Sustainable Energy Systems

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Chapter 1: Introduction

What is Energy?

- **Energy is the capacity to do work or produce change.**
- **Forms of energy include heat, light, motion, and electricity.**
- **Energy is essential for powering homes, industries, and transportation.**

Conventional sources of energy

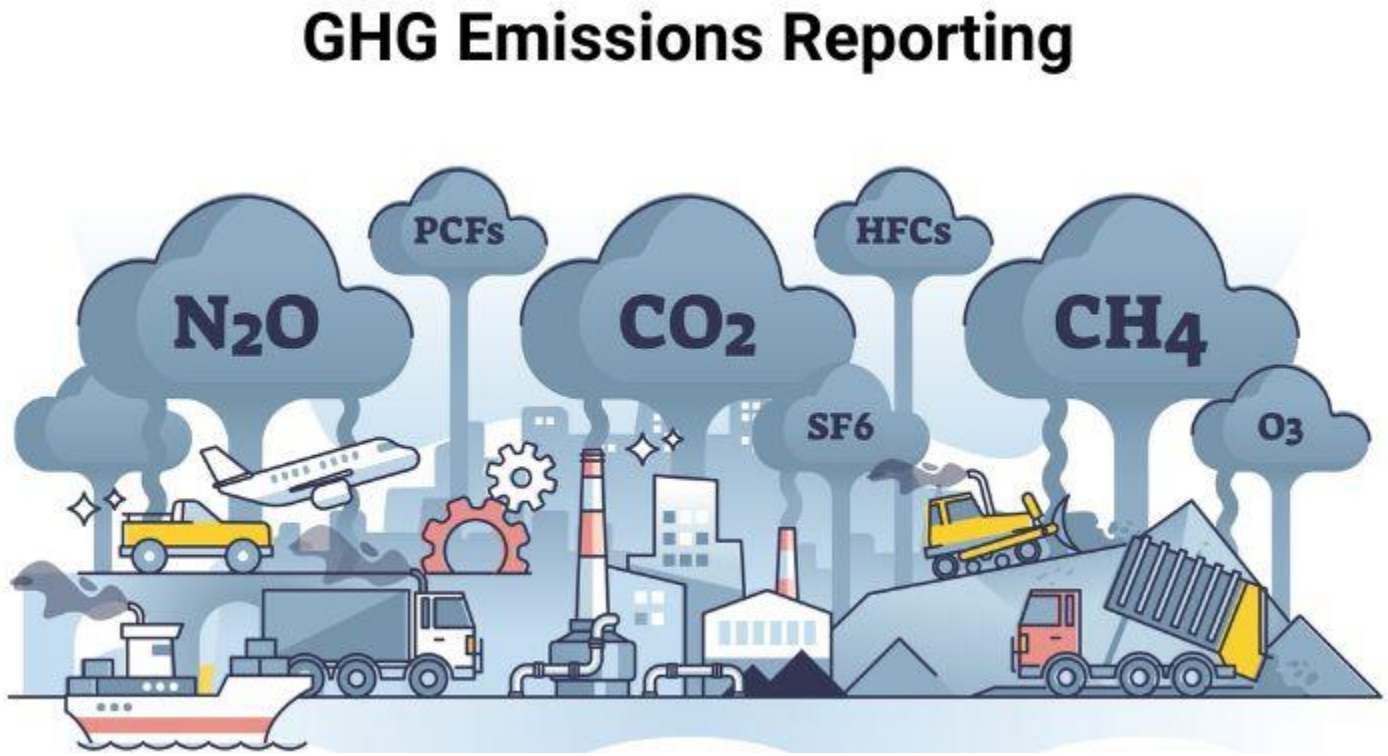
- **Conventional sources of energy are the ones that are commonly used, and generally non-renewable sources of energy, which are being used since a long time.**

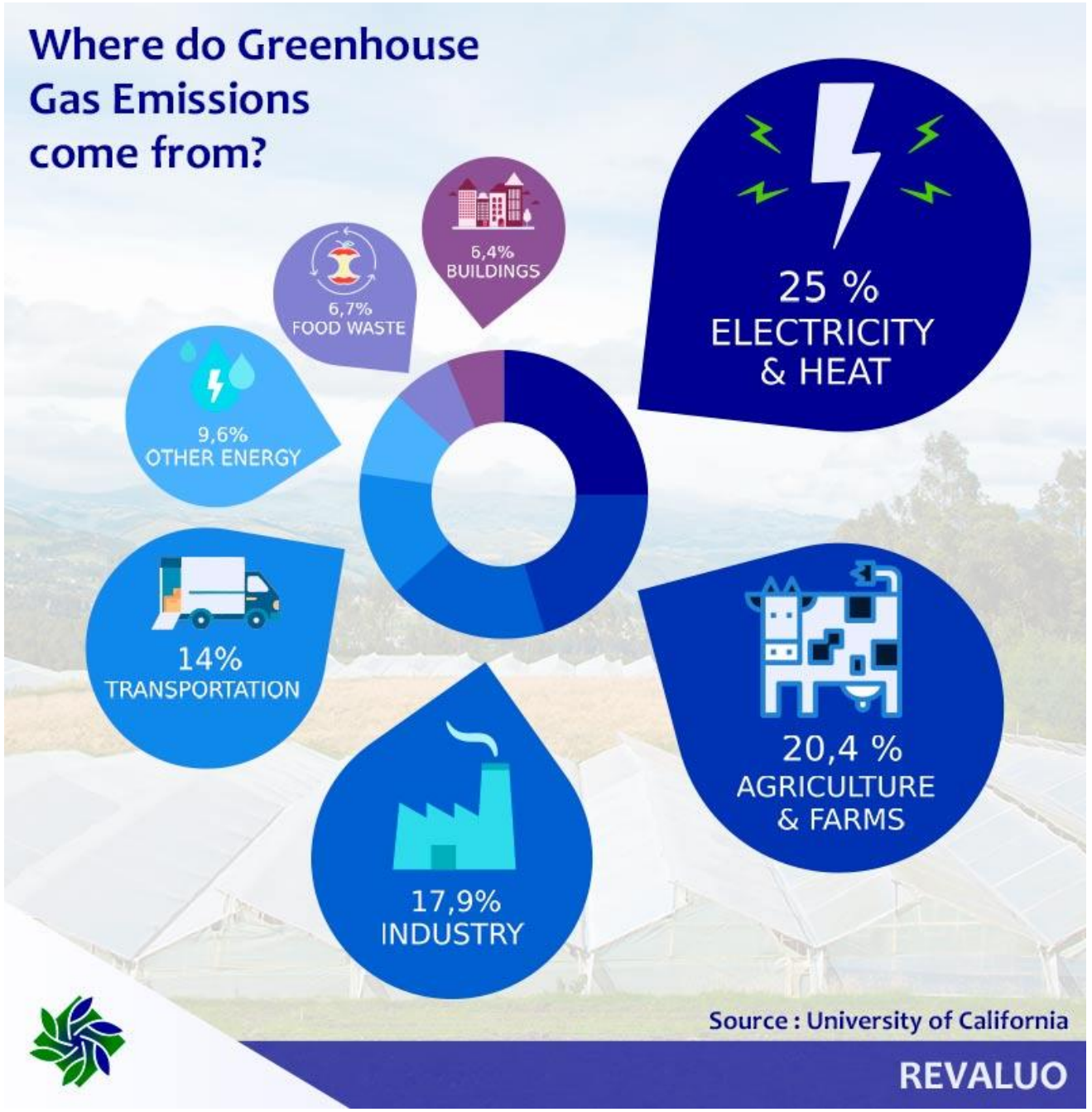
- **Examples of conventional sources of energy include oil, natural gas, and coal.**

- **The fossil fuels oil, gas and coal, provide more than 85 percent of energy consumed in the World.**

What is the problem?

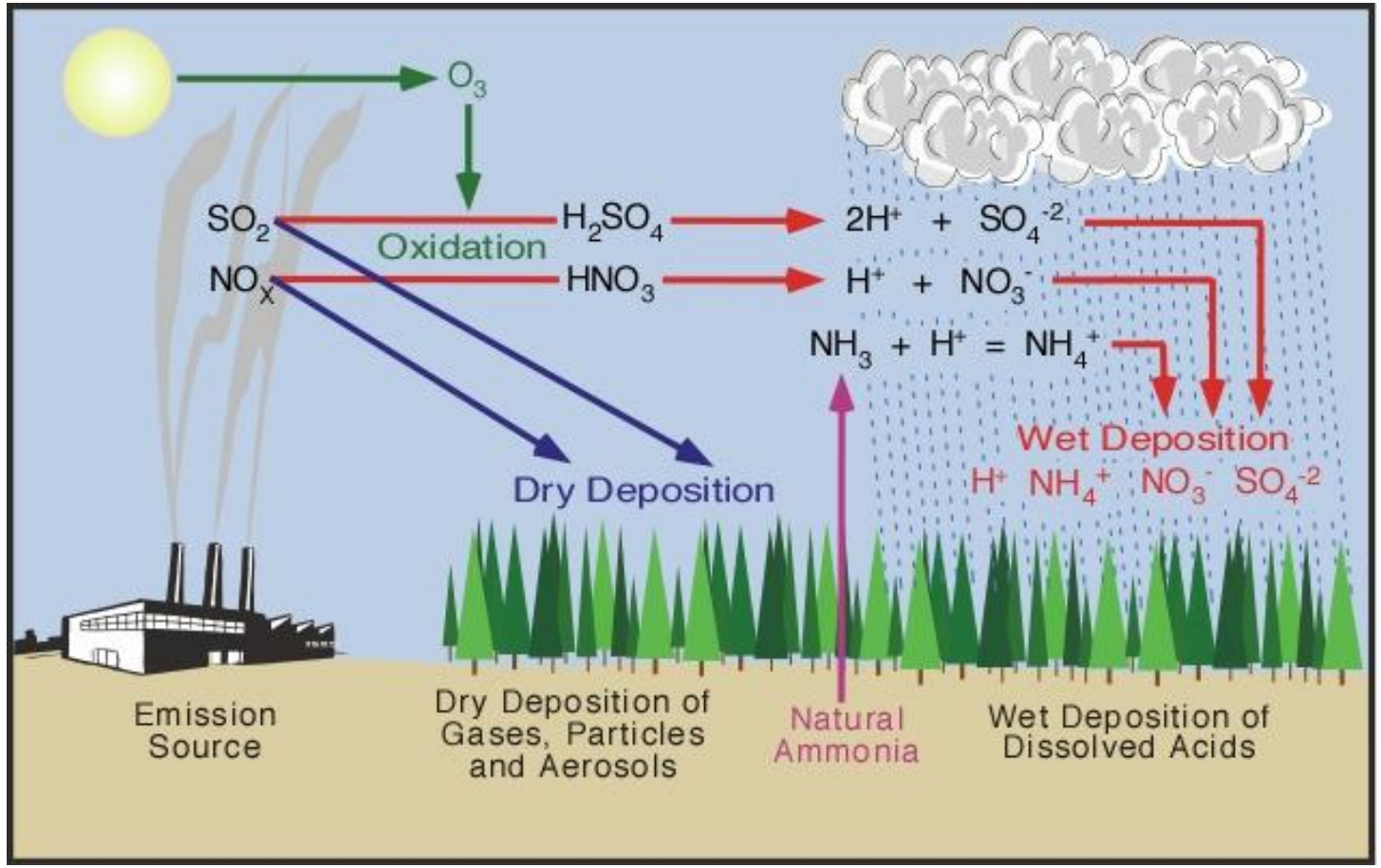
- . Burning fossil fuels (both for heating and as fuel for vehicles) is the main source of 'greenhouse gases' (GHG), carbon dioxide and others which affect the atmosphere and are altering the climate.




Where do Greenhouse Gas Emissions come from?
6,4% BUILDINGS
6,7% FOOD WASTE
25 % ELECTRICITY & HEAT
9,6% OTHER ENERGY
14% TRANSPORTATION
20,4 % AGRICULTURE & FARMS
17,9% INDUSTRY
Source : University of California
REVALUO

Acid rain

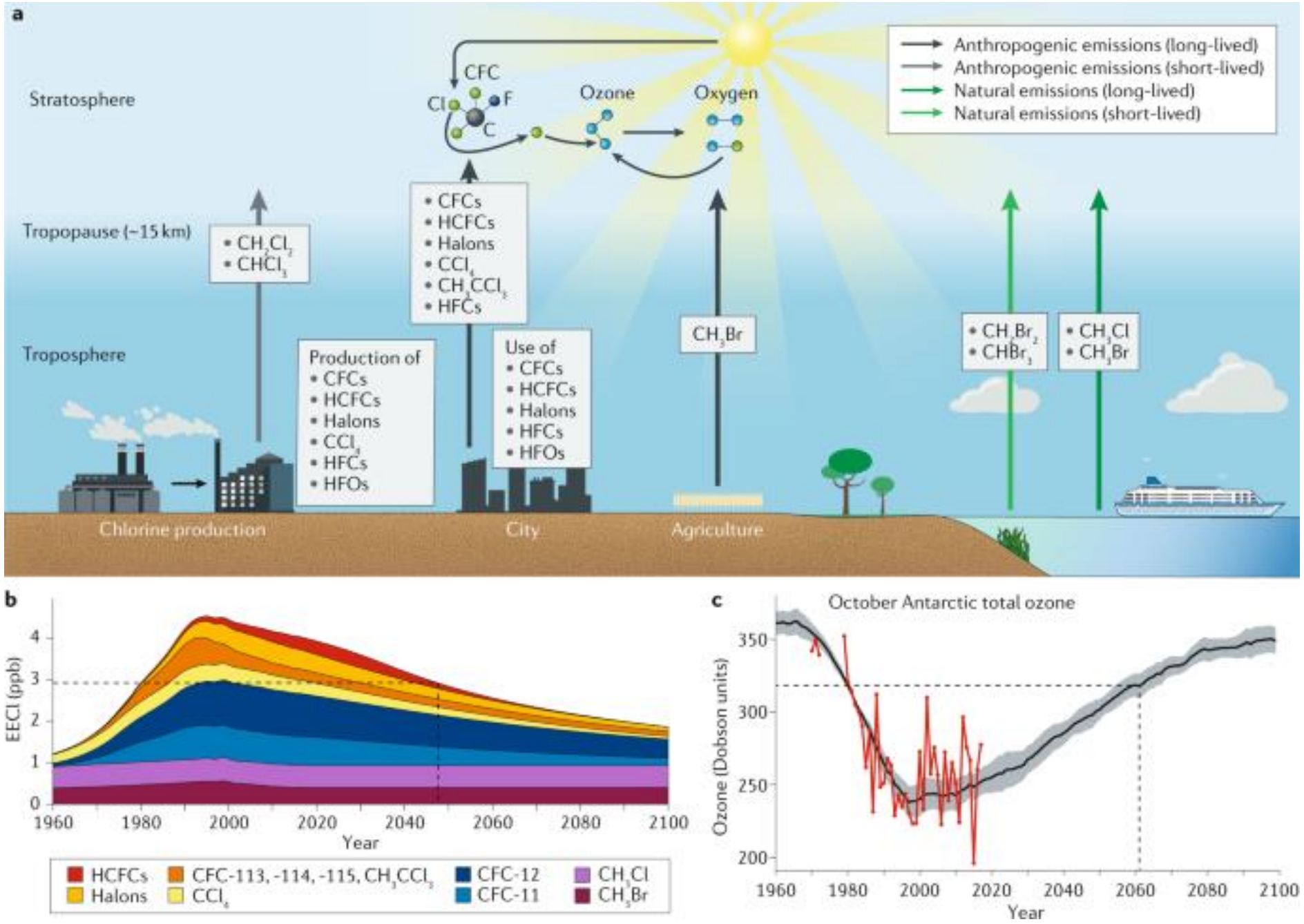
- Power plants produce large amounts of nitrogen oxides and sulfur dioxide—the pollutants that cause acid rain
- Unpolluted rain is naturally acidic (pH ≈ 5.6), while polluted rain could have pH values as low as 3.
- • Chemical reactions in the atmosphere convert SO2, NOx, and VOCs to acidic compounds and associated oxidants.



- Acid rain has been shown to have adverse impacts on
- – forests,
- – freshwaters
- – soils,
- – killing insect and aquatic life-forms
- – causing damage to buildings
- – having impacts on human health

Ozone depletion

- The ozone layer protects the Earth from the ultraviolet rays sent down by the sun
- The fact that the ozone layer was being depleted was discovered in the mid-1980s.
- The main cause of this is the release of CFCs, chlorofluorocarbons (organic compound that contains carbon, chlorine, and fluorine).
- Production and the use of fossil fuels relate to the emission of ozone layer-depleting chemicals, including CFCs


a
Anthropogenic emissions (long-lived)
Anthropogenic emissions (short-lived)
Natural emissions (long-lived)
Natural emissions (short-lived)
Stratosphere
Tropopause (~15 km)
Troposphere
CFC
Cl
F
C
Ozone
Oxygen
• CH2Cl2
• CHCl3
• CFCs
• HCFCs
• Halons
• CCl4
• CH3CCl3
• HFCs
Production of
• CFCs
• HCFCs
• Halons
• CCl4
• HFCs
• HFOs
Use of
• CFCs
• HCFCs
• Halons
• HFCs
• HFOs
CH3Br
• CH2Br2
• CHBr3
• CH3Cl
• CH3Br
Chlorine production
City
Agriculture
b
EECl (ppb)
0
1
2
3
4
1960
1980
2000
2020
2040
2060
2080
2100
Year
HCFCs
Halons
CFC-113, -114, -115, CH3CCl3
CCl4
CFC-12
CFC-11
CH3Cl
CH3Br
c
October Antarctic total ozone
Ozone (Dobson units)
200
250
300
350
1960
1980
2000
2020
2040
2060
2080
2100
Year

$$O_{2(g)} \xrightarrow{UV} O_{(g)} + O_{(g)}$$

$$O_{2(g)} + O_{(g)} \xleftrightarrow{UV} O_{3(g)}$$

$$CF_2Cl_{2(g)} \xrightarrow{UV} \dot{C}l_{(g)} + \dot{C}F_2Cl_{(g)}$$

$$\dot{C}l_{(g)} + O_{3(g)} \longrightarrow Cl\dot{O}_{(g)} + O_{2(g)}$$

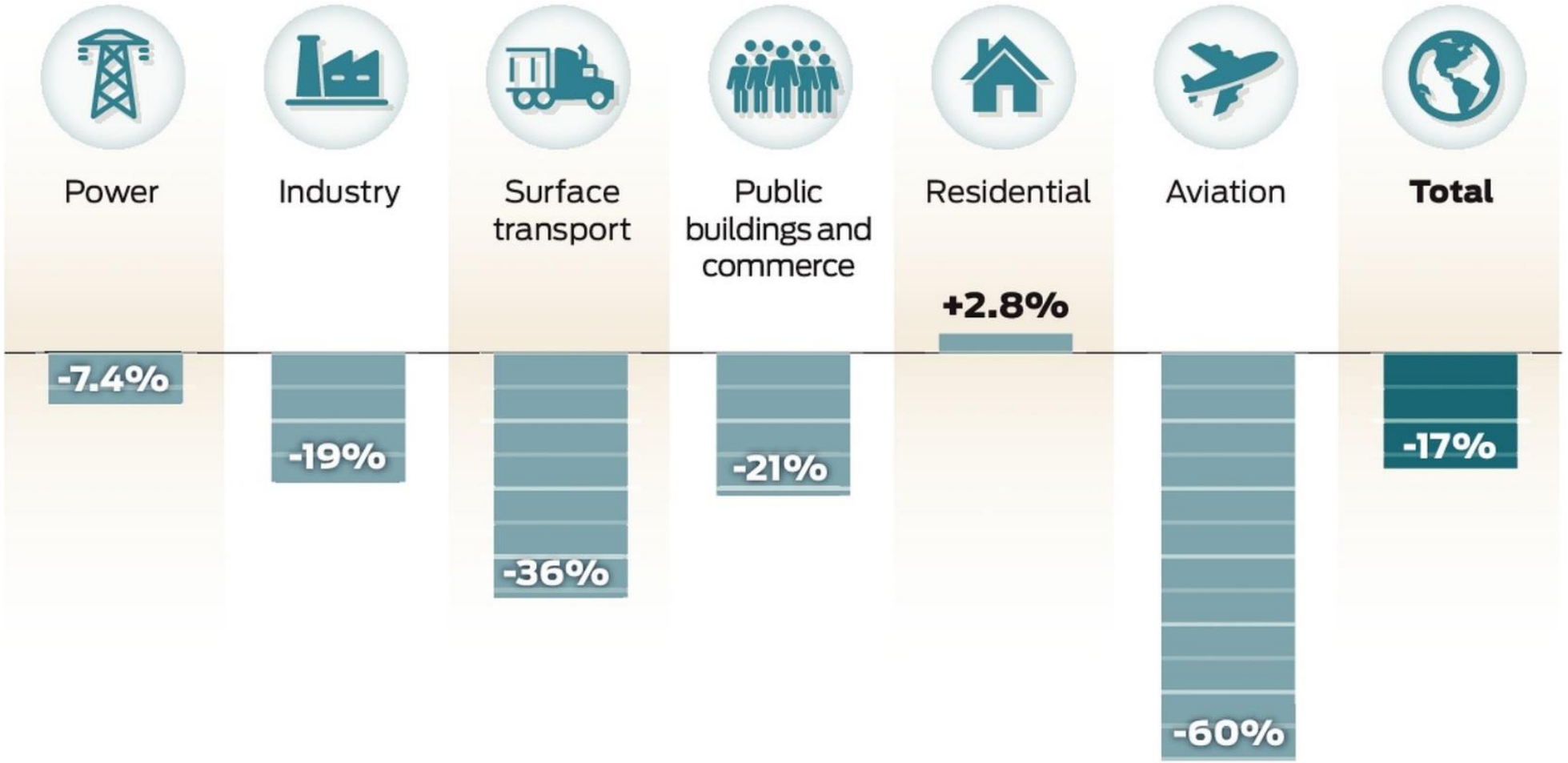
$$Cl\dot{O}_{(g)} + O_{(g)} \longrightarrow \dot{C}l_{(g)} + O_{2(g)}$$

Global Warming

- The main driver of climate change is **increased greenhouse gas emissions** caused by human activities.
- Burning fossil fuels such as coal, oil and natural gas to produce energy is the greatest contributor to greenhouse gas emissions.
- These gases trap heat in the Earth's atmosphere, initiating a phenomenon called the greenhouse effect.
- Other human activities that contribute to greenhouse gas emissions include desertification, industrial production, and agricultural practices.

Greenhouse gas reductions

The shutdown of the global economy during the coronavirus outbreak led to drops in carbon dioxide emissions that peaked April 7, according to a new study. The reduction on that date, compared with 2019, is the result of declines across various economic sectors.



Sources: Global Carbon Project, Nature Climate Change, Getty Images

Todd Trumbull / The Chronicle

What is Sustainable Energy?

- Sustainable energy is energy obtained from renewable sources that naturally replenish.
- These sources do not deplete over time and have minimal environmental impact.
- Examples include solar, wind, and hydropower energy.

Renewable Energy Sources

- **Solar energy: Uses sunlight to generate electricity.**

- **Wind energy: Utilizes wind turbines to convert wind into electricity.**

- **Hydropower: Generates energy from flowing water.**
- **Biomass: Organic materials like wood and waste used to produce energy.**

- **Geothermal energy: Harnesses heat from beneath the Earth's surface**

Importance of Renewable Energy

- **Renewable energy sources help reduce greenhouse gas emissions.**
- **They provide long-term economic benefits and energy security.**
- **Renewable energy mitigates the negative effects of climate change.**

Economic Benefits of Renewable Energy

1. Cost of Electricity Generation from Renewable vs. Conventional Sources

- **Solar Energy**:
  - The cost of electricity generation from solar systems in 2020 ranged from 2-4 cents per kilowatt-hour (kWh), while fossil fuel-based power plants ranged between 5-17 cents per kWh.

- **Wind Energy**:
  - The cost of electricity generation from wind energy ranged from 3-6 cents per kWh, compared to conventional sources like coal or natural gas.

Source: International Renewable Energy Agency (IRENA) – Renewable Energy Costs Report 2020.

General Economic Advantages of Renewable Energy

- **Lower Operational Costs**: Renewable energy relies on free resources (like sunlight and wind), significantly reducing operational costs compared to fossil fuel plants that require fuel purchases.

- **Reduced Maintenance Costs**: Systems like solar panels and wind turbines generally require less maintenance than conventional power plants.

- **Price Stability**: Fossil fuel prices are highly volatile, leading to fluctuating electricity costs, while renewable energy provides more price stability.

Example from Palestine: محطة نور أريحا

- **Solar Power Project in Palestine**:
  - In the Jericho solar power plant project, approximately 15% of electricity costs were saved by switching to solar energy.
  - **Future Savings**: It is estimated that electricity costs in Palestine could decrease by 20% in the long term if renewable energy adoption expands.
- 20,000 solar panels spread over 86 dunoms to produce 7.5 megawatts of clean electricity

Solar Power Plant at Palestine Technical University.

- **Capacity**: Produces **500 kW** of electricity.
- **Purpose**: Provides a significant portion of the university's electricity needs, promoting the use of renewable energy and reducing carbon emissions.
- 1500 solar panels.

Challenges and Opportunities in Renewable Energy

- **Technical and economic challenges.**

- **Future opportunities for expansion in sustainable energy**