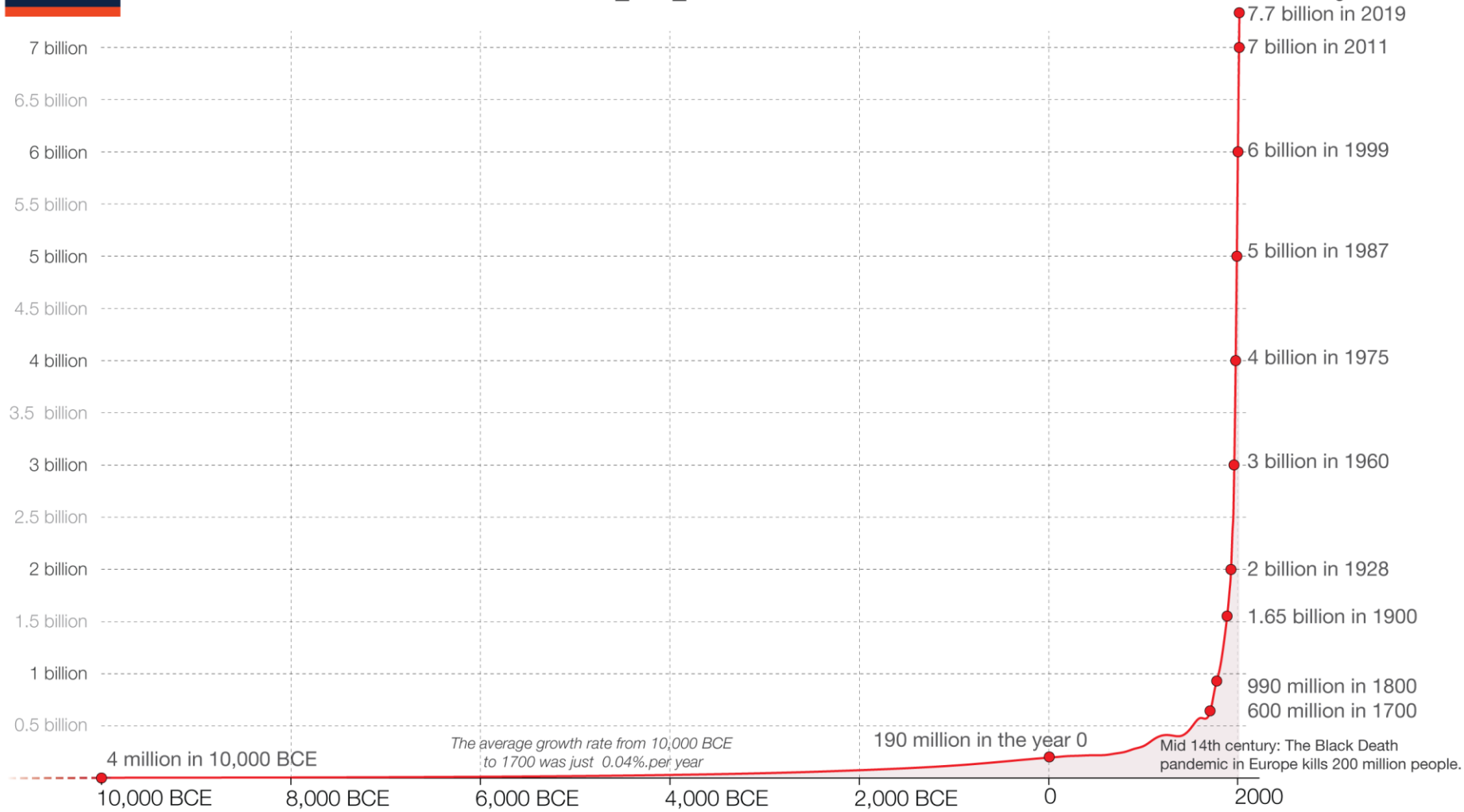


Population growth, energy, and environment

The size of the world population over the last 12,000 years

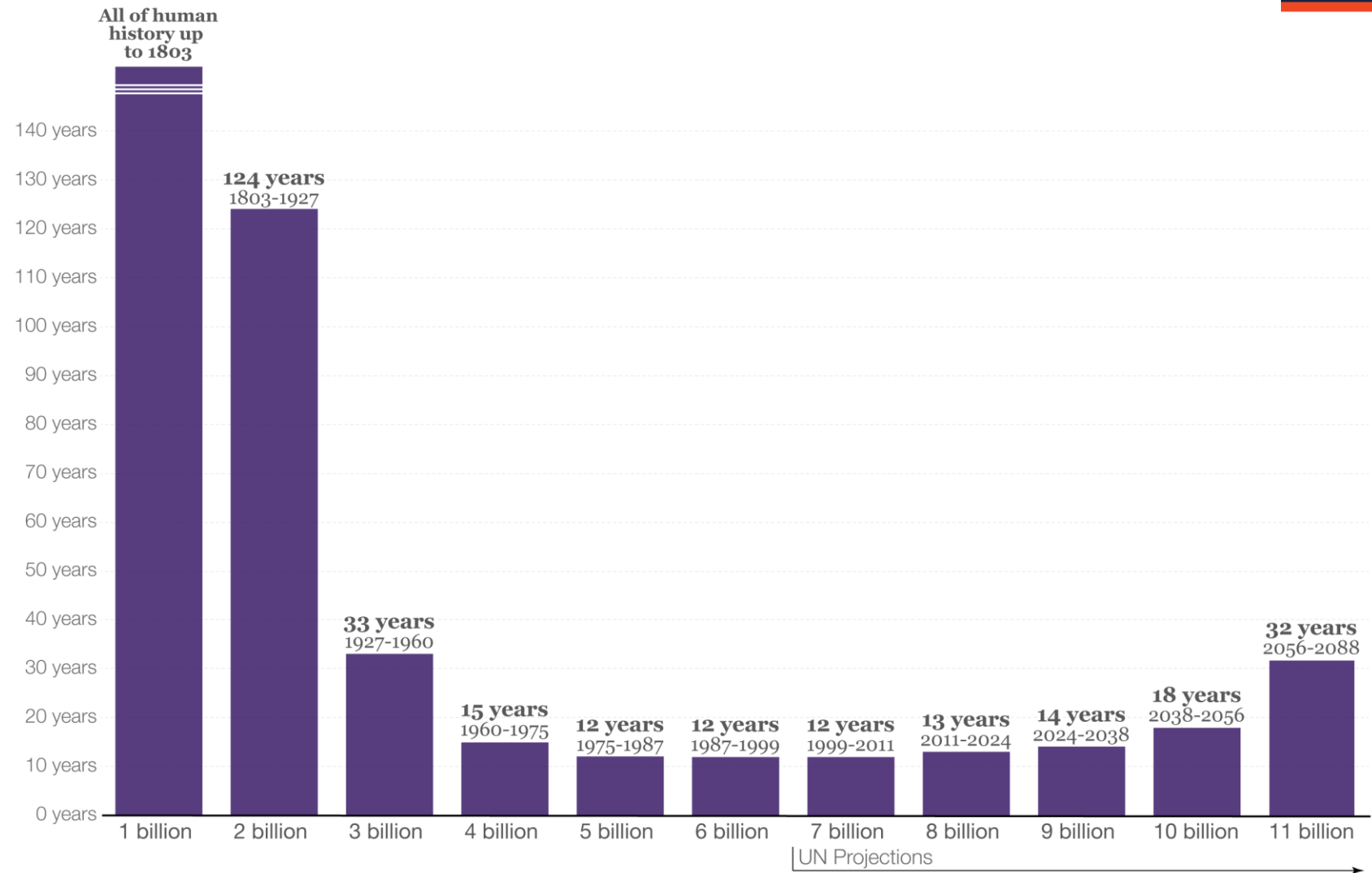


Based on estimates by the *History Database of the Global Environment* (HYDE) and the United Nations. On OurWorldinData.org you can download the annual data.

This is a visualization from OurWorldinData.org, where you find data and research on how the world is changing.

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Time it took for the world population to increase by one billion



Data source: History Database of the Global Environment (HYDE); UN World Population Prospects (2015 Revision); UN Medium Projection (2015 Revision)
This is a visualization from [OurWorldinData.org](https://www.ourworldindata.org), where you find data and research on how the world is changing.

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Malthusian trap

- Thomas Malthus (1766 – 1834), cleric, economist, scholar.
- En Essay on the Principle of Population.

„The power of population is so superior to the power of the earth to produce subsistence for man, that premature death must in some shape or other visit the human race.“

- Irish famine (1845 – 1849)

Malthusian trap

- Paul R. Ehrlich and Anne Ehrlich.
- The Population Bomb (1968); The Population Explosion (1990); Optimum Human Population Size (1994).
- "The battle to feed all of humanity is over. In the 1970s hundreds of millions of people will starve to death in spite of any crash programs embarked upon now. At this late date nothing can prevent a substantial increase in the world death rate
..."
- „We must have population control at home, hopefully through a system of incentives and penalties, but by compulsion if voluntary methods fail.“

Population growth principles

Population growth

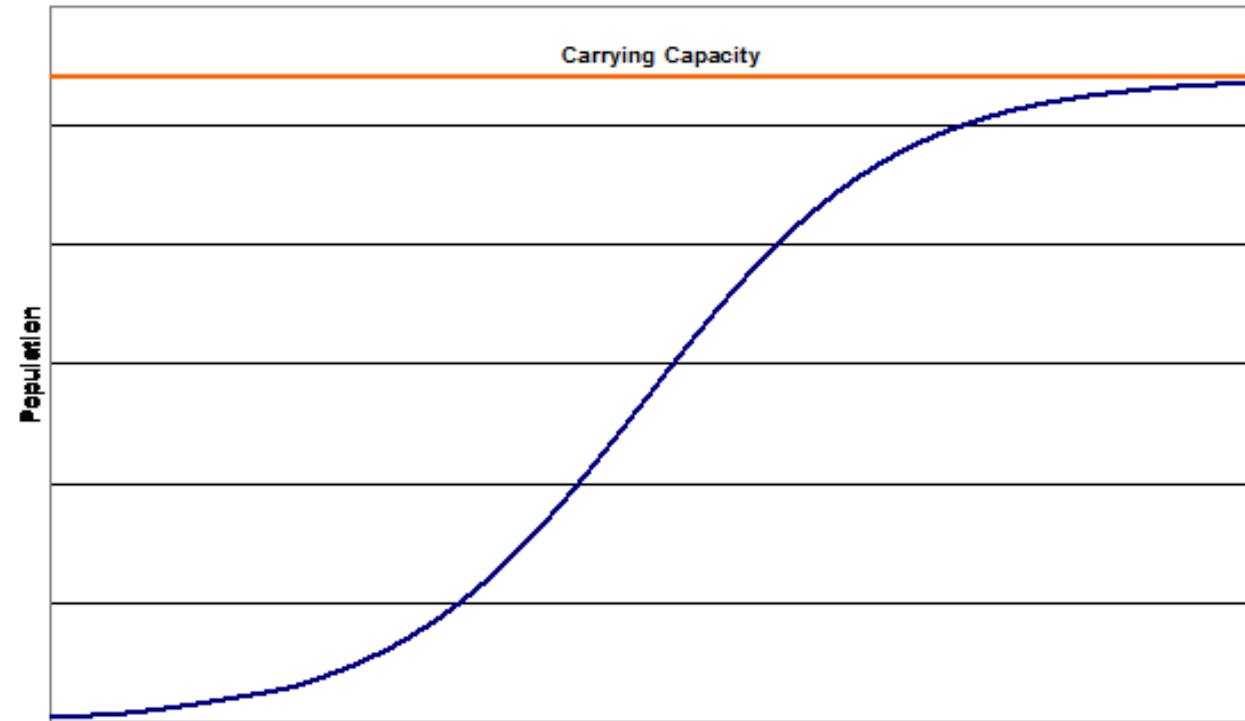
- Driven by fecundity (reproductive rate) – how many offsprings individual may have in his lifetime.
- A population doesn't grow to its full potential (indefinitely).
- Limits of population growth (limiting factors) – conditions for life and reproduction.
- Carrying capacity – number of inhabitants (also people) that ecosystem can sustain with available sources.

What factors determine carrying capacity?

- Density dependent factors
- Density independent factors

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 (famine, emigration) come into play.
- If a population is below, birth rates tend to increase, population grows.



Population and energy nexus

Hypothesizing the energy-population growth relationship

- Limits of growth are suppressed by „infinite“ amount of energy from fossil fuels (mechanisation of agriculture + medical advances + sewage systems + living in formerly uninhabitable places, etc.).

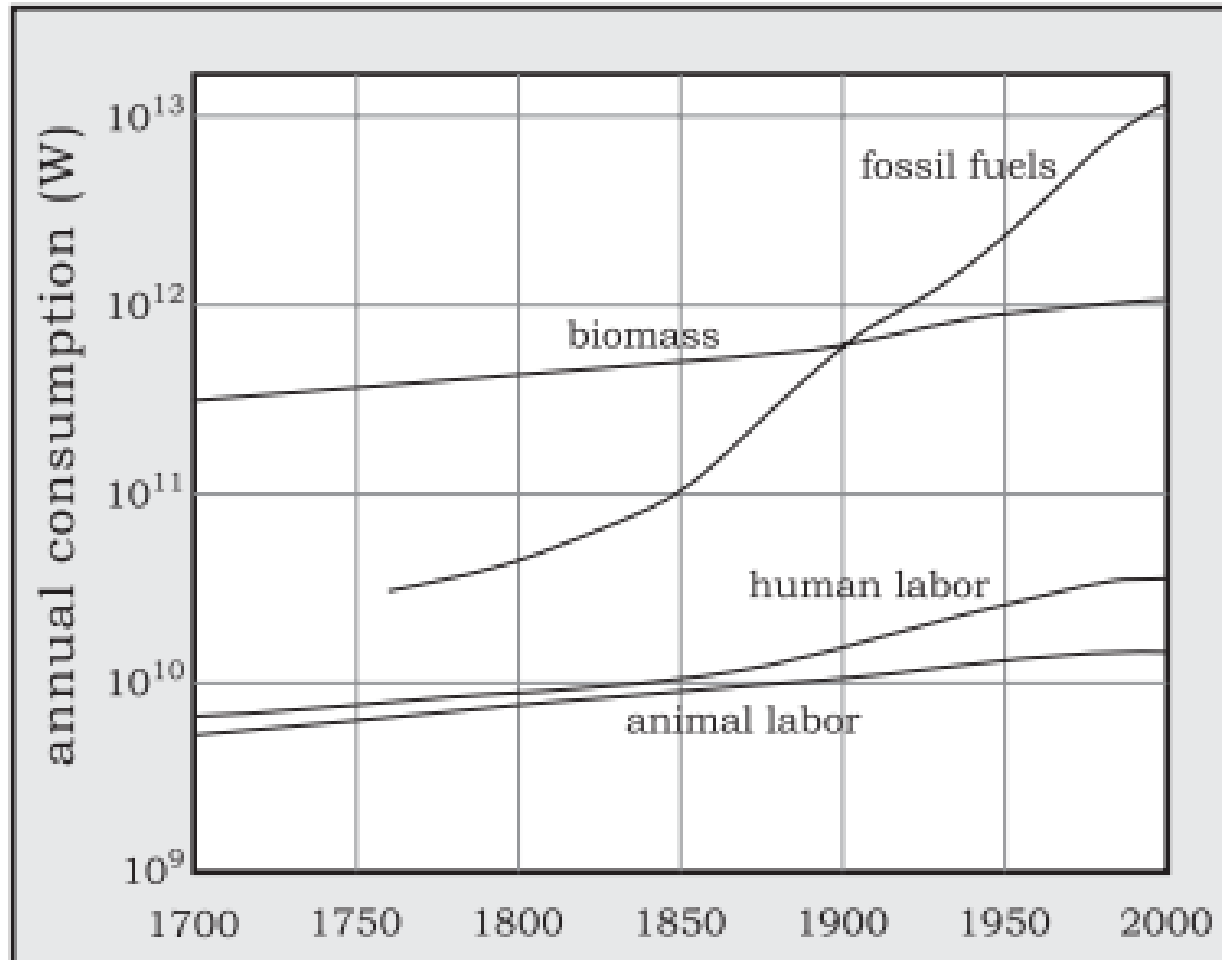
Society	Energy Sources (additive)	Energy Type	Energy Quality	Carrying Capacity
Hunter-gatherers	stone and iron tools	Traditional and Biomass	↓	↓
Agriculturalists	+ wind, water and draught animals			
Pre-industrial societies	+ wood			
Industrial societies	+ coal	Fossil Fuels		
Modern Economy	+ oil and gas			

Steady-state energy expenditure over 1-minute period

Activity (<i>n</i> = 19)	Median	Max.	Min.
Standing Jump (kJ)	41.7925	59.2362	10.3225
Arm Swing (kJ)	9.8870	25.9959	4.1720
Squat (kJ)	15.1821	24.1215	8.4139
Jumping Jack (kJ)	47.3117	80.5382	34.4308

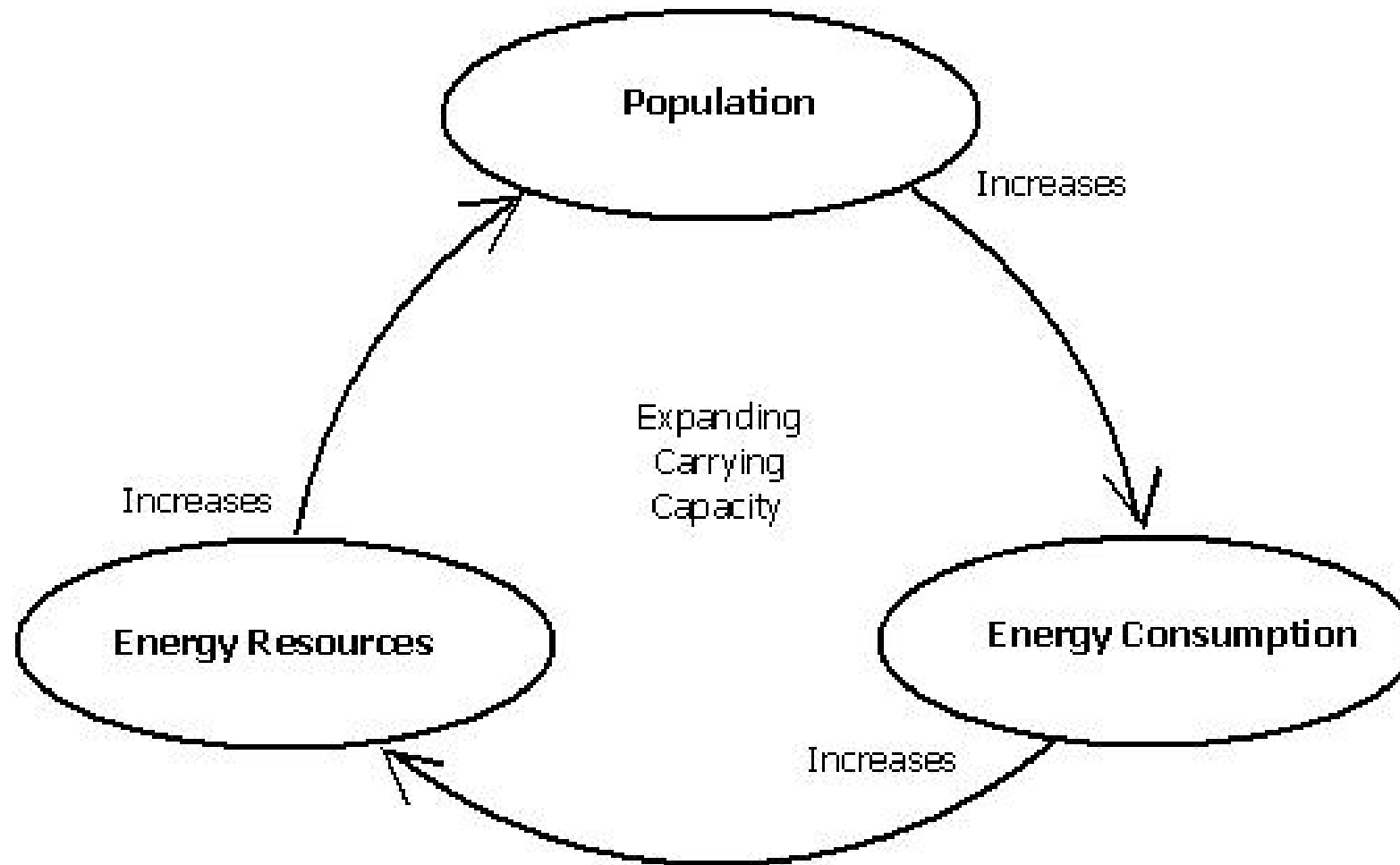
Germany per capita 2022 (statista): 139,4 GJ \approx 0,392 GJ/d \approx 0,016 GJ/h \approx 271 kJ/min

Development in energy consumption



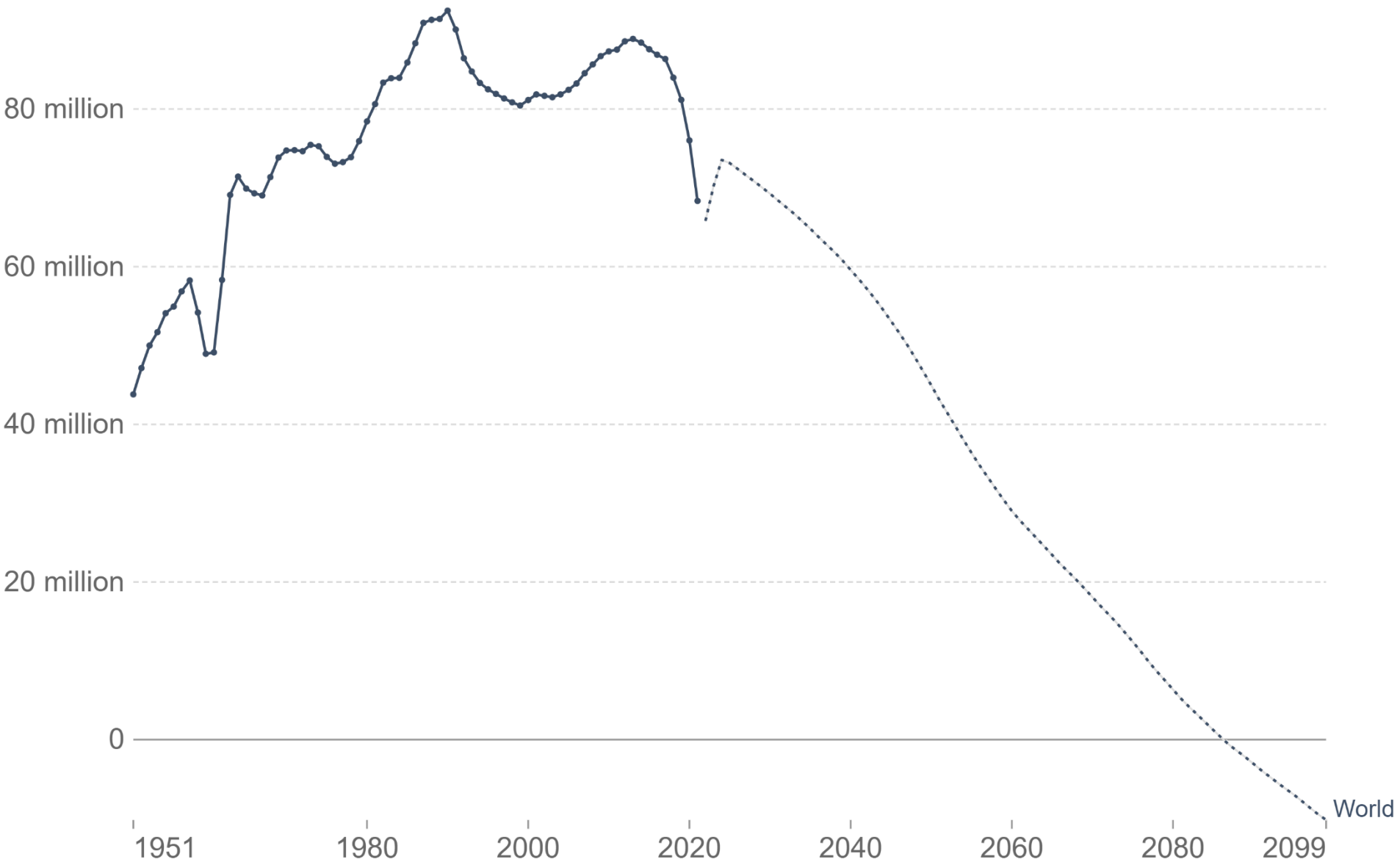
Global consumption of primary energy, 1750–2000.

Energy-population relation



Population trends

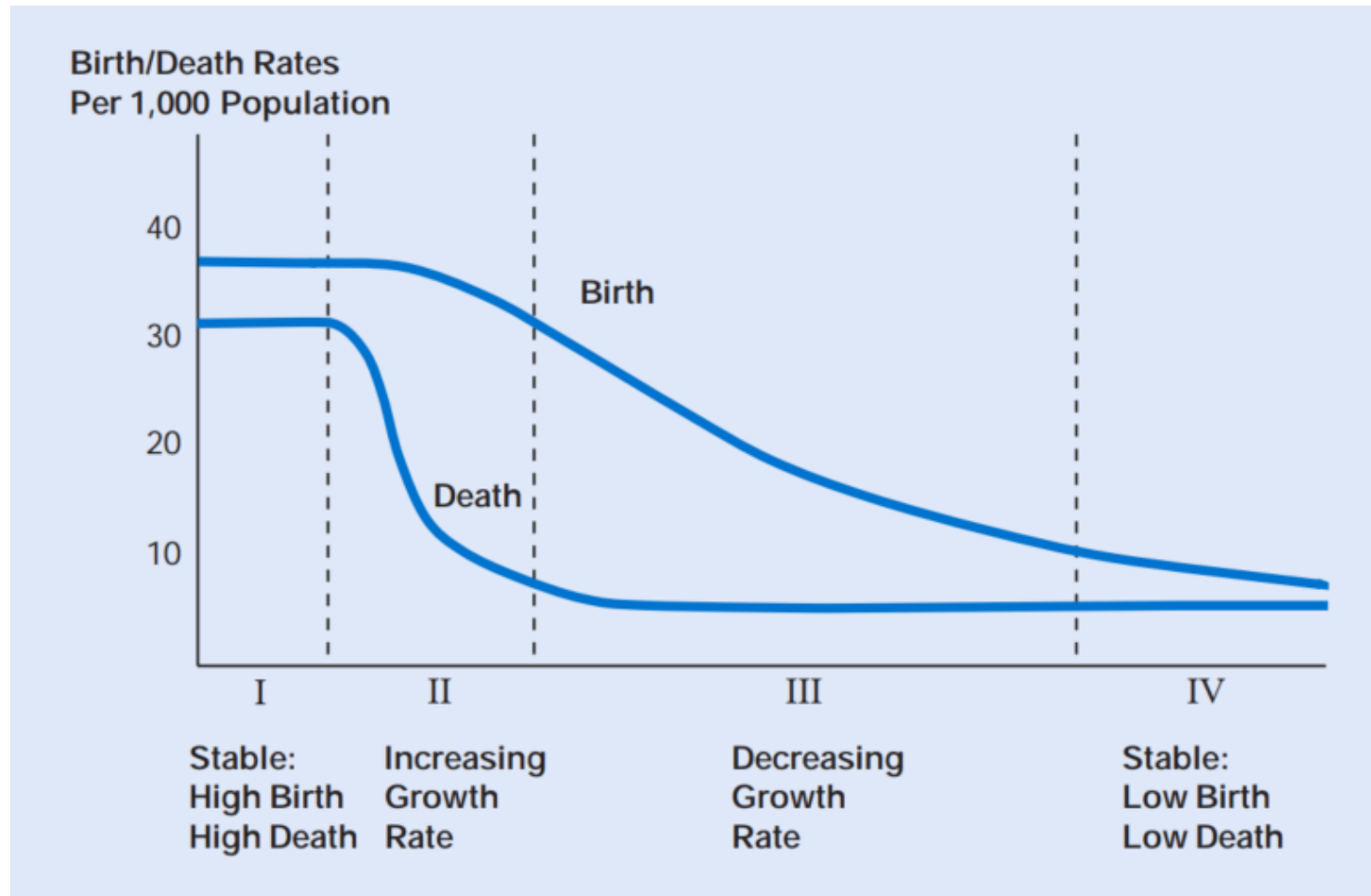
Population growth: The annual change of the population, World



Source: United Nations - Population Division (2022)



Demographic transition model

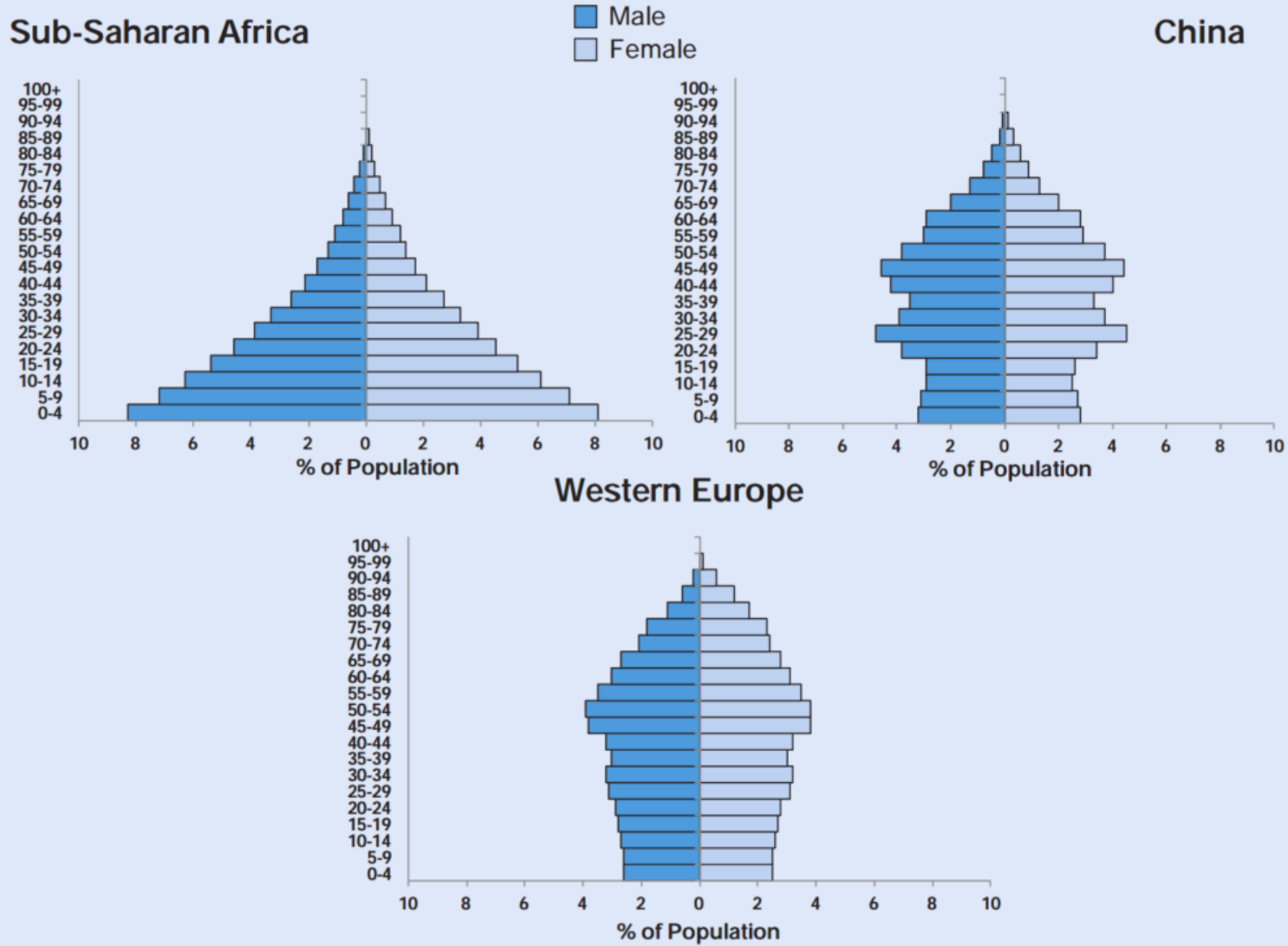


The number of people is growing but the rate of population growth actually peaked around 1962. And has been declining ever since. At its peak the human population was growing at about 2,2 % per year and these days it's declined to around 1,1 % per year and it is still falling.

Drivers of population growth

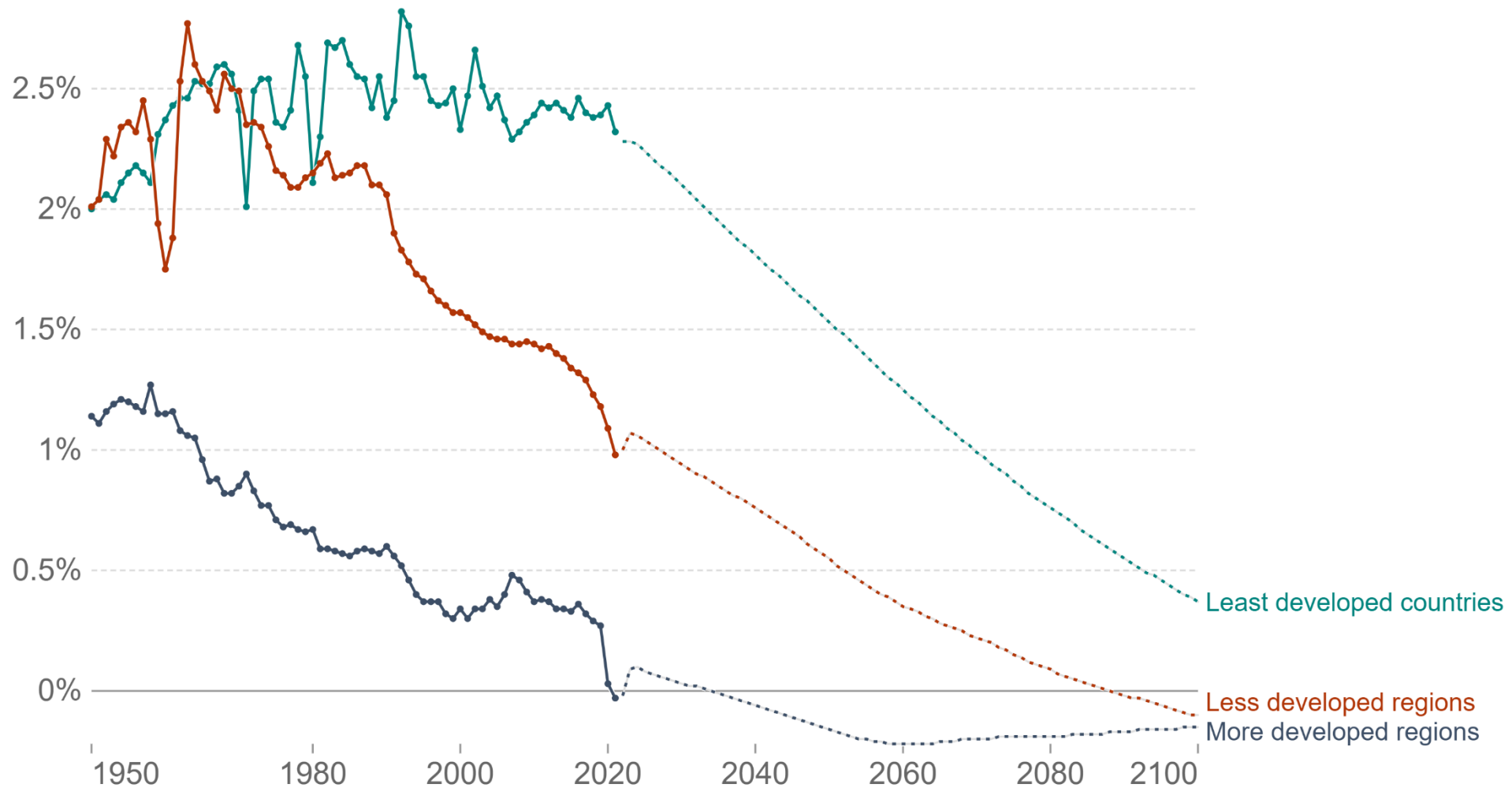
- Economic drivers
 - Agricultural economy and kids as a working force.
 - Savings – children as a pension security.
- ↓
- Shift from agricultural to an industrial economy.
 - Opportunity costs of mother's time.
 - Costs of housing due to the urbanization and industrialization (cities).
 - Costs of education.
 - Increased standards (more costs).
- Cultural and social drivers.
 - Status of women related to the number of children.
 - Religion, etc.
 - Availability of contraception

Figure 15.7 Population Age Structures for Sub-Saharan Africa, Western Europe, and China, 2015



Population growth rate by level of development

Historic population growth rates by the level of development of the region, with projections to 2099 using the UN medium scenario.



Source: United Nations - Population Division (2022)

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

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.

Population growth and economic development

Economy of population growth

- As long as marginal output of person is positive, additional people equals additional output.
- If marginal output is smaller than average output, economic growth still present, but growth per capita decreases.
- Economic output = capital stock x labor force x technology x natural resources.
(But law of diminishing returns).

Some negative effects of (rapidly) growing population

- Increased dependency ratio (people not working/total population):
 - Capital invested in children cannot be invested - > capital accumulation and economic growth slowed down. Female availability.
- Increase income inequality:
 - rapidly growing population => excess supply of labor, bringing the wage rates down.
 - Income inequality can create social tensions => radicalization of young societies.
 - More than half of projected (UN) increase in global population up to 2050 in just 9 countries – DRC, Egypt, Ethiopia, India, Indonesia, Nigeria, Pakistan, Tanzania, USA.
- Natural resource limitation.

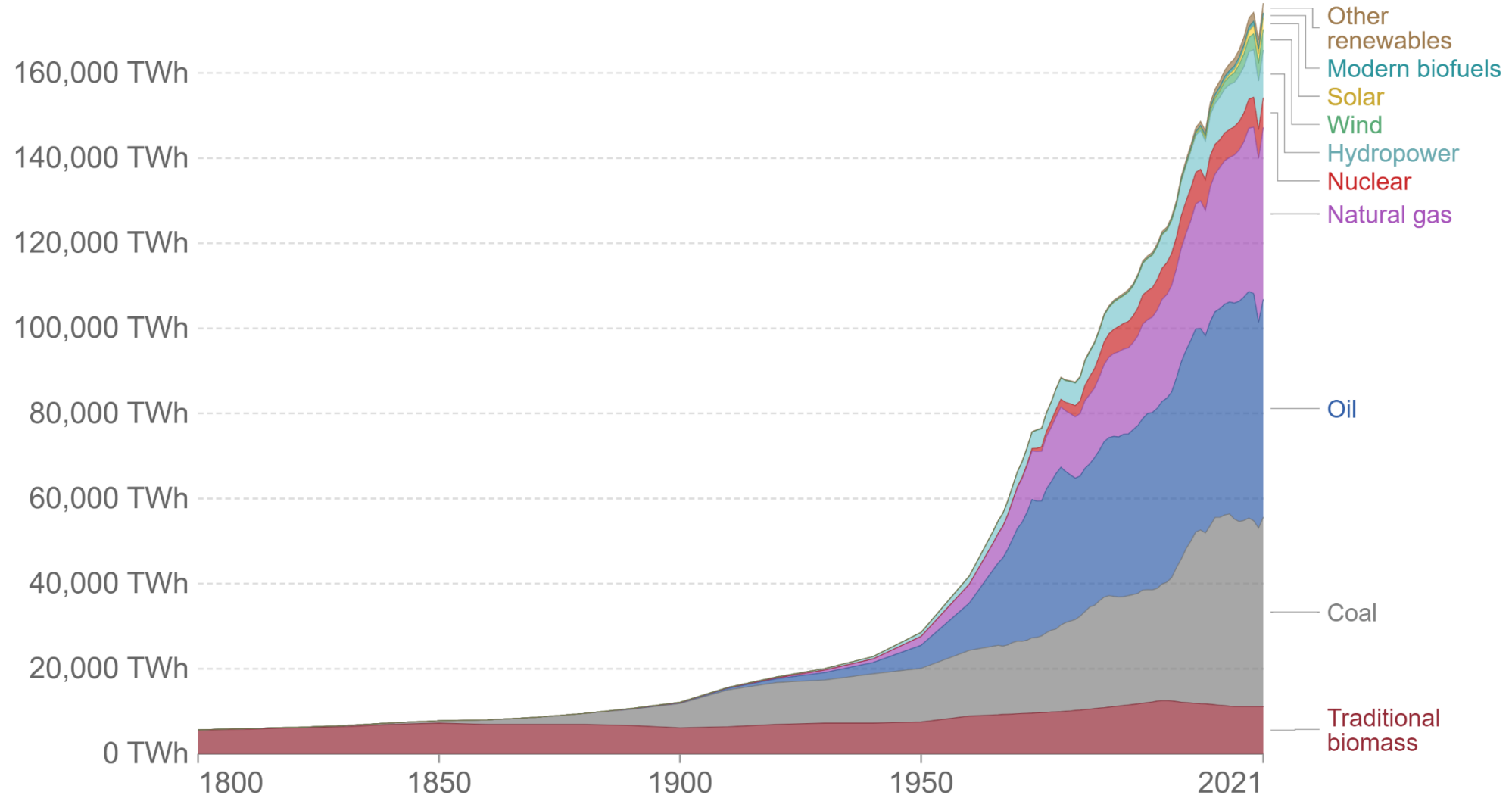
Population – environment nexus

Environmental aspects of population growth

- Population growth as a major source of environmental degradation – demand on both deplatable and renewable resources.
 - Land as a central factor in agriculture – ‘induced innovation hypothesis’ vs. ‘downward spiral hypothesis’.
- => Technology as a solution or cause of the problem?

Global primary energy consumption by source

Primary energy is calculated based on the 'substitution method' which takes account of the inefficiencies in fossil fuel production by converting non-fossil energy into the energy inputs required if they had the same conversion losses as fossil fuels.



Cornucopians vs. doomsters

Cornucopians/boomsters – sustainability is nothing to worry about.

- Julian Simon (1932 – 1998) – The Ultimate Resource (1981).
- Ehrlich – Simon wager - 1980 over the price of 5 selected metals a decade later.

Doomsters – unbreachable environmental limits.

The Voluntary Human Extinction Movement.

Sources

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

Nathan, D. et.al. (2015): Estimating Physical Activity Energy Expenditure with the Kinect Sensor in an Exergaming Environment.