EMISSIONS FROM AIR TRAFFIC

The greenhouse effect is great! The problem is just that human beings are reinforcing the natural variant and the result – global warming – is the main challenge. It goes without saying that the emissions produced by air traffic are also having an impact.

BY: Jenny Palm **ILLUSTRATION:** Tobias Flygar

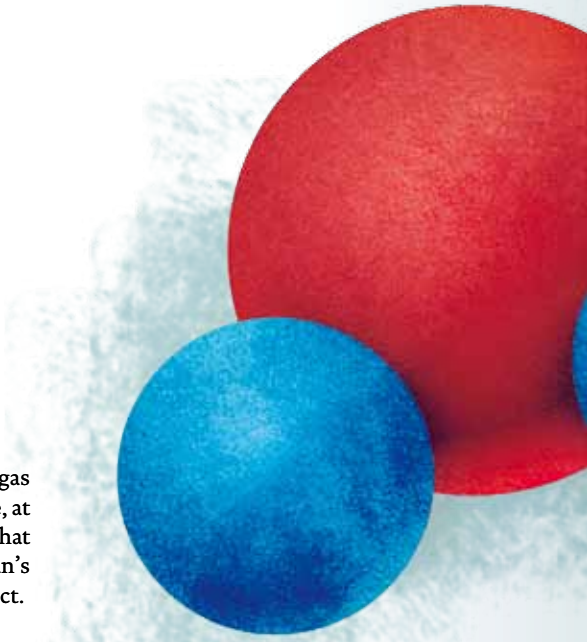
MOST OF THE greenhouse effect on the earth is completely natural, as the atmosphere has always contained greenhouse gases. It is also absolutely essential for our living environment. Currently, the average temperature on the earth's surface is 14 degrees Celsius. Without the natural greenhouse effect, we would instead be shivering at minus 19 degrees Celsius.

However, following industrialisation in the 19th century, the greenhouse effect has become far greater than Mother Nature intended and the temperature on earth is steadily increasing. The exact reasons for climate change are the subject of furious discussion between researchers all over the world. The vast majority nonetheless agree that it is the greenhouse gases generated by human activity that have caused most of this temperature increase. Examples of human impact include the burning of fossil fuels, such as oil, coal and fossil gas.

THIS IS WHERE air traffic comes into the picture. Air traffic contributes to global warming by burning aviation fuel which then creates carbon dioxide (CO_2) and water vapour. CO_2 is a greenhouse gas that remains in the atmosphere for a long time, at least 100 years. In global terms, it is estimated that air traffic accounts for about 4.6 per cent of man's combined contribution to the greenhouse effect.

WATER VAPOUR, H_2O, is an important greenhouse gas. Even if air traffic discharges fairly large amounts of water vapour, these emissions are a very small part of the total amount of water that exists naturally in the atmosphere. The largest part of the water vapour that is discharged by aircraft finds its way to the troposphere and quickly disappears in the form of precipitation. At higher altitudes, however, small amounts of water vapour can perhaps accumulate and help to warm the earth.

Condensation trails are created when the hot exhaust gases from aircraft are mixed with the cold ambient air and form ice particles. In dry air, these ice particles evaporate quickly into condensation trails and disappear. In damper air, these condensation trails can remain for several hours. They can also grow, if the ice particles absorb water from the ambient air.



Carbon dioxide, CO_2

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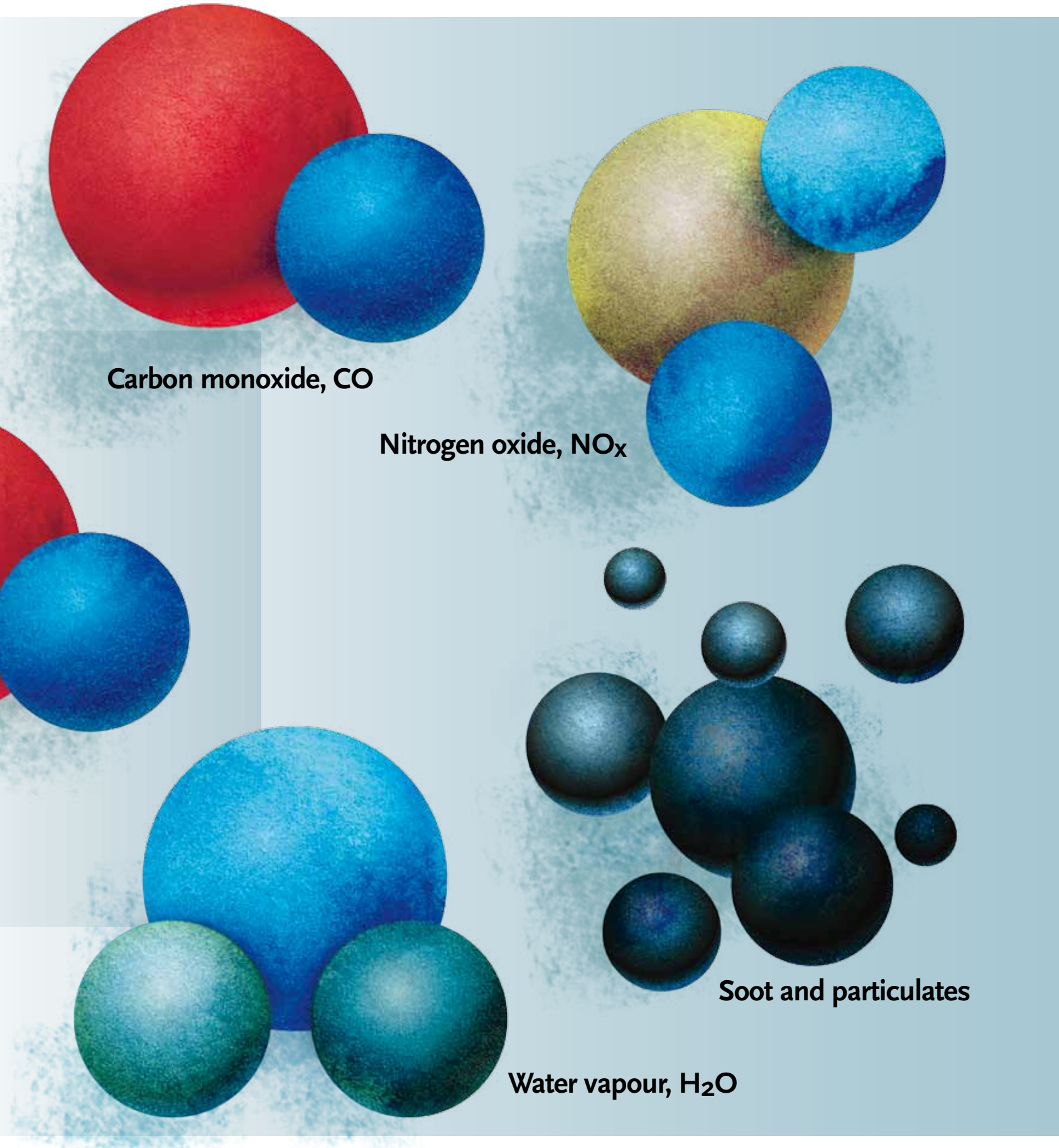
Carbon monoxide, CO
Nitrogen oxide, NO_x
Soot and particulates
Water vapour, H_2O

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The formation of condensation trails is largely dependent on the local atmospheric conditions and even a small shift in the flight path can reduce the likelihood of long-lasting condensation trails. Condensation trails have the same effect as thin, high clouds and can help to warm the earth's surface. The number of condensation trails that are created by air traffic could increase if air traffic increases and also if more air traffic is operated in air in which condensation trails form more easily.

MOREOVER, THE EMISSIONS produced by air traffic can increase cirrus clouds. Condensation trails that do not disappear because of specific atmospheric conditions may cause the development of cirrus clouds in certain atmospheric conditions. In addition, aerosols, small particles, from air traffic can influence the cirrus clouds that already exist by changing the length of their life and composition. More research is needed in these areas to increase our knowledge.

At high altitudes, emissions of nitrogen oxide, NO_x, can cause the ozone to break down, while emissions of NO_x at lower altitudes help to create ozone. Nitrogen oxide also helps to break down the greenhouse gas methane, which counteracts the heating of the atmosphere. In spite of this, the total impact of nitrogen oxide emissions from air traffic is a contribution to warming. The emission of nitrogen oxide that reaches ground level, from local emissions at airports has the same negative effect on health and the acidification of the environment as emissions from road traffic, for example.

THE EMISSION of sulphur dioxide, SO_2, from the sulphur in aviation fuel creates aerosols that reflect sunlight and reduce warming. Sulphur also adds to acidification.

Carbon monoxide, CO, and incompletely combusted hydrocarbons, HC, are also formed when aviation fuel is burned and take part in the process of creating ozone. ◀

FACTS **GREENHOUSE EFFECT**

The atmosphere contains greenhouse gases and the most common of these are water vapour and carbon dioxide. Greenhouse gases absorb most of the thermal radiation from the earth's surface before it reaches space. They then re-transmit the absorbed radiation, but not only to space but in all directions, even downwards. A large part of the thermal radiation that is transmitted from the earth's surface is returned in this way. The more greenhouse gases, the higher the temperature.

EMISSIONS

Carbon dioxide (CO_2)

Carbon dioxide is the gas that is thought to contribute most to the greenhouse effect. It is formed whenever hydrocarbon fuel is burned. This gas has a long life cycle and therefore has an impact for a long time.

Water vapour (H_2O)

Water vapour has an insignificant effect on the environment in the lowest layer of the atmosphere (up to around 11 km), but it has a long life in the stratosphere (approx. 11-50 km). The white condensation trails after aircraft are created in the stratosphere and could be the cause of the growing global occurrence of cirrus clouds, which in turn contribute to global warming.

Carbon monoxide (CO)

Almost all the carbon in the fuel oxidises completely and becomes carbon dioxide. A small part of the combustion process is, however, incomplete and can result in carbon monoxide, for example, which eventually leads to ozone formation.

Nitrogen oxide (NO_x)

Nitrogen oxide is formed by the high temperatures in the combustion chamber. It helps to create acidification and over-fertilisation and to the formation of ground-level ozone. NOx also influences the greenhouse effect.

Soot and particulates

Soot and particulates are residual products from jet fuel. Soot absorbs heat and therefore helps to create the greenhouse effect.

Read more on pages 10–13: The aircraft industry is working intensively to reduce fuel consumption – and thereby also the emission of greenhouse gases.

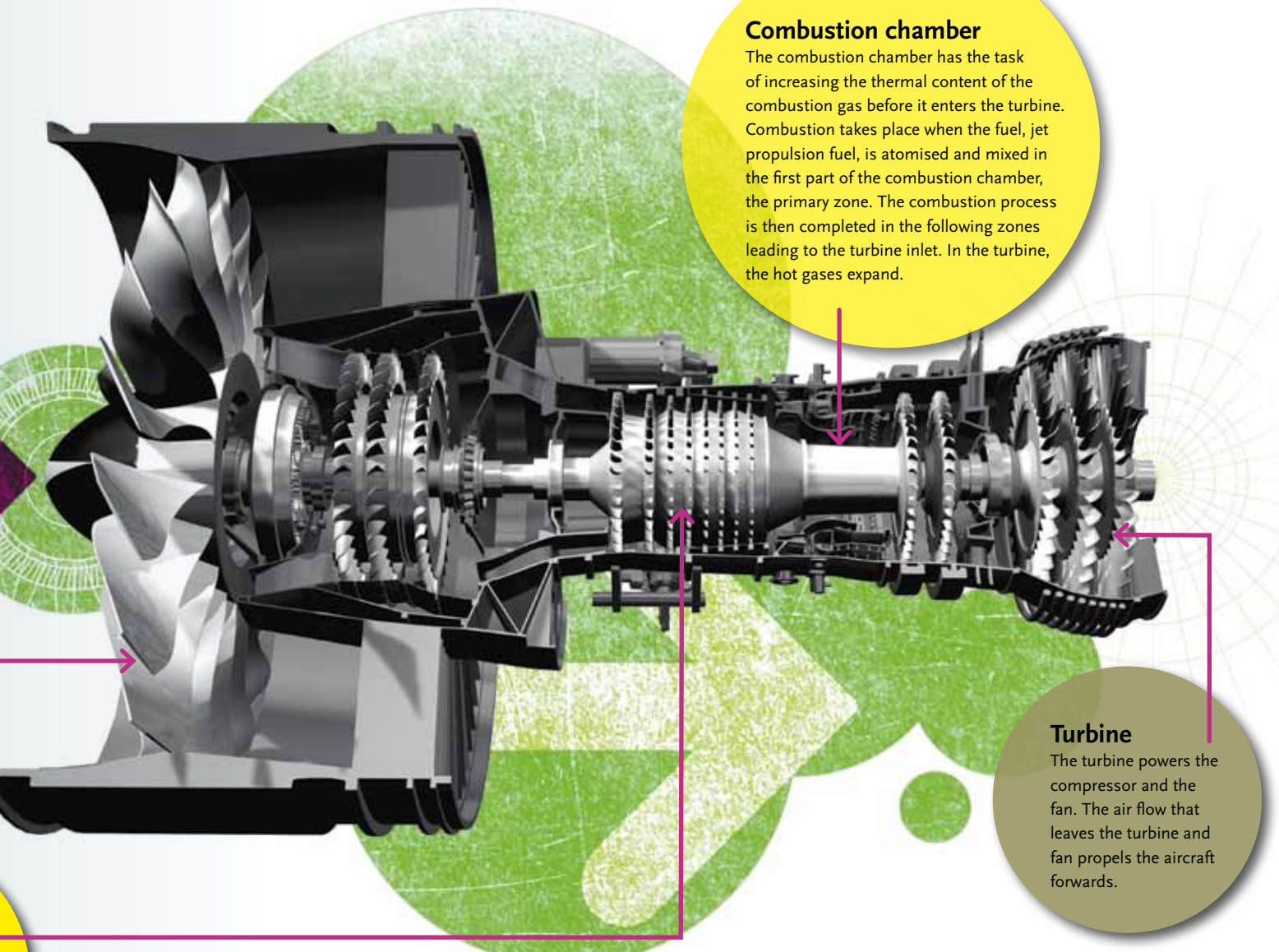
ENGINE: HOW

We know that air traffic has a negative effect on the environment. To understand why, we also need to understand how the heart of the aircraft, the jet engine, works.

Fan
The fan sucks large amounts of air into the engine.

Compressor
The compressor compresses the air, which is then directed into the combustion chamber.

IT WORKS



Combustion chamber

The combustion chamber has the task of increasing the thermal content of the combustion gas before it enters the turbine. Combustion takes place when the fuel, jet propulsion fuel, is atomised and mixed in the first part of the combustion chamber, the primary zone. The combustion process is then completed in the following zones leading to the turbine inlet. In the turbine, the hot gases expand.

Turbine

The turbine powers the compressor and the fan. The air flow that leaves the turbine and fan propels the aircraft forwards.

ISAAC NEWTON formulated the principle that "for every action, there is an equal and opposite reaction". In simple terms, it would be true to say that the jet engine works according to this precise principle. The air that is forced out at the rear produces the same power moving forwards.

It begins when air is sucked into the compressor and is compressed, thereby increasing the pressure. The air then enters the combustion chamber, where it is mixed with fuel. The heat and pressure make the gas expand and rush out through the turbine. The air current that is pushed backwards propels the aircraft forwards.

So when are the undesirable emissions created? Carbon dioxide and water are formed when the fuel is combusted in air. However, combustion is not always complete and carbon monoxide and uncombusted hydrocarbons then form. When combustion takes place at high temperature, nitrogen also reacts with the oxygen in the air and forms nitrogen oxide (NO_X), which is another emission. ◀

How can air traffic be made cleaner? Read more about the engines of the future on pages 14-17.