MAJOR REASONS FOR CLIMATE CHANGE:

INDUSTRIAL CHEMICALS

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- **DISCLAIMER …**
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• MAJOR REASONS …

The major reasons for climate change include a mix of natural and, overwhelmingly, human-made (anthropogenic) factors:

1. Burning of Fossil Fuels;
2. Deforestation;
3. Industrial Activity;
4. Agriculture & Livestock;
5. Transportation;
6. Waste and Garbage;
7. Plastics;
8. Urbanization and Energy Consumption; and
9. Industrial Chemicals.

INDUSTRIAL CHEMICALS …

- Industrial chemicals play a significant role in climate change, both directly and indirectly;
- These substances can contribute to global warming, deplete the ozone layer, and pollute air and water systems, all of which influence the Earth's climate systems; and
- Here's a breakdown of their major impacts:

• GREENHOUSE GAS EMISSIONS …

- Many industrial processes emit greenhouse gases (GHGs) that trap heat in the atmosphere. Key GHGs include:
  - Carbon Dioxide (CO_2): Emitted during the combustion of fossil fuels in manufacturing, energy production, and chemical processing;
  - Methane (CH_4): Released from petrochemical plants and during the production and transport of coal, oil, and natural gas;
  - Nitrous oxide (N_2O): Emitted from chemical manufacturing, especially in the production of fertilizers and nitric acid; and
  - Fluorinated gases (HFCs, PFCs, SF_6): Synthetic gases used in refrigeration, air conditioning, and electronics manufacturing. Though emitted in smaller quantities, they are thousands of times more potent than CO_2 in trapping heat.

- **OZONE-DEPLETING SUBSTANCES (ODS) …**
  - Certain industrial chemicals, such as chlorofluorocarbons (CFCs) and halons, contribute to the depletion of the ozone layer, which protects the Earth from harmful ultraviolet (UV) radiation. While many ODS have been phased out under the Montreal Protocol, their replacements (HFCs) are powerful greenhouse gases.

- **AIR POLLUTION AND CLIMATE CHANGE …**
  - Industrial emissions often include aerosols (tiny solid or liquid particles suspended in air), such as:
    - Sulfates and Nitrates, which can reflect sunlight and temporarily cool the atmosphere; and
    - Black Carbon (soot), which absorbs heat and contributes to atmospheric warming and glacier melt.
  - These particles can also impact cloud formation and precipitation patterns, complicating climate models.

• CHEMICALS WASTE & WATER SYSTEMS …

- Improper disposal of industrial chemicals contaminates water bodies, harming ecosystems that help regulate carbon cycles (e.g., oceans absorbing CO_2); and
- Some chemicals also hinder the growth of phytoplankton, reducing oceanic carbon capture.

- **LAND USE AND INDUSTRIAL EXPANSION …**
  - The chemical industry contributes to deforestation and land degradation, either directly (e.g., clearing land for chemical plants) or indirectly (e.g., via production of agricultural chemicals that lead to monocultures and soil degradation); and
  - These land-use changes reduce the Earth's capacity to absorb CO_2.

- **MITIGATION EFFORTS …**
  - To address the climate impact of industrial chemicals:
    - Regulations such as the Kyoto Protocol, Paris Agreement, and Kigali Amendment (targeting HFCs) have been key steps;
    - Cleaner production methods, carbon capture, and alternative green chemicals are being developed; and
    - Corporate sustainability initiatives now often include reducing chemical emissions and transitioning to circular economy models.

EXAMPLES

- **CARBON DIOXIDE (CO_2) …**
    - Source: Cement production, steel manufacturing, fossil fuel combustion.
    - Impact: Major contributor to the greenhouse effect, accounting for over 75 percent of global GHG emissions; and
    - Example: Cement factories release CO_2 both from burning fossil fuels and from the chemical conversion of limestone into lime.

- **HYDROFLUAROCARBONS (HFCs) ...**
  - Source: Used in air conditioning, refrigeration, and foam-blowing agents;
  - Impact: Potent greenhouse gases—some HFCs are thousands of times more effective at warming the atmosphere than CO_2; and
  - Example: HFC-134a, commonly used in car air conditioners, has a global warming potential (GWP) of about 1,430 times that of CO_2 over 100 years.

- **METHANE (CH_4) …**
  - Source: Natural gas leaks, petrochemical production, coal mining;
  - Impact: A greenhouse gas 84–87 times more powerful than CO_2 over a 20-year period; and
  - Example: Leaks from natural gas infrastructure in petrochemical plants contribute significantly to methane emissions.

- **NITROOUS OXIDE (N_2O) …**
  - Source: Production of nitric acid (used in fertilizers) and adipic acid (used in nylon manufacturing);
  - Impact: Has a GWP nearly 300 times that of CO_2 and also contributes to ozone layer depletion; and
  - Example: Nylon factories emit N_2O during the production process.

- **PERFLUOROCARBONS (PFCS) & SULFUR HEXAFLURIDE (SF6) ...**
  - **Source:** Electronics manufacturing, magnesium production, and high-voltage electrical equipment;
  - **Impact:**
    - **PFCs:** Extremely long atmospheric lifetimes (up to 50,000 years); and
    - **SF_6:** The most potent known greenhouse gas, with a GWP of over 23,500.
  - **Example:** SF_6 used as an insulator in electrical switchgear can leak and persist in the atmosphere for centuries.

- **BLACK CARBON (SOOT) …**
  - **Source:** Incomplete combustion of fossil fuels and biomass in industrial boilers or diesel engines;
  - **Impact:** Absorbs sunlight, warms the atmosphere, and accelerates glacier and snow melt; and
  - **Example:** Industrial diesel engines emit black carbon particles, contributing both to air pollution and regional climate warming.

- **PERSISTENT ORGANIC POLLUTANTS (POPS) ...**
  - Source: Industrial chemicals like PCBs (polychlorinated biphenyls), pesticides;
  - Impact: Harm aquatic ecosystems that act as carbon sinks; indirectly affect climate regulation; and
  - Example: PCBs, once widely used in electrical equipment, persist in oceans and harm marine life that regulates CO_2.

CANADA

- **INDUSTRIAL CHEMICALS …**
  - The impact of industrial chemicals on climate change in Canada is significant, though often underrepresented in climate discussions;
  - Industrial chemicals—used in manufacturing, agriculture, mining, oil refining, and other sectors—contribute to greenhouse gas (GHG) emissions, ozone depletion, and environmental pollution; and
  - Some of these chemicals are potent climate forcers, with global warming potentials (GWPs) far exceeding carbon dioxide (CO_2).

INDUSTRIAL CHEMICALS AND CLIMATE CHANGE …

- Industrial chemicals are responsible for millions of tonnes of CO_2-equivalent emissions annually in Canada;
- Major contributors include:
  - Hydrofluorocarbons (HFCs);
  - Nitrous oxide (N_2O);
  - Sulfur hexafluoride (SF_6); and
  - Carbon tetrachloride, perfluorocarbons (PFCs).
- These chemicals are often byproducts of industrial processes, refrigerants, or used in heavy industry (e.g. aluminum production, power transmission, chemical manufacturing).

REGION-SECIFIC IMPACTS

1. WESTERN CANADA …

- **ALBERTA:**
- Oil and gas processing emits volatile organic compounds (VOCs), methane, and other chemicals;
- Petrochemical industry near Edmonton produces synthetic fertilizers, plastics, and solvents;
- Industrial flaring and refining release GHGs and climate-warming pollutants like black carbon and benzene; and
- Sulfur hexafluoride (SF_6) is used in electrical systems—an extremely potent GHG.

1. WESTERN CANADA ...

- **BRITISH COLUMBIA:**
- Smaller industrial base, but refrigerant emissions from urban HVAC systems are significant; and
- Mining operations in the interior and north produce chemical byproducts, including mercury and VOCs.

2. CENTRAL CANADA ...

- ONTAIO:
- Heavy manufacturing and chemical production (e.g., Sarnia's "Chemical Valley") release numerous industrial pollutants;
- Use of HFCs and PFCs in refrigeration, air conditioning, and industrial foam blowing contributes to high-GWP emissions; and
- Nitrous oxide (N_2O) from chemical fertilizer plants is a major concern.

2. CENTRAL CANAD ...

- QUEBEC:
- Major aluminum smelting industry uses perfluorocarbons (PFCs) with very high GWPs;
- Refrigeration and industrial gases are common sources of HFC emissions; and
- Chemical waste from pulp and paper mills and industrial plants can leach into soils and water.

3. NORTHERN CANADA …

- Diesel generators and outdated refrigeration systems often use banned or phased-out refrigerants like CFCs and HCFCs, which still linger in isolated infrastructure; and
- Leaks from old cold storage and mining operations can release legacy chemicals into the environment.

- **FEDERAL REGULATIONS …**
  - Canadian Environmental Protection Act (CEPA) regulates toxic substances and industrial chemicals;
  - HFC phase-down in line with the Kigali Amendment to the Montreal Protocol; and
  - Pollution Prevention Planning for industrial sectors to reduce high-GWP emissions.

- **INDUSTRY PRACTICES …**
  - Replacement of high-GWP refrigerants with low-GWP alternatives (e.g., CO_2 or ammonia);
  - Leak detection and repair programs (LDAR) to prevent fugitive chemical emissions; and
  - Process optimization to reduce nitrous oxide and methane releases from industrial plants.

QUESTIONS & ANSWERS