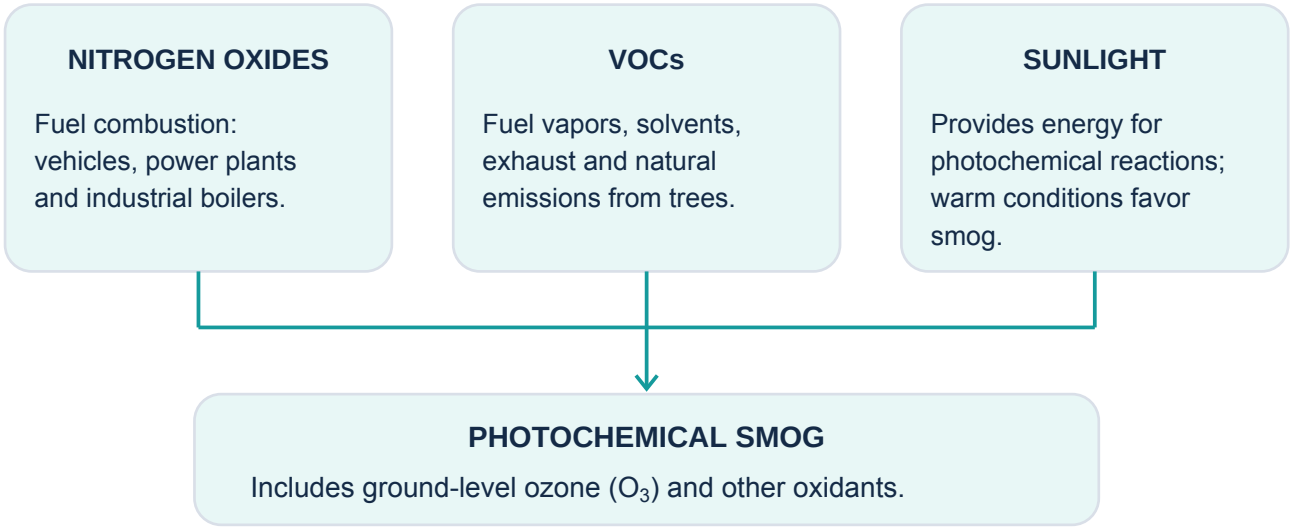
Sunlight transforms emissions

Photochemical smog is a mixture produced by sunlight-driven atmospheric reactions. Ground-level ozone is a major secondary pollutant in the mixture; it is not simply emitted from a tailpipe.

1. PRECURSORS + LIGHT → SECONDARY POLLUTANTS



Conceptual pathway, not a balanced chemical equation.

2. VOLATILE MEANS ABLE TO ENTER THE AIR READILY

VOCs are organic compounds that can enter air as gases or vapors. Examples include formaldehyde and components of gasoline; gasoline is a mixture, not one chemical. Some trees release natural VOCs. The presence of natural precursors does not make the resulting smog harmless.

3. KEEP THE POLLUTANT AND ITS PRECURSORS SEPARATE

Nitrogen oxides and reactive VOCs participate in reactions that form ozone. Reducing smog therefore means controlling its precursors. Protective stratospheric ozone and harmful ground-level ozone are the same molecule in different atmospheric locations.

Secondary ozone and emission sources: US EPA, Ground-level Ozone Basics.
Daytime photochemical ingredients: NOAA, The Dark Side of Ozone Chemistry.
Volatility and organic compounds: US EPA, Technical Overview of VOCs.
Natural VOCs and example compounds: College Board CED, Topic 7.2.

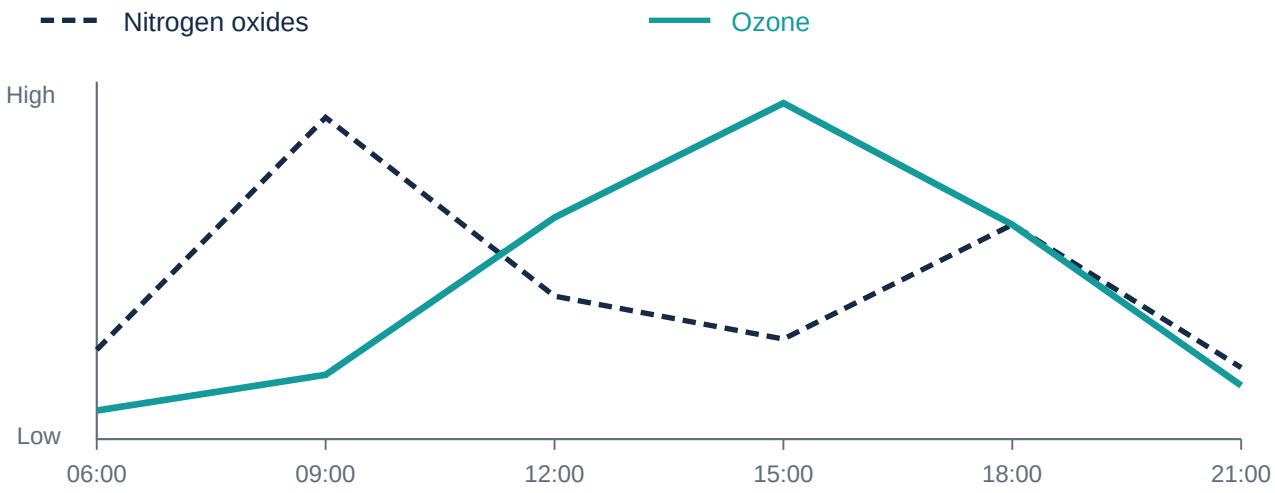
Scope: College Board AP Environmental Science CED, Topic 7.2, pp. 141-142.

Why the ozone peak comes later

In many urban settings, morning traffic emits nitrogen oxides before ozone reaches its daily maximum. Sunlight-driven chemistry takes time; ozone often peaks in the afternoon or early evening.

1. A TYPICAL SUNNY-DAY PATTERN

Relative concentration: schematic, not measured data



Illustrative timing only; relative heights do not compare pollutant quantities.

2. WARM, SUNNY AND STAGNANT CONDITIONS

Strong sunlight drives the reactions, and warmer conditions often favor ozone formation. Light winds and poor mixing allow pollutants to accumulate. These conditions often occur in summer, but high ozone can also occur in colder seasons under suitable local conditions.

3. POLLUTION DOES NOT STOP AT A CITY BOUNDARY

Wind can dilute pollution locally while transporting ozone and precursors downwind. Rural communities may therefore experience high ozone even when local emissions are small. Compare weather as well as emissions when interpreting measurements; traffic alone does not explain every daily pattern.

Daily timing and seasonal variation: US EPA, Patient Exposure and the Air Quality Index.
Weather and dispersion: National Weather Service, Weather and Air Quality.
Sunlight, temperature and rural ozone: US EPA, Ground-level Ozone Basics.

Scope: College Board AP Environmental Science CED, Topic 7.2, pp. 141-142.

Reduce the ingredients, reduce harm

Smog control targets nitrogen oxides and reactive VOCs before they produce secondary pollutants. The aim is cleaner air, not simply moving the visible haze somewhere else.

1. HEALTH: IRRITATED EYES AND AIRWAYS

Photochemical smog can irritate eyes and cause respiratory problems. Ozone is a strong oxidant that can inflame airways, trigger coughing and worsen asthma. Children, older adults, people with asthma and people active outdoors can be especially vulnerable. Risk depends on concentration and exposure.

2. PLANTS: LESS PHOTOSYNTHESIS AND GROWTH

Ozone entering sensitive leaves can reduce photosynthesis, slow growth and cause visible injury. Effects on individual plants can alter habitat quality and ecosystem composition. This is an extension of the human-health focus: air pollutants also affect biological productivity.

3. CONTROL BOTH PRECURSOR GROUPS

Nitrogen oxides: reduce fuel combustion through efficient energy use and shared transport, and use appropriate engine or industrial emission controls.

VOCs: prevent fuel-vapor leaks, contain or recover vapors, and use lower-emission solvents and coatings. Connect each action to the precursor it reduces rather than merely calling it green.

4. EXTENSION: CHECK WHAT A REDUCTION REALLY MEANS

Suppose a city cuts VOC emissions from 120 to 90 tonnes per day. The decrease is 30 tonnes per day, or 30 ÷ 120 × 100% = 25%.

That does not prove ozone concentration falls by 25%. Ozone also depends on nitrogen oxides, sunlight, weather and transport. Measure the resulting air quality as well as the emissions.

Respiratory effects and sensitive groups: US EPA, Health Effects of Ozone Pollution.
Photosynthesis, growth and ecosystems: US EPA, Ecosystem Effects of Ozone Pollution.
Precursor reduction and eye irritation: College Board CED, Topic 7.2.
Transport, energy use and vapor controls: AirNow, What You Can Do.

Scope: College Board AP Environmental Science CED, Topic 7.2, pp. 141-142.