

1.4 Examples

1.4.1 Environment

1. Air Pollution

(a) WHO

- Estimates 7 million people die from cancer every year, which is 70% as that of all cancers combined.
- Other organizations estimate the death toll to be even higher
- 95% of the world's population is exposed to mean annual levels of air pollution that exceed WHO guidelines.
- In 2016, 58% of outdoor air pollution related premature deaths were caused by fine particulate matter resulting in stroke or heart disease

(b) Our World in Data

- Fortunately, indoor air pollution,² declined rapidly from 100 000 deaths per year in 1990 to 30 000 per annum in 2019
- Unfortunately, in the same period, the death rate from outdoor air pollution has largely remained the same.

(c) (Article from) Nature Communications

- Even in low concentrations, small particulate pollution has been shown to
 - Take years off people's lives
 - Huge negative impact on QoL while living (e.g.: Lung cancer and diseases)
 - Described as "the world's leading environmental health risk factor"

(d) Results from course and fine particulate matter in the air we breathe:

- Course particulate matter – Largely formed from natural processes: Dust from deserts, and seafoam. Though also caused by some man-made processes: Dust kicked up from roads

Can get deep inside your lungs and cause problems

- Fine particulate matter (Even more deadlier, the real killer) – Mostly from burning of fossil fuels to boost the economy (E.g. Coal)

(e) Burning of fossil fuels

- (Article published on Nature) Responsible for between 30-40% of the direct disease burden of outdoor air pollution
- Estimated 3.6 million deaths a year can be prevented by the direct and indirect phaseout of fossil fuels

(f) Ironically helping us fight climate change

- Reflect sunlight away; (more spectrally, infrared thermal radiation) which would otherwise reach the Earth
- IPCC estimates reflective sulfates cool the planet by around 0.8°C

2. Renewable Energy

(a) Solar Panels: (Our World In Data)

- 10 years ago: much cheaper to build a new power plant that burns fossil fuels than to build a new solar photovoltaic (PV) or wind plant.
- Wind was 22%, and solar 223% more expensive than coal.
- Decreased drastically from \$106.09/W in 1976 to \$0.38/W in 2019

- Dropped by a whopping 80% from 2009 to 2019
- Now, renewables are actually cheaper than fossil fuels per unit energy

(b) Energy Storage

- Price of batteries declined by 97% in the last three decades.
- Prices of lithium-ion batteries (the most pervasive type of batteries) declined by a factor of 40, while capacity increased by a factor of 50 000.

Prices declined at an average of 18.9% for every doubling in cumulative capacity

3. Nuclear Energy

(a) NE saved 1.8 mil lives from air pollution related deaths

(b) Extremely low death toll

- 31 people died, with no increased cancer rates generally in any considerable scale, in the Chernobyl accident (OECD Nuclear Energy Agency)

- Poor and unsafe RBMK reactor design
- Improper, unstable operation of the reactor

- 0 people died directly as a result of a Fukushima accident, but 573 died during evacuation (United States Nuclear Regulatory Commission)

(c) Nuclear Waste Disposal is done Responsibly (U.S. Nuclear Regulatory Commission)

- Stored in spent fuel pools and dry casks.

- Both provide good protection for safety of the public and the environment ⇒ Can even survive unharmed from a head on impact from a train collision

- Transportation of N.W. in the U.S. ⇒ No waste released / harm caused to ppl or environment in past 40 yrs

(d) Other forms of energy can be surprisingly cause a higher death toll

- Dam accidents:

- Malpasset Dam collapse killed 423

- Vaïont / Vajont dam killed 2000

- Vale dam killed 270

- According to Harvard University, nuclear energy has the least impact on human life amongst coal, natural gas, wind, and nuclear energy

(e) Actual Problems with Nuclear Energy Use:

- Lack of public awareness on actual safety of nuclear energy

- Expensive and Multi-billion dollar cost ⇒ Not suitable for all countries

- Risks of nuclear weapons construction through nuclear energy generation

E.g.: Iran tried on a number of occasions to create nuclear weapons hidden behind the veil of nuclear energy. Used this as a bargaining chip.

(f) Biofuels

i. Advantages (Theoretically)

- Produced from renewable food sources
- Fossil fuels are non-renewable while CO2 emitted is reabsorbed by the plants ⇒ Renewable and sustainable

ii. Disadvantages

- Highly Energy Intensive Production Process

In the U.S. (World's largest producer of bioethanol), biofuels took up 28.9 times more energy than the whole of Singapore in 2020

- Takes up a ghormous land area (Unsustainable Land Use)

²Like from burning coal and wood for warmth

- Provides 2.25% of total energy generation
 - But uses a stupendous 18.5% of land in the U.S.
 - Land has a wide assortment of essential uses
 - E.g.: Direct human consumption, animal food
 - Impact: Significantly increased food prices
- NCEE Study – 4.5 bil litre increase in bioeth causes a 2-3% increase in food price
- Impact: Encourage destruction of natural habitats
 - 4050 km² of croplands expanded per year.
 - Financially unsustainable
 - Bioethanol with corn grain requires 29% more fossil fuel energy input than energy content of bioethanol produced, i.e. net negative in energy.
 - Energy Policy Act of 2005 and Energy Independence and Security Act are necessary financial incentives for biofuel production to be viable
 - Unsustainable Water Usage
 - Biofuels use 70-400x more water than other primary energy sources (excluding hydro)
 - increased competition for water
4. Climate Change
- (a) NOAA (National Oceanic and Atmospheric Administration)
- June 2022 was Earth's 6th-warmest on record
 - Antarctic sea ice shrank to a record low for the month in June 2022
 - Polar ice coverage hit near-record low globally; June 2022 saw the second-lowest June sea ice coverage (extent) on record. Only June 2019 had a smaller sea ice extent.
- (b) N.A.S.A. (National Aeronautics and Space Administration)
- While Earth's climate has changed throughout its history, the current warming is happening at a rate not seen in the past 10,000 years.
 - Current warming is occurring roughly 10 times faster than the average rate of warming after an ice age. Carbon dioxide from human activities is increasing about 250 times faster than it did from natural sources after the last Ice Age.
 - The planet's average surface temperature has risen about 1.1°C since the late 19th century
 - Most of the warming occurred in the past 40 years, with the seven most recent years being the warmest.
 - Ocean absorbed 90% of excess thermal energy ⇒ Thermal Expansion of sea water
 - Shrinking Ice Sheets – Data from NASA's Gravity Recovery and Climate Experiment show Greenland lost an average of 279 billion tons of ice per year between 1993 and 2019, while Antarctica lost about 148 billion tons of ice per year
 - Retreating Glaciers – Almost everywhere around the world — including in the Alps, Himalayas, et cetera
 - Snow Cover Is Decreasing – Satellite observations reveal that the amount of spring snow cover in the Northern Hemisphere has decreased over the past five decades and the snow is melting earlier.
 - Global sea level rose about 20 centimeters in the last century. The rate in the last two decades, however, is nearly double that of the last century and accelerating slightly every year.
- Threatens Singapore, with our status as a low-lying island nation

- Extreme Events Are Increasing in Frequency – The number of record high temperature events in the United States has been increasing, while the number of record low temperature events has been decreasing, since 1950.
 - E.g.: The state of Texas suffered a major power crisis as a result of three severe winter storms
- (c) IPCC
- Scientific evidence for warming of the climate system is unequivocal. - Intergovernmental Panel on Climate Change
- (d) BBC
- The U.K. reached a new record temperature of over 40 degrees celsius in July 2022
 - On the same day, hundreds of firefighters have been tackling fires throughout the U.K. And the London Fire Brigade declared a major incident
 - E.g.: Fire swept through east London in the village of Wellington, destroying many homes (possibly started from a compost heap)
5. Increasing Ocean Acidification
- Since the beginning of the Industrial Revolution, the acidity of surface ocean waters has increased by about 30%.
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 - The ocean has absorbed between 20% and 30% of total anthropogenic carbon dioxide emissions in recent decades (7.2 to 10.8 billion metric tons per year).