Population growth and energy

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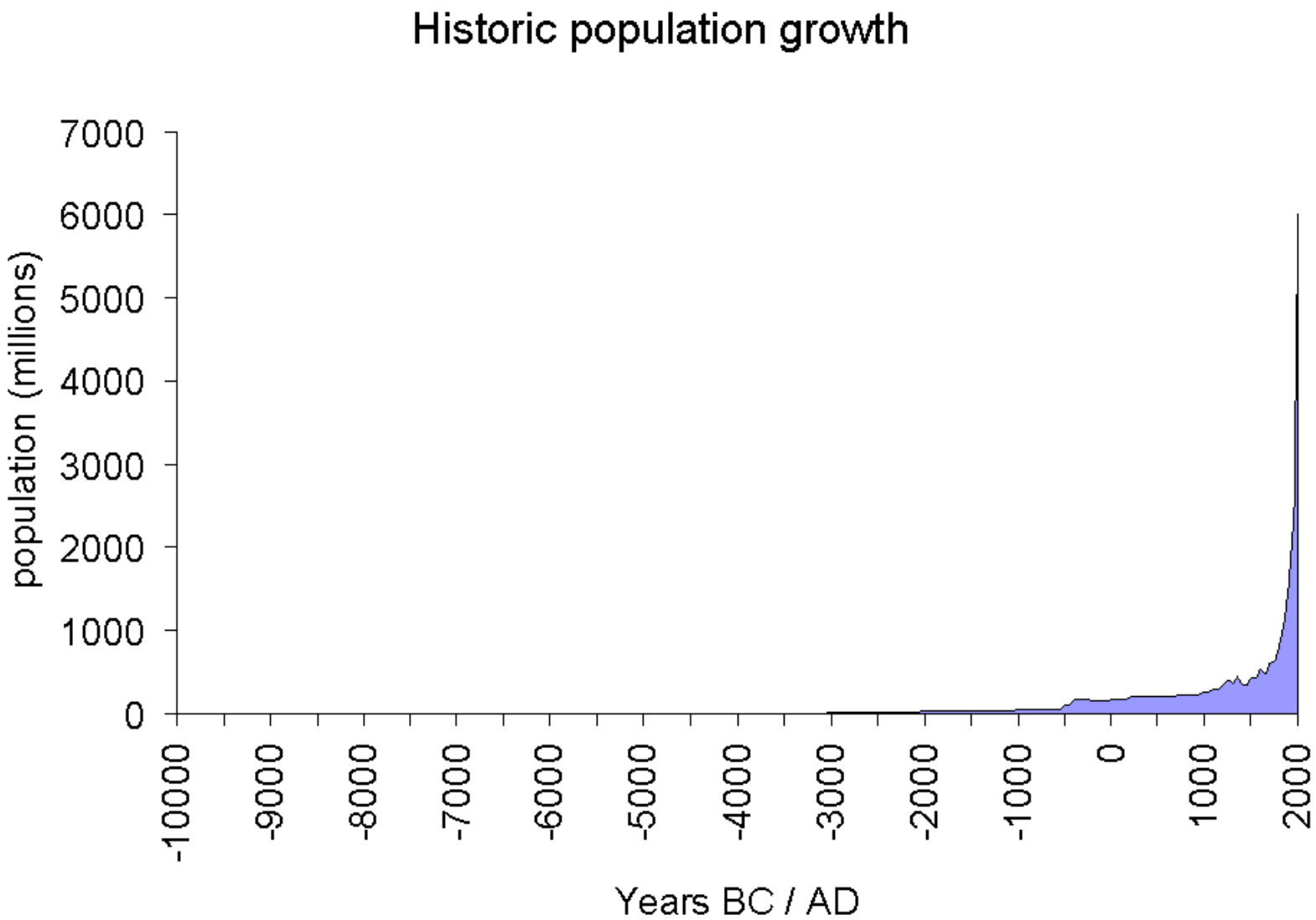

Source: US Census Bureau via Wiki

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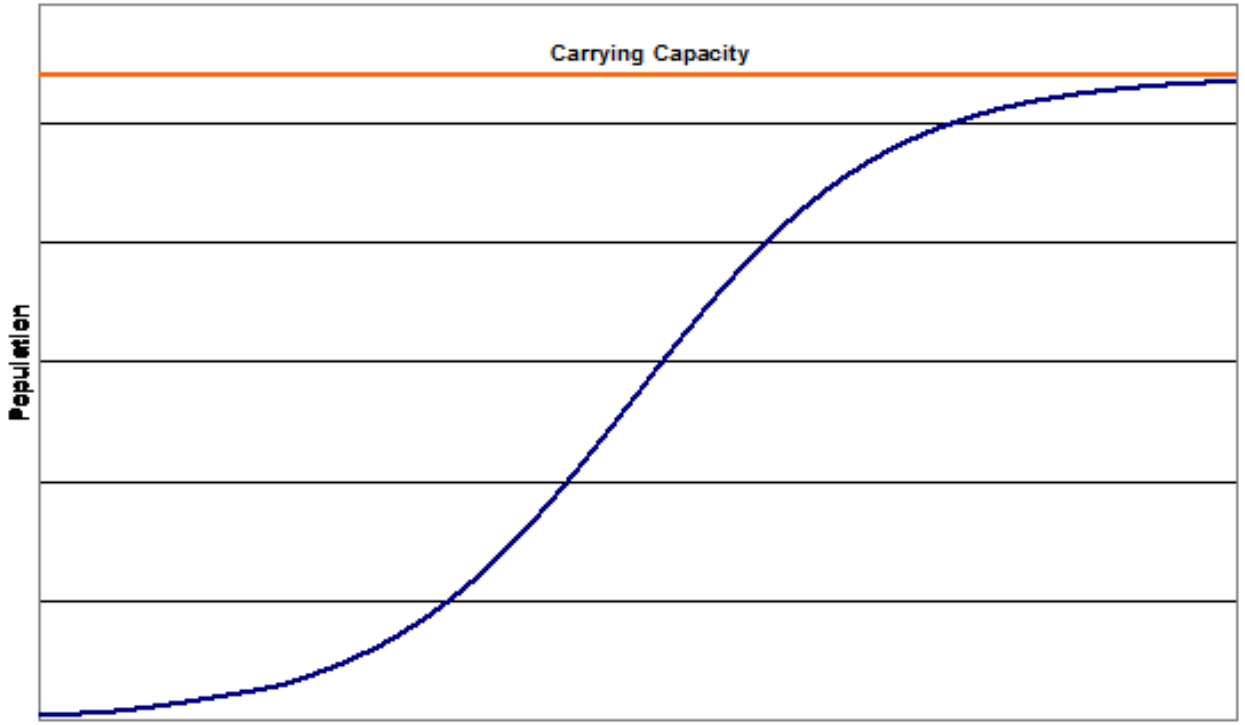
Population growth

- Driven by fecundity (reproductive rate) – how many offspring individual may have in his lifetime.
- A population doesn´t grow to its full potential (indefinitelly).
- Limits of population growth – conditions for life and reproduction.
- Limiting factors
- Carrying capacity – number of inhabitants (also people) that ecosystem can sustain with available sources.

Population growth

- Early populations grow quickly, unimpeded by resource constraints.
- As population grows, competition for resources grows.
- Mature population tend to reach equilibrium and fluctuate around it. If outgrows its carrying capacity regulating factors (femine, emigration) come into play.
- If a population is bellow, birth rates tend to increase, population grows.



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What factors determine carrying capacity?

- Density dependent factors
- Density independent factors

Hypothesizing the energy-population growth relationship

- Limits of growth are supressed by „infinite“ amount of energy from fossil fuels (mechanisation of agriculture + medical advances + savage systems + living in formerly unhabitable places).

The first energy era (hunter - gatherers)

- Human metabolism + fire.
- Muscles to secure food, shelter, aquiring material.
- Useful work of healthy adult: 50 – 90W.
- Energy returns in foraging – barely positive to as much as 40x .
- First usage of draft animals to cultivate the field (the very beginning of the agriculture)
- Sustainable (= able to be maintained at a certain level) economy = damages were reparable.

= If the ecosystem was harmed too much and stopped providing the resources, people moved to another place.

The first energy transition

- Early, preindustrial agriculture (beginning between 9000 BC and 6000 BC, lasting app. 16th century)
- Domestication of draft animals + fire to produce metals = increase of energy usage.
- Animals: 200 – 500W.
- Fire to produce bricks and containers and to smelt metals.
- Charcoaling to convert wood to charcoal to iron (inefficient process).
- Nearly complete deforestation of some parts of Mediterranean (Spain, Cyprus, Syria – iron) and the Near East (Iran, Afghanistan – copper).
- Considerable impact of people on the environment. Development is prevented by the limits of the environment.
- Still no spare resources for education, science, tech development.

First prime movers

- Muscles replaced by waterwheels and windmills to grain milling, oil pressing, wood sawing etc.
- Late 11th century England – more than 5600 water mills, 1/350 people.
- Higher performance of draft animals (better harnessing, shoeing etc.)
- Production of metals limited by the limits of environment.
- Early 18th century – typical English furnace produced app. 300 tons of pig iron/year. 8kg of charcoal per 1kg of iron, 5kg of wood per 1kg of charcoal = annual demand 12 000 tons of wood. All natural forests gone.
- 1 mill tons of iron requires ¼ of the British Isles under coppiced wood.
- = in 1200 London surrounding is deforested, by 1500 metal ores shipped to Ireland, Scotland, Wales for smelting, then the the industry moves to U.S.

Industrial age

- Substitution of animate energy by engines and energies of fossil fuels (still in process in dome areas – Africa)
- By 1900 several European countries energized by coal.
- Previously the lack of energy prevents the population from (also economic) expansion. No spare resources for education, science, technological development. It was changed by the fossil fuels.
- Watt´s steam machines 20kW. Industrialization, transportation, rise of well being. An inexpensive and reliable supply of heat and electricity.
- But environmental consequences (serious changes of interactions in the ecosystem)
- = fossil fuels provided a critical amount of energy for the humankind to develop. They (for uncertain period of time) removes the limits of (economic and population) expansion.

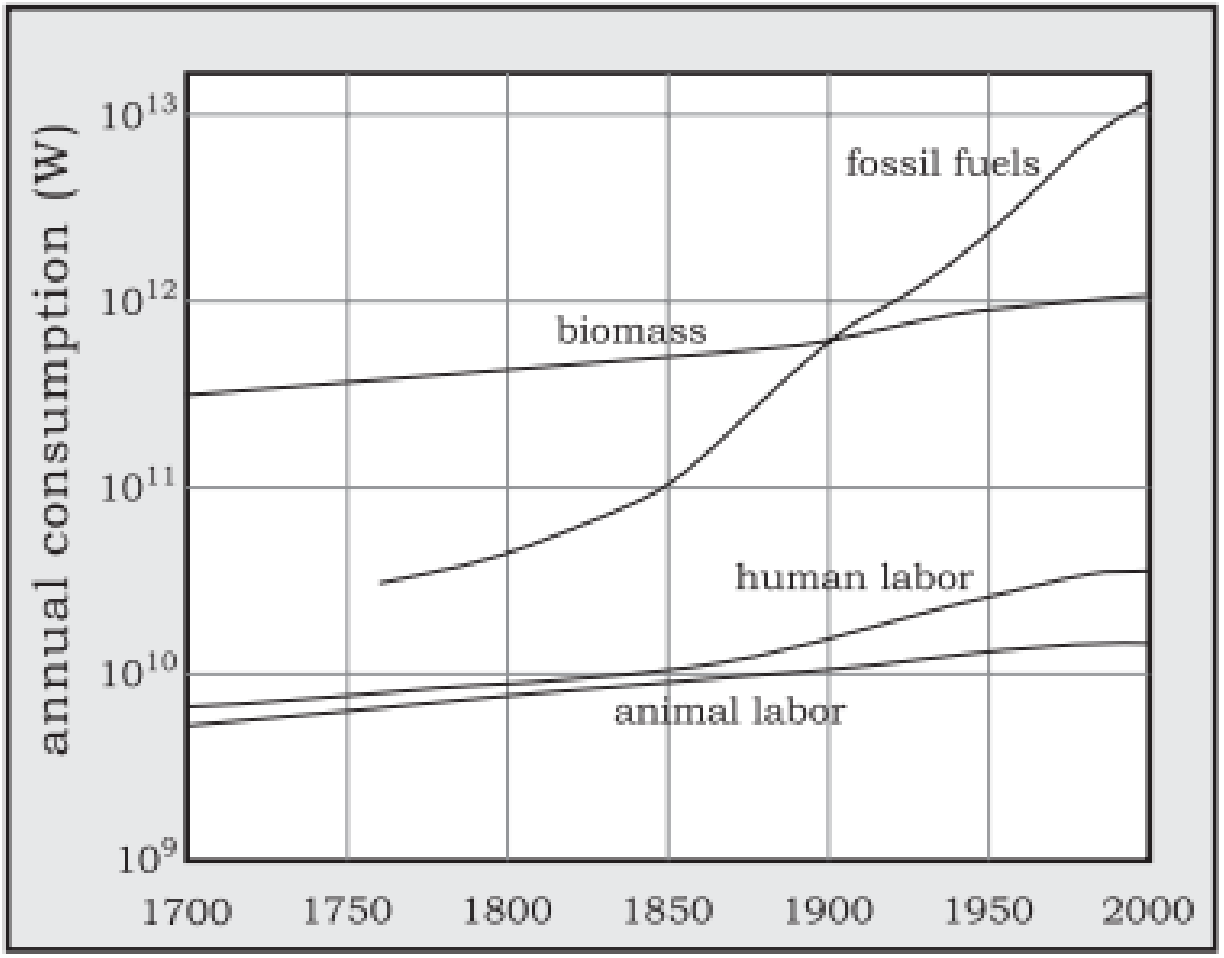
Latest energy transition

- Started by the first electricity plants in 1880s
- Electricifaciton and inovation
- An inexpensive and relable supply of electricity transformed every aspect of everyday activities – light, time-saving gadgets, energizing transport, boosting industrial production.
- By 1950 oil and gas approx. 35 % of the world´s primary energy supply and by 2000 their combined share over 60 %. With coal fossil fuels provides 90 % of all commercial primary energy supply.

= fossil fuels drive up farm productivity and hence reducing (drasticaly) agricultural population by mechanizing industrial production and letting the labor force move into the service sector.

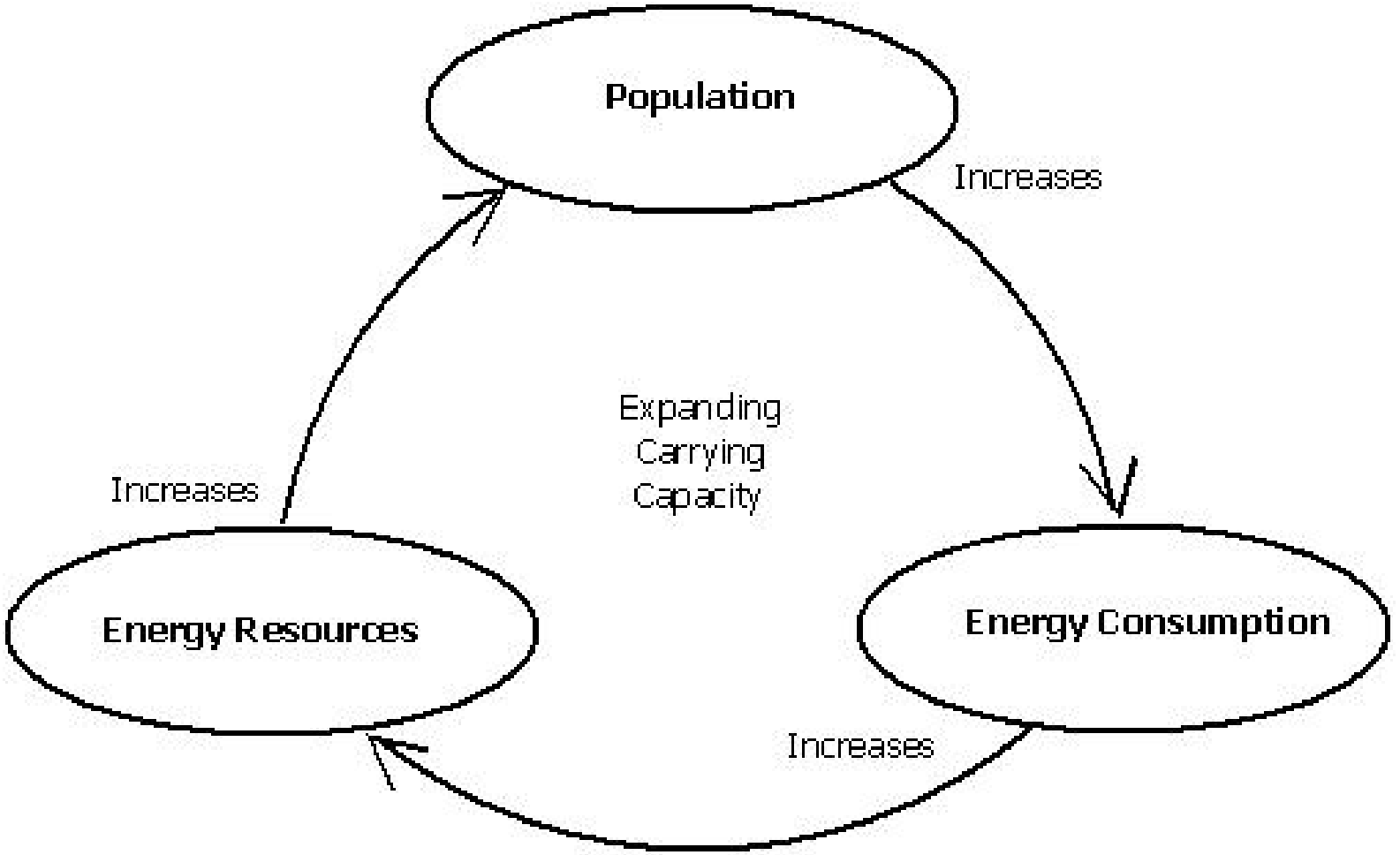
- But their impact on the environment is tremendous.

Development in energy consumption



Global consumption of primary energy, 1750–2000.

Energy-population relation



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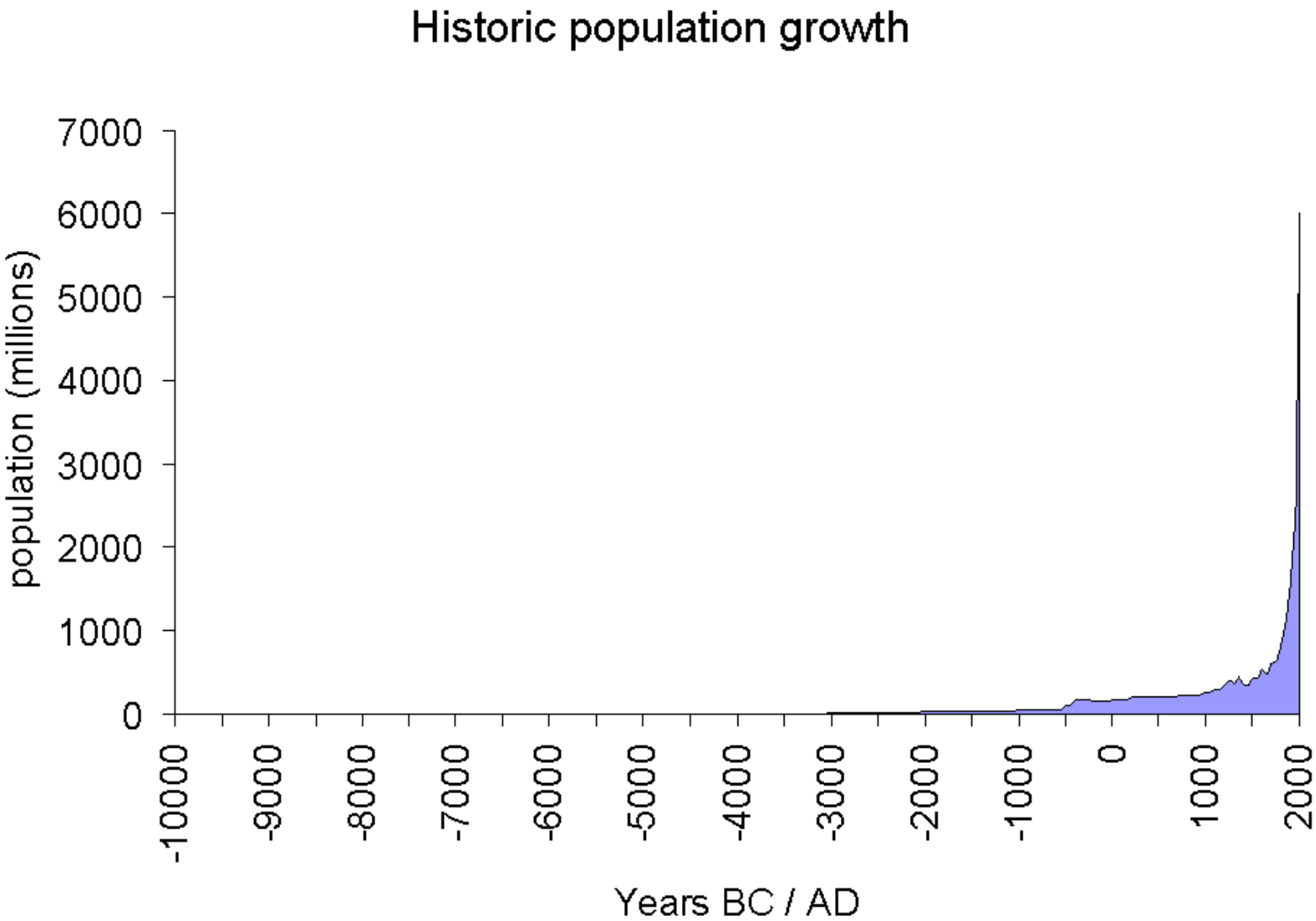

Source: US Census Bureau via Wiki

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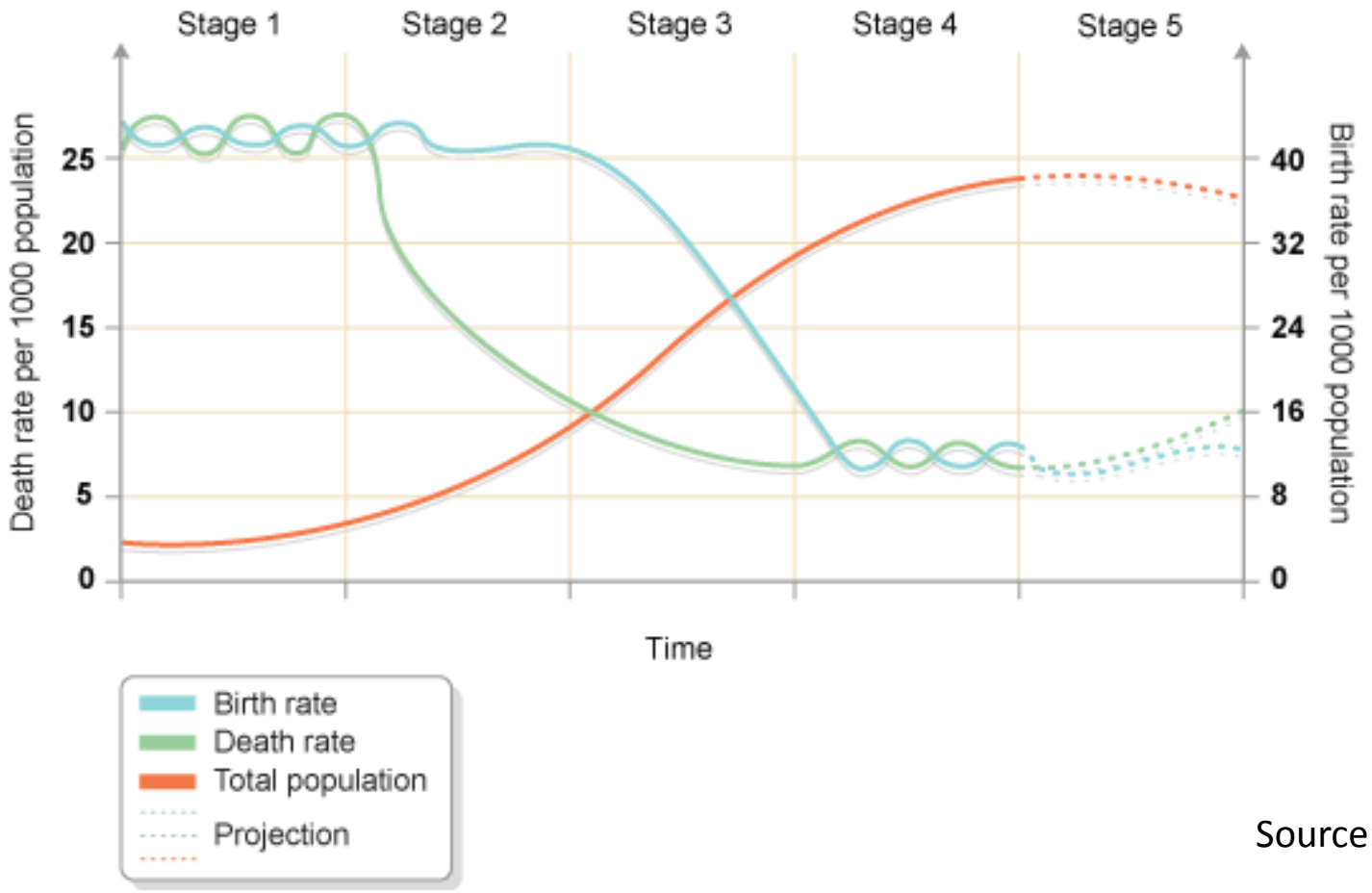
Demographic transition model



Source: W. Thompson

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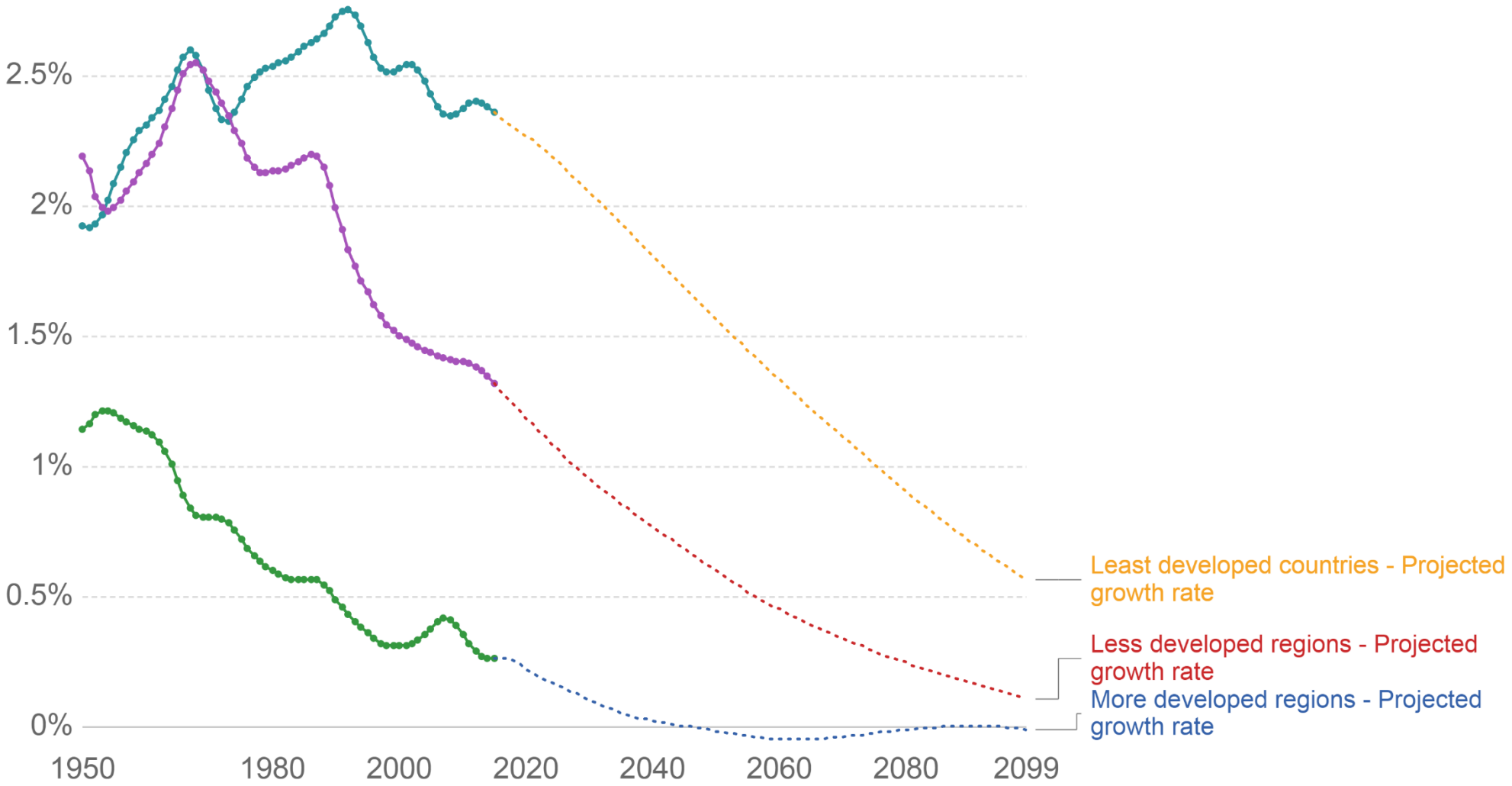
Population growth rate by world region, 1955-2015 and projections through 2100

Projections use the UN medium variant

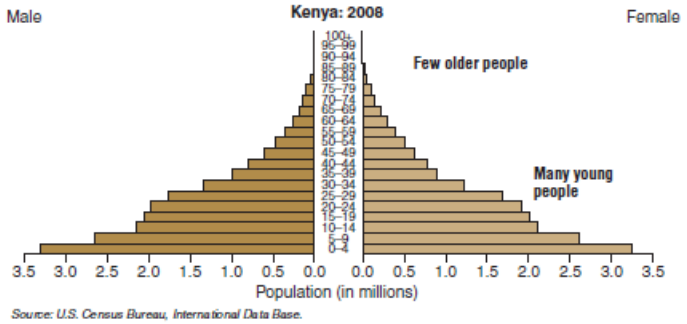


Source: UN Population Division (2017 Revision)

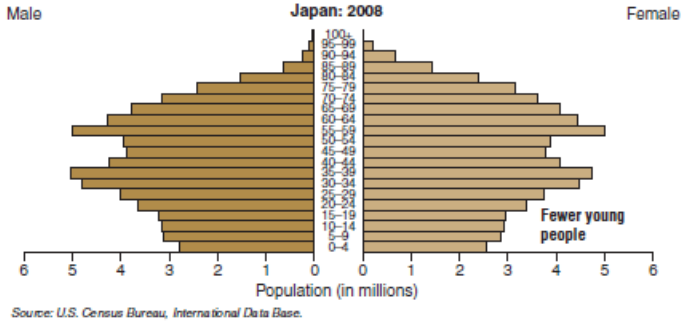
OurWorldInData.org/world-population-growth/ • CC BY-SA

Note: More developed regions comprise Europe, Northern America, Australia/New Zealand and Japan; less developed regions comprise all regions of Africa, Asia (excluding Japan), Latin America and the Caribbean plus Melanesia, Micronesia and Polynesia; least developed countries are 48 countries, 33 in Africa, 9 in Asia, 5 in Oceania plus one in Latin America and the Caribbean.

Age structure



Source: U.S. Census Bureau, International Data Base.



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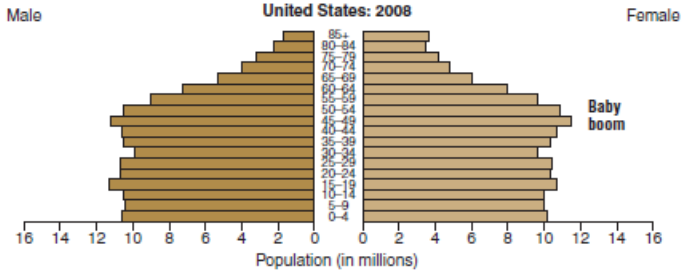

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Conclusions

= correlation between availability of energy and population (limiting factors suppressed by unlimited supplies of high-quality energy).

- energy needed to provide for existing population + accommodate expected increase.

= but fossil fuels are compromising the Earth´s ability to provide essential services

= other source of energy needed?

Thomas Malthus (1766-1834)

- An Essay on the Principle of Population.
  - Food is necessary for people to survive
  - Children will continue to be born
  - The power of population growth is indefinitely greater than the power of the Earth to produce subsistence.
- Malthusian trap (population growth instead of high standard of living).

X

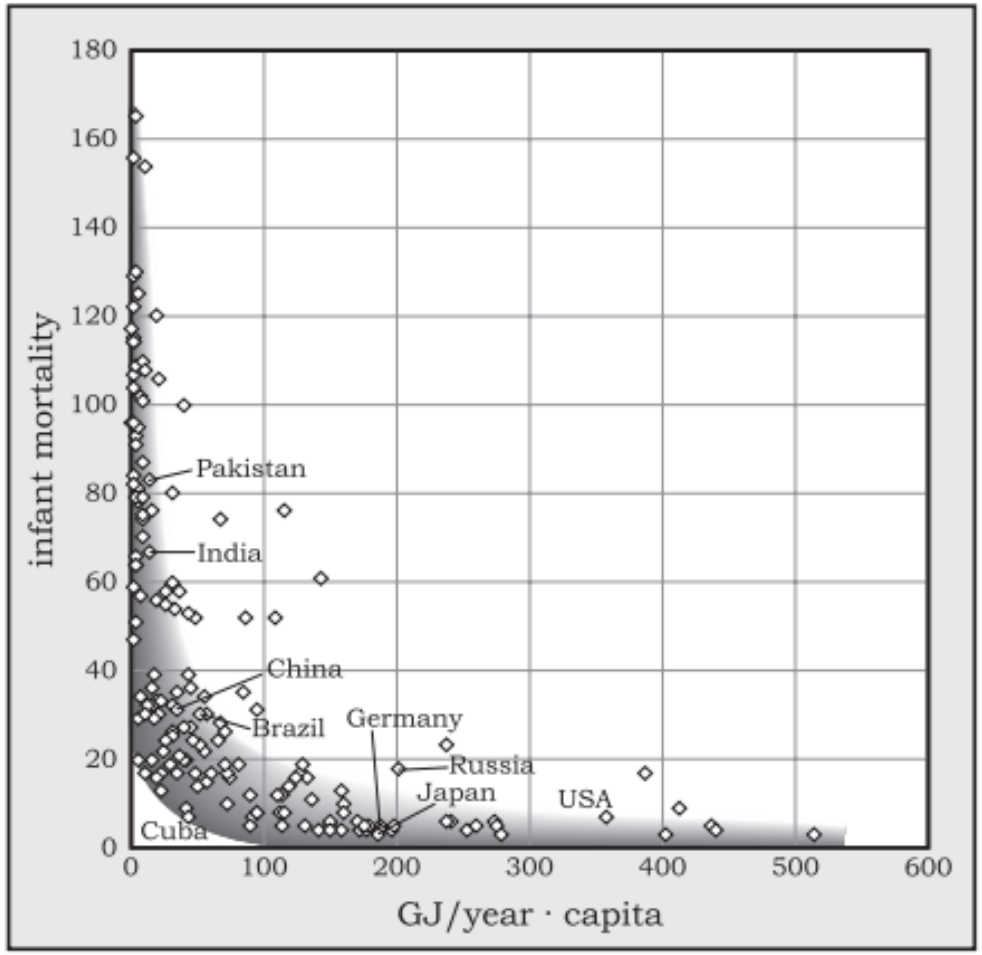
- Technological development.
- Relationship between afluence and population growth (demographic transition theory).

Perspectives

- Cornucopians (boomsters, vs. Malthus and followers = doomsters)
- Reformists: Work within existing structures to make society more “green”
- Revolutionaries: Sustainability is not possible without radical change
- Environmental determinists: Ecological limits will impose changes on society whether we like it or not

- The Voluntary Human Extinction Movement

Technological development



Per capita energy use and infant mortality.

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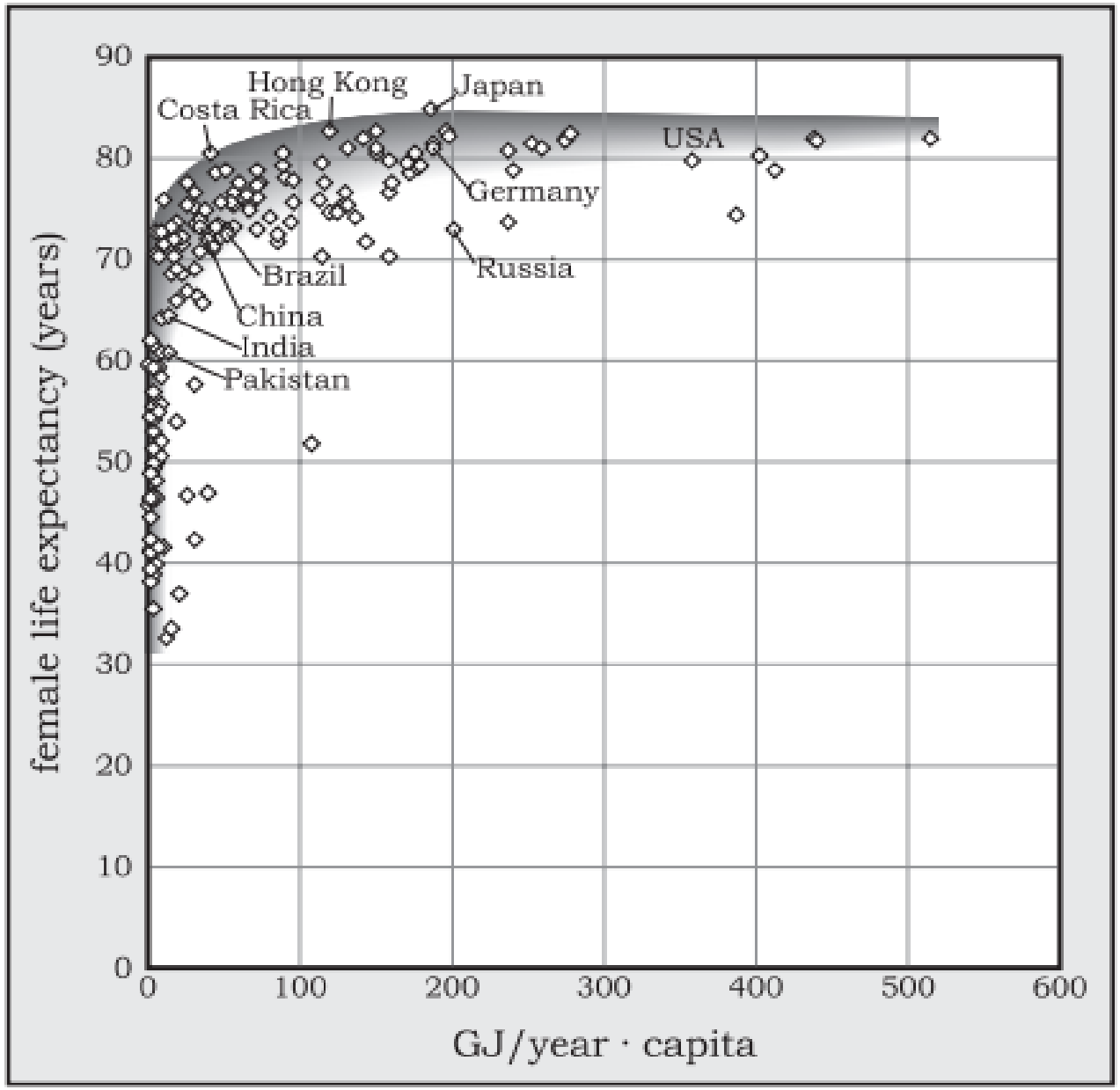

Per capita energy use and female life expectancy at birth.

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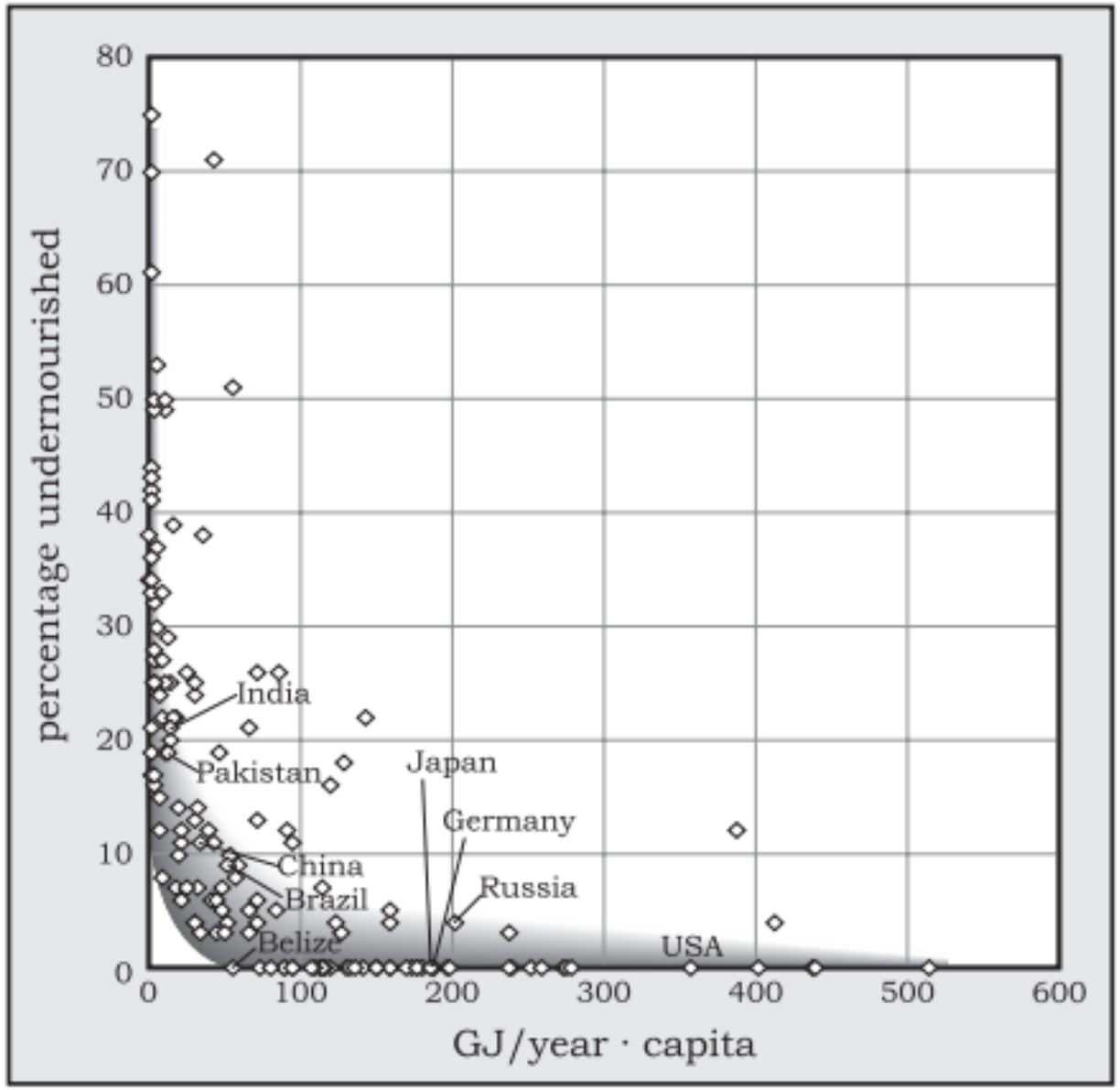

Per capita energy use and malnutrition.

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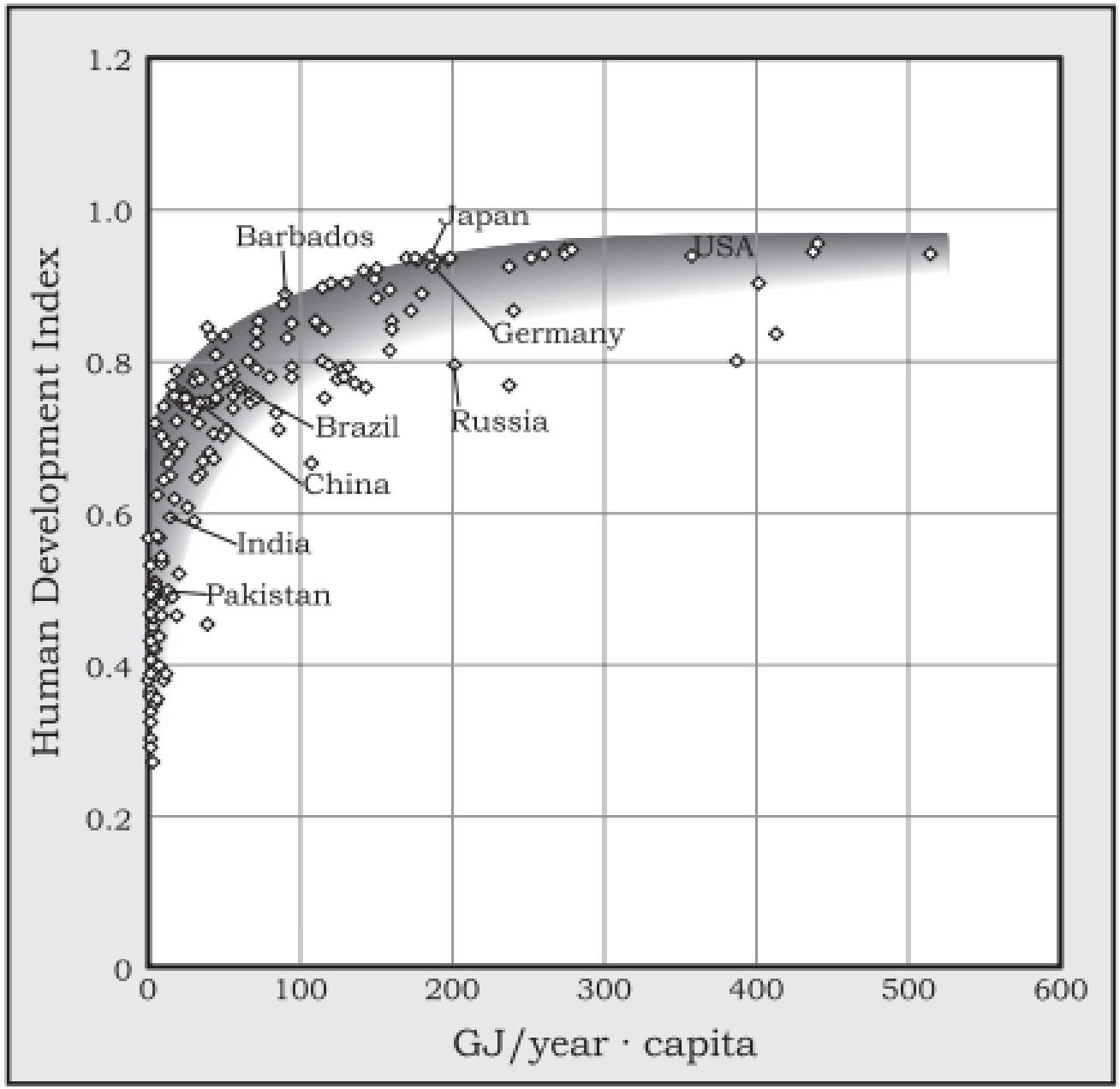

Per capita energy use and HDI.

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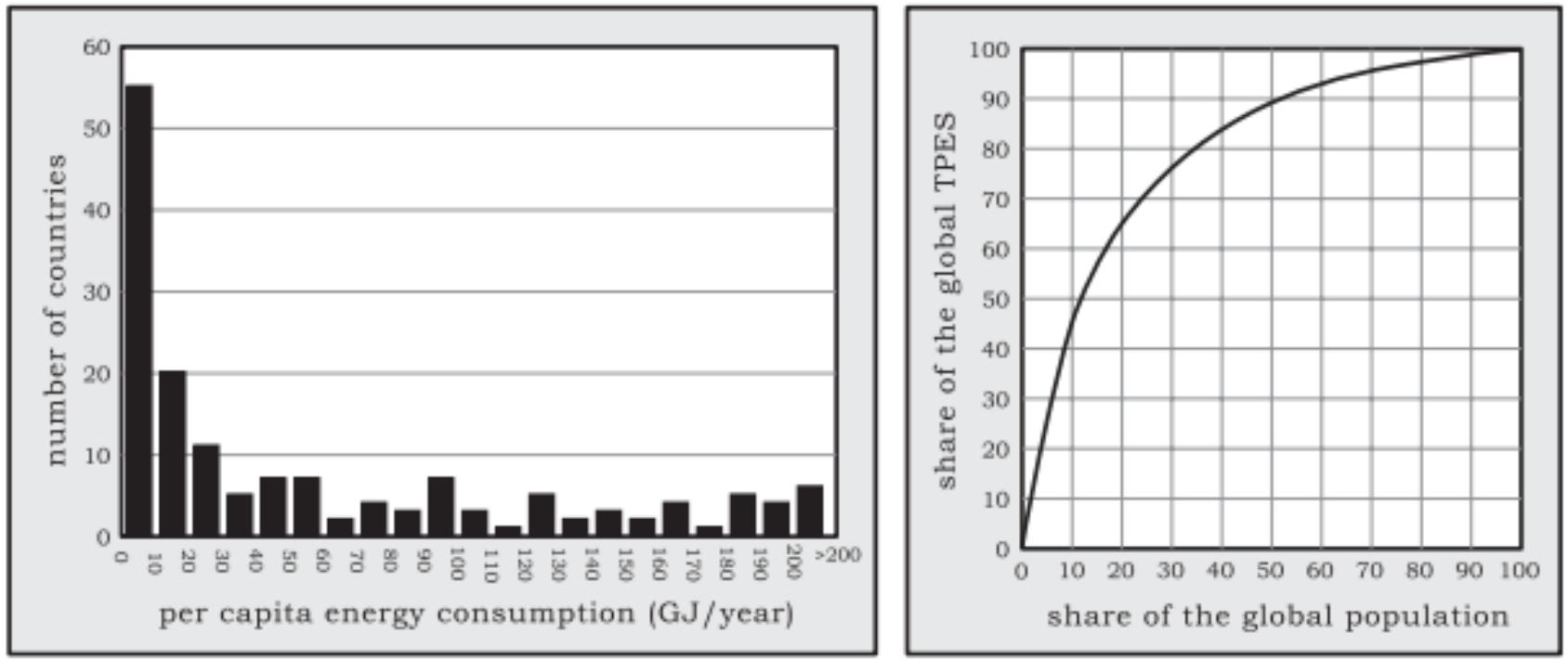
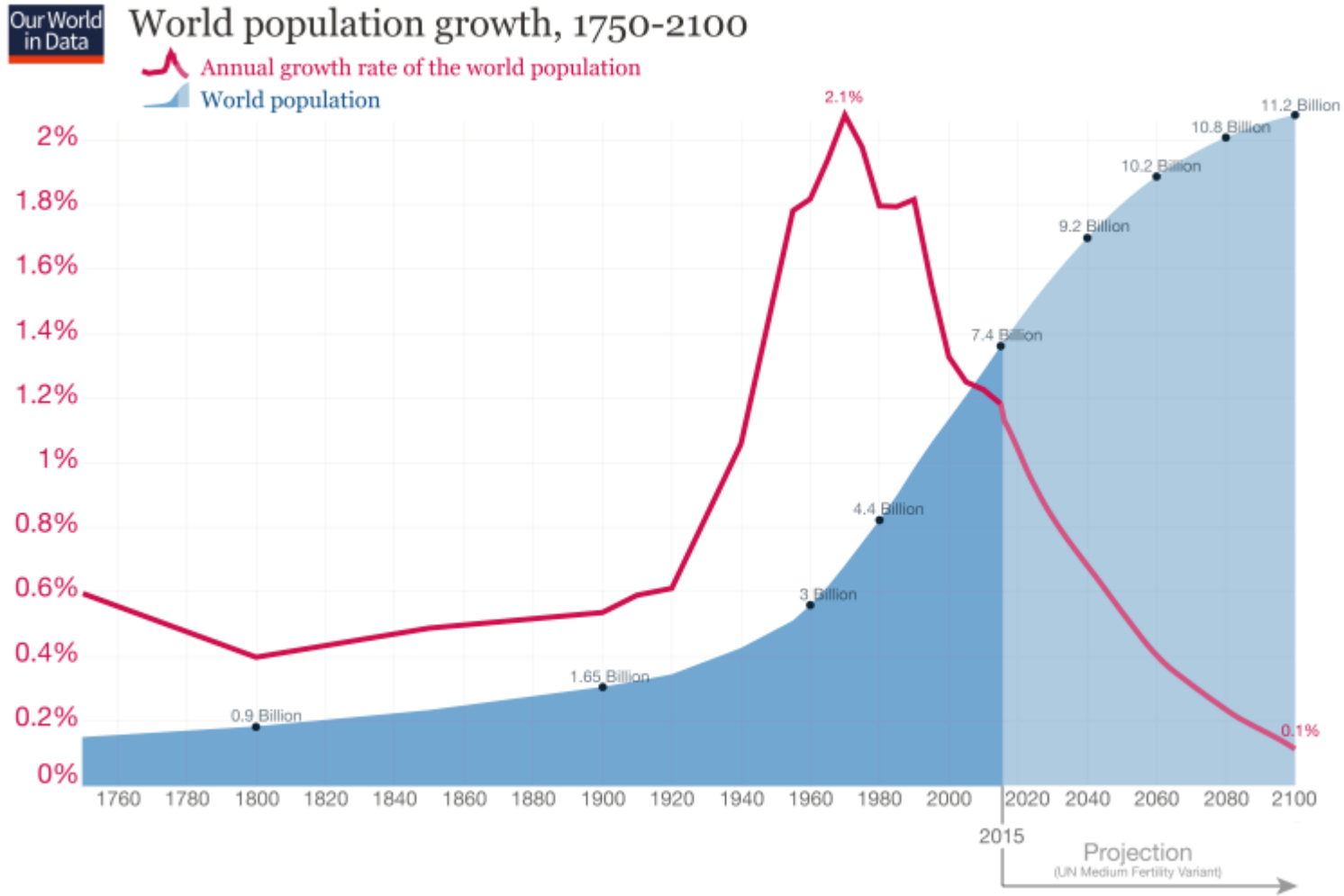


Pronounced inequities of global energy consumption.

Sources

Zabel, G.: Peak People: The Interrelationship between Population Growth and Energy Resources. Energy Bulletin.



Data sources: Up to 2015 OurWorldInData series based on UN and HYDE. Projections for 2015 to 2100: UN Population Division (2015) – Medium Variant.
The data visualization is taken from OurWorldinData.org. There you find the raw data and more visualizations on this topic.

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