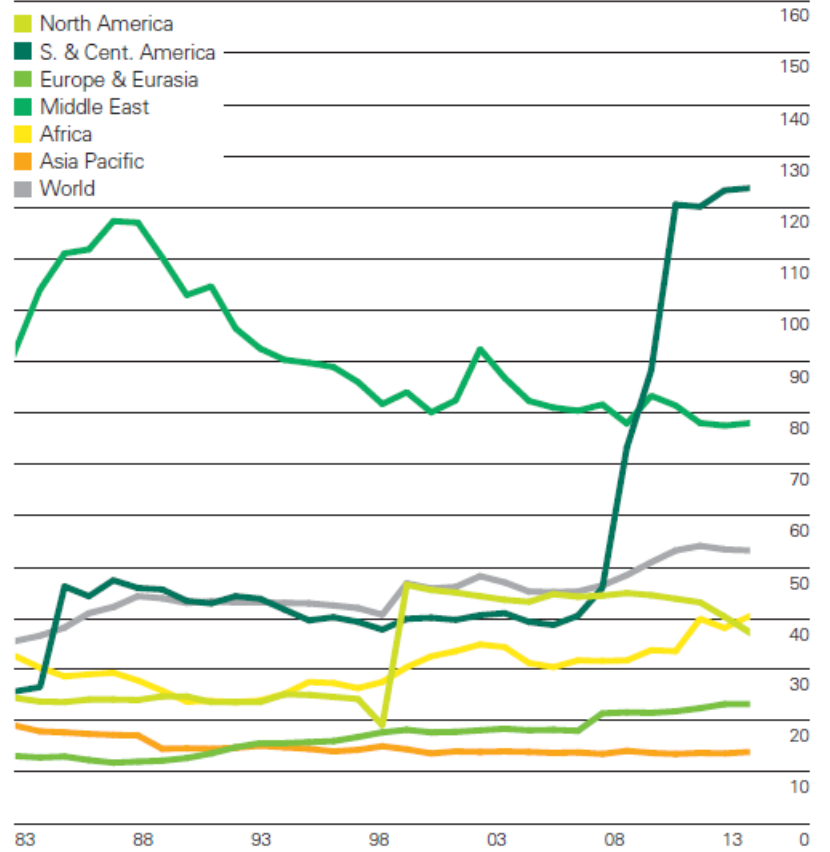
Reserves-to-production (R/P) ratios

Years

2013 by region



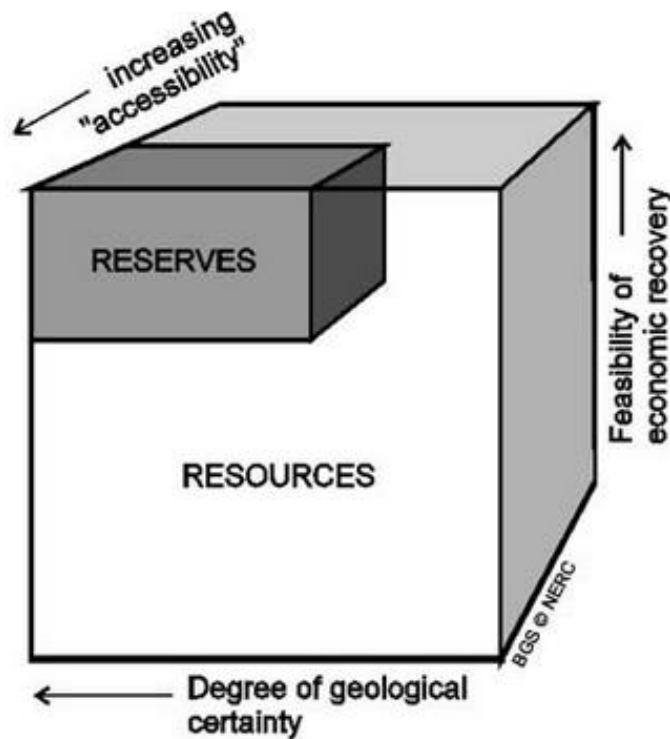
History



Resources and reserves

- **Energy resources** are the stocks (e.g. oil, coal, uranium) and flows (e.g. wind, sunshine, falling water) of energy offered by nature. Alternatively, they are the occurrences of material in recognizable form.
- **Energy reserves** are the amount of resources currently technologically and economically recoverable.

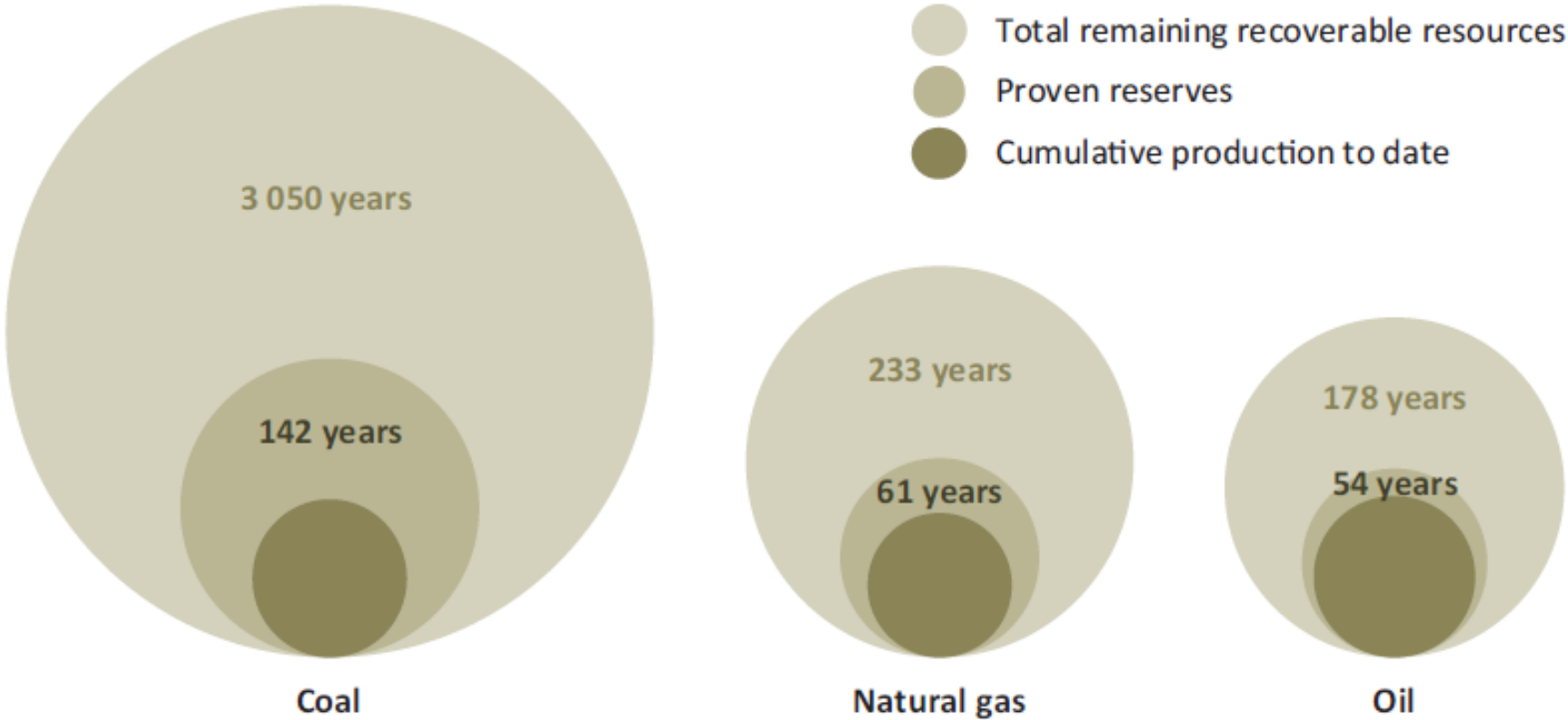
Resources and reserves



Three dimensions:

- **Economic** (lower costs / higher prices which make affordable to exploit already known and technically reachable/exploitable deposits)
- **Technical** (new techniques to reach/exploit already known deposits)
- **Geological** (unknown deposits)

Resources and reserves



Oil availability



Sheik Ahmed Zaki Yamani,
Saudi Oil Minister, 1973

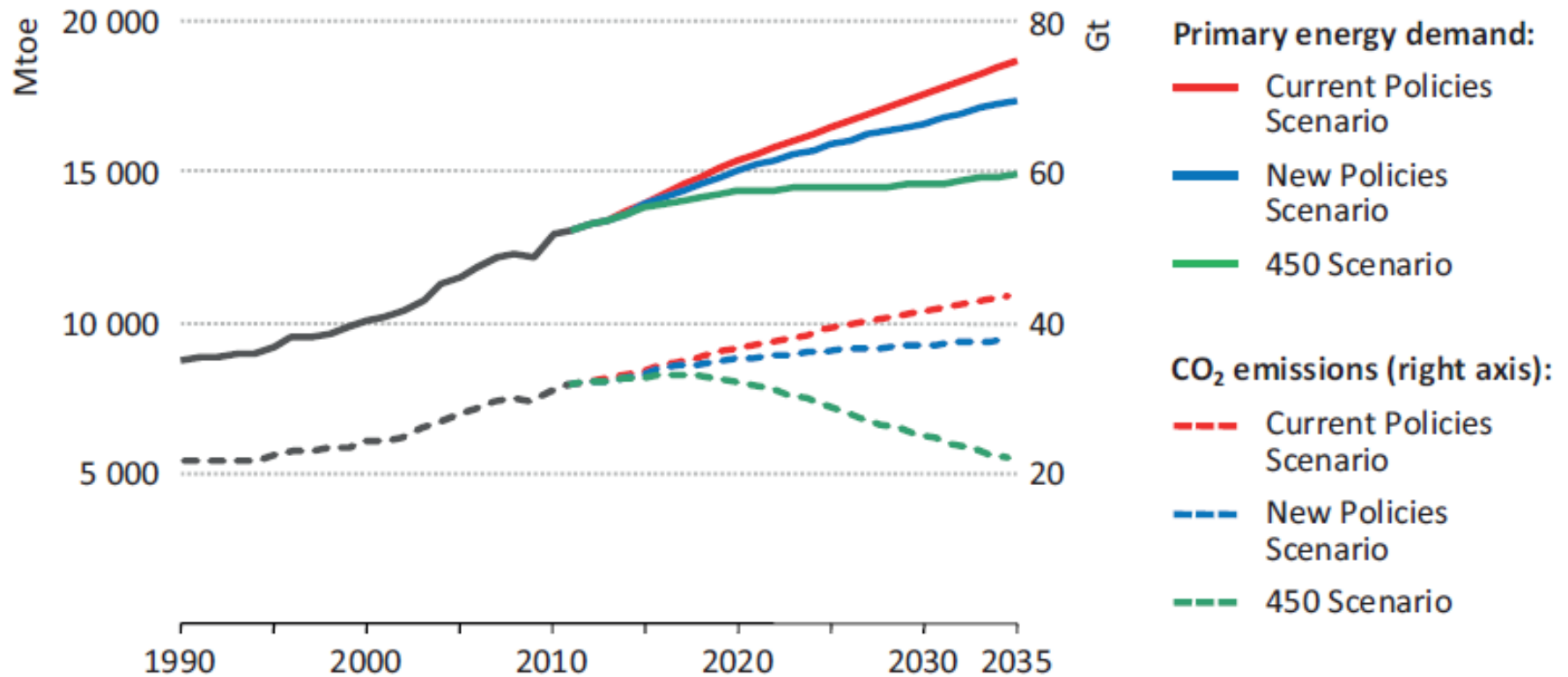
لم العصر الحجري لا تنتهي بسبب وجود
نقص في الحجارة، وعصر النفط لن ينتهي
بسبب نقص في النفط

“The Stone Age didn't end
because of a shortage of stones,
the Oil Age won't end because of
a shortage of oil.”

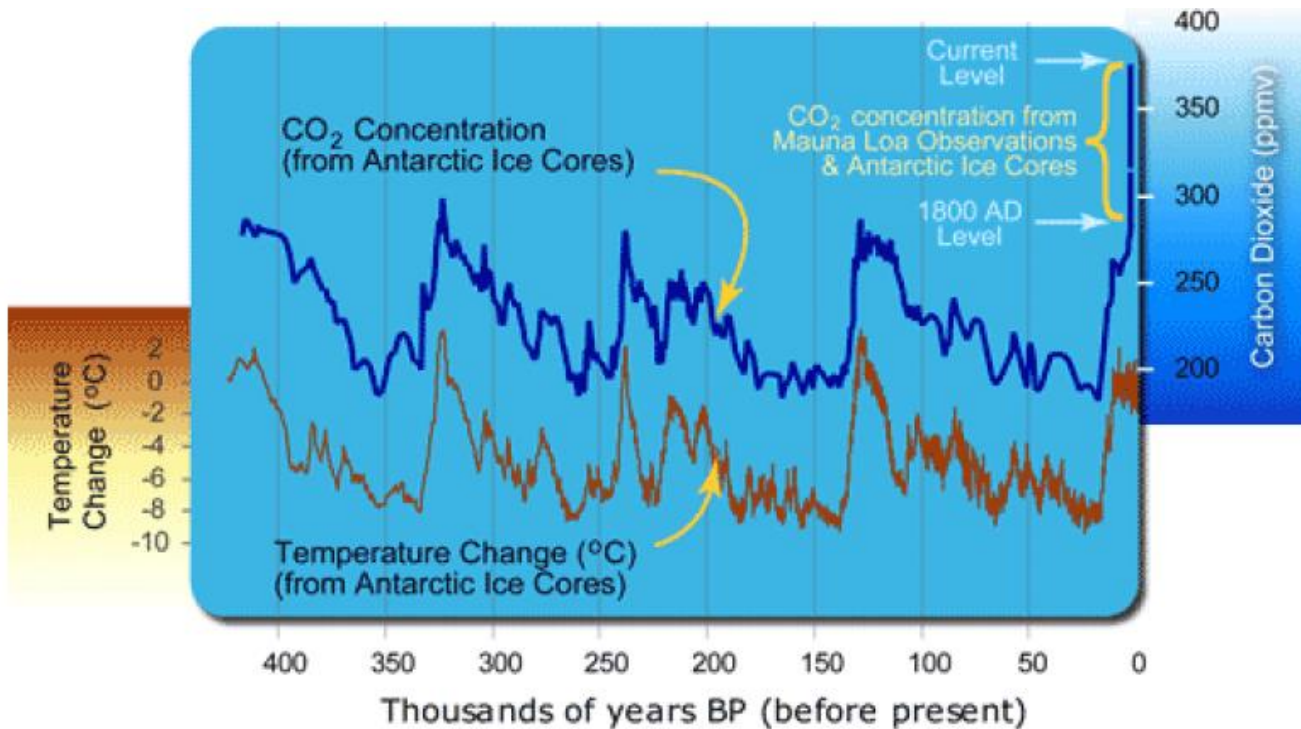
Energy security

- Energy security is the uninterrupted provision of vital energy services.
- For many industrial countries, the key energy security challenges are dependence on imported fossil fuels and reliability of infrastructure.
- Oil is at the center of contemporary energy-security concerns for most nations, regions, and communities. Oil products provide over 90% of transport energy in almost all countries. Thus, disruptions of oil supplies may have catastrophic effects.
- Imports of natural gas, stability of the electricity system, “demand security” for low-income exporting countries are, among others, additional dimensions of energy security.

Energy demand and CO₂ emissions

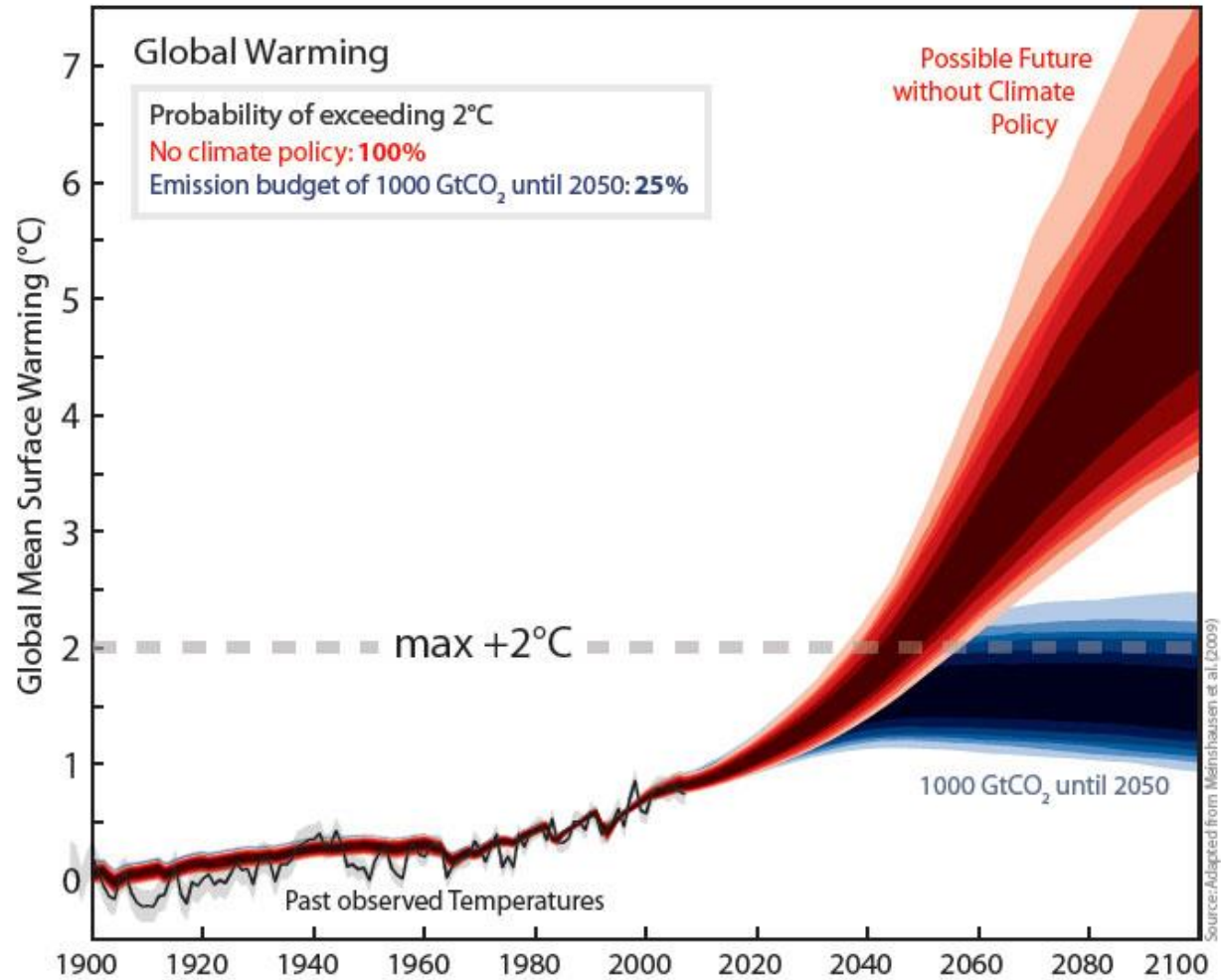


GHG emissions / temperature correlation

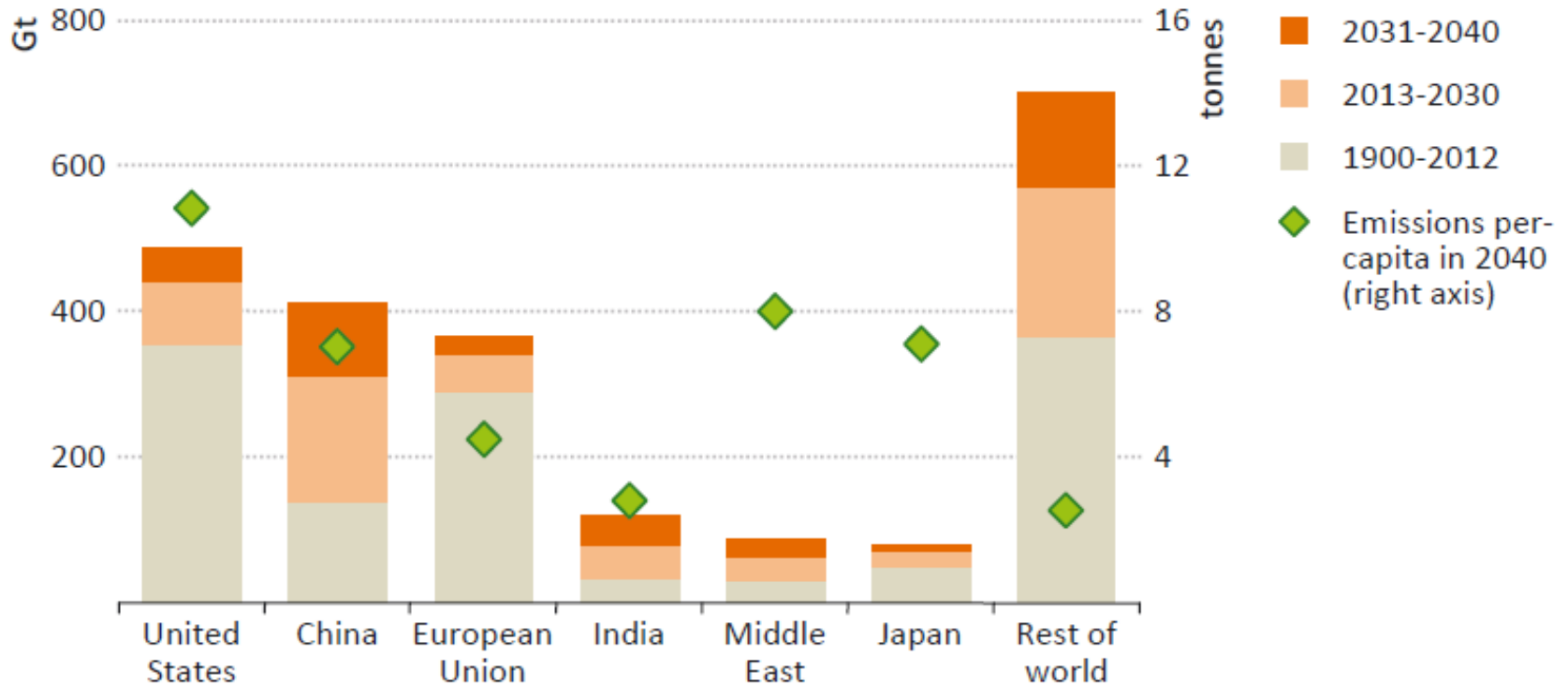


“Global atmospheric concentrations of carbon dioxide, methane and nitrous oxide have increased markedly as a result of human activities since 1750 and now far exceed pre-industrial values determined from ice cores spanning many thousands of years” (IPCC, 5th Assessment Report, Working Group I, The Physical Science Basis)

Temperature increase projections



Who has to cut emissions?



Cumulative energy-related CO₂ emissions by region in the New Policies Scenario