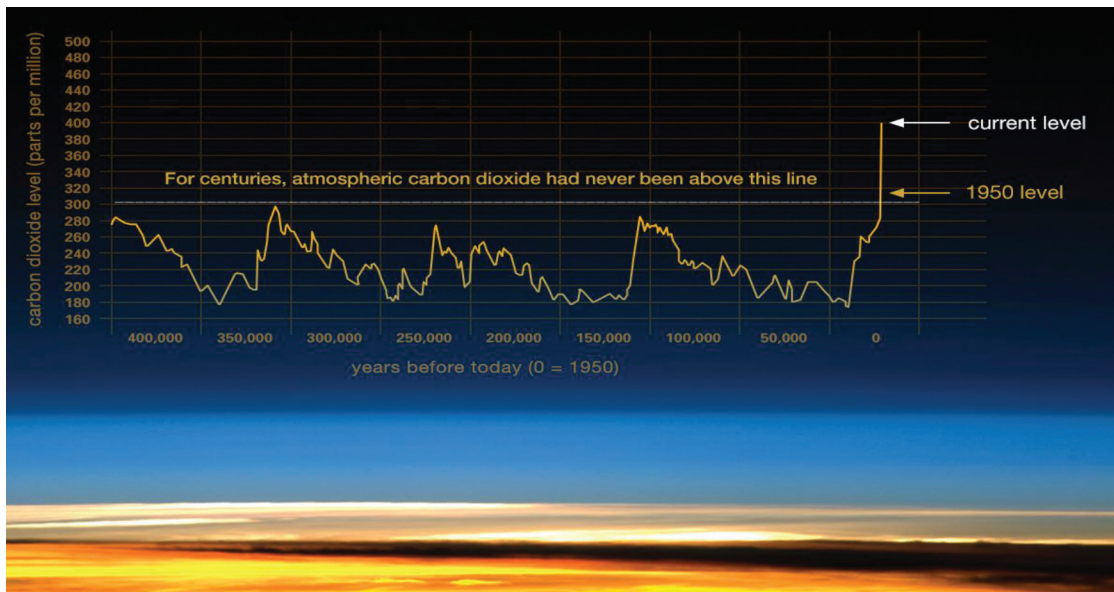


# Future Earth (Global Climate Change)

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The Earth's climate has changed throughout history. Just in the last 650,000 years there have been seven cycles of glacial advance and retreat, with the abrupt end of the last ice age about 7,000 years ago marking the beginning of the modern climate era — and of human civilization. Most of these climate changes are attributed to very small variations in Earth's orbit that change the amount of solar energy our planet receives. The current warming trend is of particular significance because most of it is extremely likely (greater than 95 percent probability) to be the result of human activity since the mid-20<sup>th</sup> century and proceeding at a rate that is unprecedented over decades to millennia. One most significant cause for this warming is the emission of carbon dioxide into the environment. The heat-trapping nature of carbon dioxide and other gases was demonstrated in the mid-19th century. Their ability to affect the transfer of infrared energy through the atmosphere is the scientific basis of many instruments. There is no question that increased levels of greenhouse gases must cause the Earth to warm in response.

## The evidence for rapid climate changes

**Global temperature rise:** The planet's average surface temperature has risen about 1.62 degrees Fahrenheit (0.9 degrees Celsius) since the late 19th century, a change driven largely by increased carbon dioxide and other human-made emissions into the atmosphere.

**Warming oceans:** The oceans have absorbed much of this increased heat, with the top 700 meters (about 2,300 feet) of ocean showing warming of more than 0.4 degrees Fahrenheit since 1969.

**Shrinking ice sheets:** The Greenland and Antarctic ice sheets have decreased in mass. Data from NASA's Gravity

Recovery and Climate Experiment show Greenland lost an average of 281 billion tons of ice per year between 1993 and 2016, while Antarctica lost about 119 billion tons during the same time period. The rate of Antarctica ice mass loss has tripled in the last decade.

**Decreasing snow cover:** Satellite observations have revealed that the amount of spring snow cover in the Northern Hemisphere has decreased over the past five decades and that the snow is melting earlier.

**Sea level rise:** Global sea level rose about 8 inches in the last century. The rate in the last two decades, however, is nearly double that of the last century and is accelerating slightly every year.

**Ocean acidification:** Since the beginning of the Industrial Revolution, the acidity of surface ocean waters has increased by about 30 percent. This increase is the result of humans emitting more carbon dioxide into the atmosphere and hence more being absorbed into the oceans. The amount of carbon dioxide absorbed by the upper layer of the oceans is increasing by about 2 billion tons per year.

## Global Carbon budget 2018

Atmospheric CO<sub>2</sub> concentration is set to reach 407 ppm on average in 2018, 45 percent above pre-industrial levels.

Chinese emissions, accounting for 27 percent of global emissions, look set to grow about 4.7 percent (2.0 percent to 7.4 percent) in 2018, reaching a new all-time high. U.S. emissions, accounting for 15 percent of global emissions, look set to grow about 2.5 percent (+0.5 percent to +4.5 percent) in 2018. It is expected that U.S. emissions will decline again in 2019, indicating that cheap gas, wind, and solar will continue to displace coal. Indian emissions,

accounting for 7 percent of global emissions, look set to continue their strong growth with about 6.3 percent (4.3 percent to 8.3 percent) in 2018, with growth across all fuels (coal +7.1 percent, oil +2.9 percent, gas +6.0 percent). EU emissions, accounting for 10 percent of global emissions, look set for a small decline of -0.7 percent (-2.6 percent to 1.3 percent) in 2018, well below the declines of -2 percent per year sustained in the decade up to 2014. Emissions in the rest of the world, the remaining 42 percent of global emissions, are expected to grow 1.8 percent (0.5 percent to 3.0 percent) in 2018.

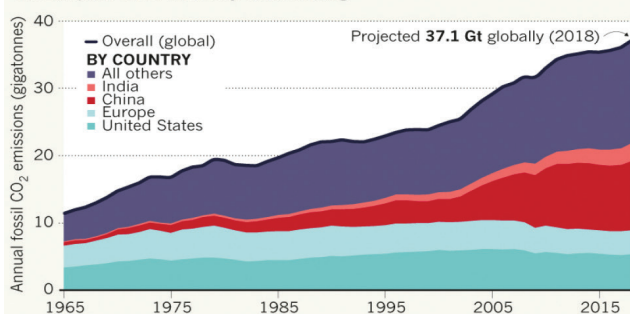
The 10 biggest emitters were China, the U.S., India, Russia, Japan, Germany, Iran, Saudi Arabia, South Korea, and Canada, with EU28 as a whole ranking third. There was also some good news: In 19 countries representing 20 percent of global emissions, emissions decreased without decrease in Gross Domestic Product (GDP) in the last decade. These were: Aruba, Barbados, Czech Republic, Denmark, France, Greenland, Iceland, Ireland, Malta, Netherlands, Romania, Slovakia, Slovenia, Sweden, Switzerland, Trinidad and Tobago, United Kingdom, USA, and Uzbekistan.

## RISING PRESSURES

Carbon dioxide emissions are growing again after pausing for a few years. Renewable sources of power are just beginning to replace fossil fuels, as their costs become competitive.

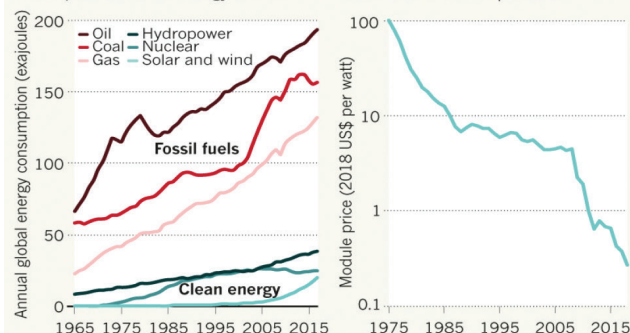
### EMISSIONS ARE STILL INCREASING

China and India still rely heavily on coal; the United States and the European Union are slowly decarbonizing.



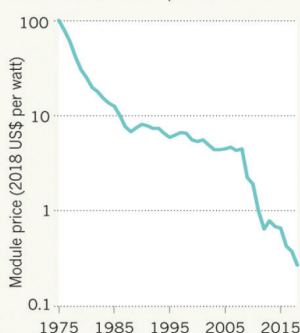
### RENEWABLES ARE PICKING UP

Half of all new energy-generation capacity is renewable. Switching to electric cars would prioritize clean energy over oil.



### SOLAR ENERGY IS AFFORDABLE

Costs have dropped by 80% over the past decade as solar installations have expanded.



## Key technologies are on track

The world is quickly and irrevocably moving towards a clean, cheap and reliable energy system. Over the past decade, the costs of generating solar energy have plummeted by 80%. Morocco, Mexico, Chile and Egypt are producing solar power for 3 US cents or less per kilowatt hour — cheaper than natural gas.

Installations are growing. Today, more than 50% of new capacity for generating electricity is renewable, with wind and solar doubling every 4 years. In developing countries, renewable now account for the majority of all new power generation, a remarkable turnaround from just a decade ago. If these trends continue, renewable will produce half of the world's electricity by 2030.

However, the electricity grid will not be completely transformed until renewables are able to deliver continuous power. Large batteries that can store and smooth out energy supplies are becoming economical faster than expected. For example, a year ago, the state of South Australia paired a Tesla battery facility with a local wind farm. By storing power for when demand is highest, the system has already repaid nearly one-third of its upfront capital costs of Aus\$90.6 million (US\$65.8 million). The costs of battery storage are expected to halve by 2030.

Abating air pollution is another powerful driver of change. Globally, air pollution contributes to seven million premature deaths every year — from cardiovascular disease, ischaemic heart disease, stroke, chronic obstructive pulmonary disease and lung cancer. People are becoming less tolerant of particulate and noxious-gas emissions from coal plants, factories and cars. China has closed coal-fired power plants in and near cities and has limited diesel-engine emissions. Pollution levels in Beijing have fallen by 35% over 5 years, but still have a long way to go. India has nine of the world's ten most polluted cities, according to the World Health Organization. The country's target is to reduce air pollution in 100 cities by 20–30% by 2024. Heavy industry is also evolving. The Energy Transitions Commission announced last month that chemicals, steel and cement can reach net zero emissions by mid-century at a cost of less than 0.5% of global gross domestic product (GDP), with a marginal impact on living standards.