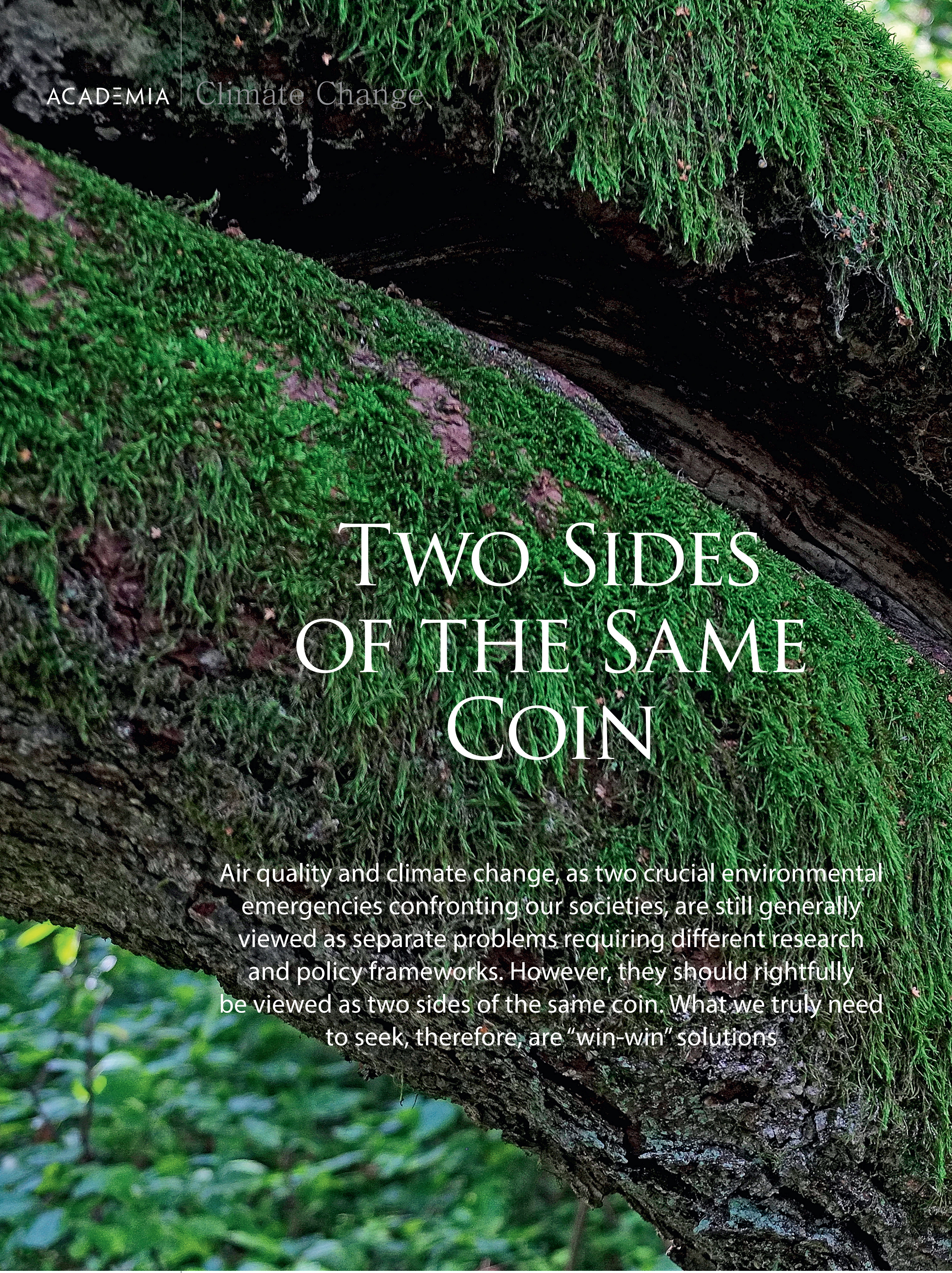


Two Sides of the Same Coin

Air quality and climate change, as two crucial environmental emergencies confronting our societies, are still generally viewed as separate problems requiring different research and policy frameworks. However, they should rightfully be viewed as two sides of the same coin. What we truly need to seek, therefore, are "win-win" solutions

Incentivizing wood-burning for household heating in lieu of fossil fuels (gas, oil), on the grounds that biomass combustion can be considered carbon-neutral, is actually a "win-lose" solution due to the large emissions of soot particles and other gaseous species so released.

Dr. Maria Cristina Facchini

Institute of Atmospheric Sciences and Climate
National Research Council, Italy

According to the World Health Organization (WHO) air pollution is the second leading cause of non-communicable diseases that are on the rise worldwide, and 4.2 million people die every year of causes attributable to air pollution. The latest WHO reports provide strong evidence in this respect, clearly linking especially long-term exposure to fine particles ($PM_{2.5}$) with deaths due to cardiovascular, respiratory diseases and cancer, as well as increased morbidity, particularly in children and asthmatics. According to the European Environmental Agency (EEA), more than 80% of the urban population in the EU Member States is exposed to particulate matter (PM) levels above the WHO guidelines.

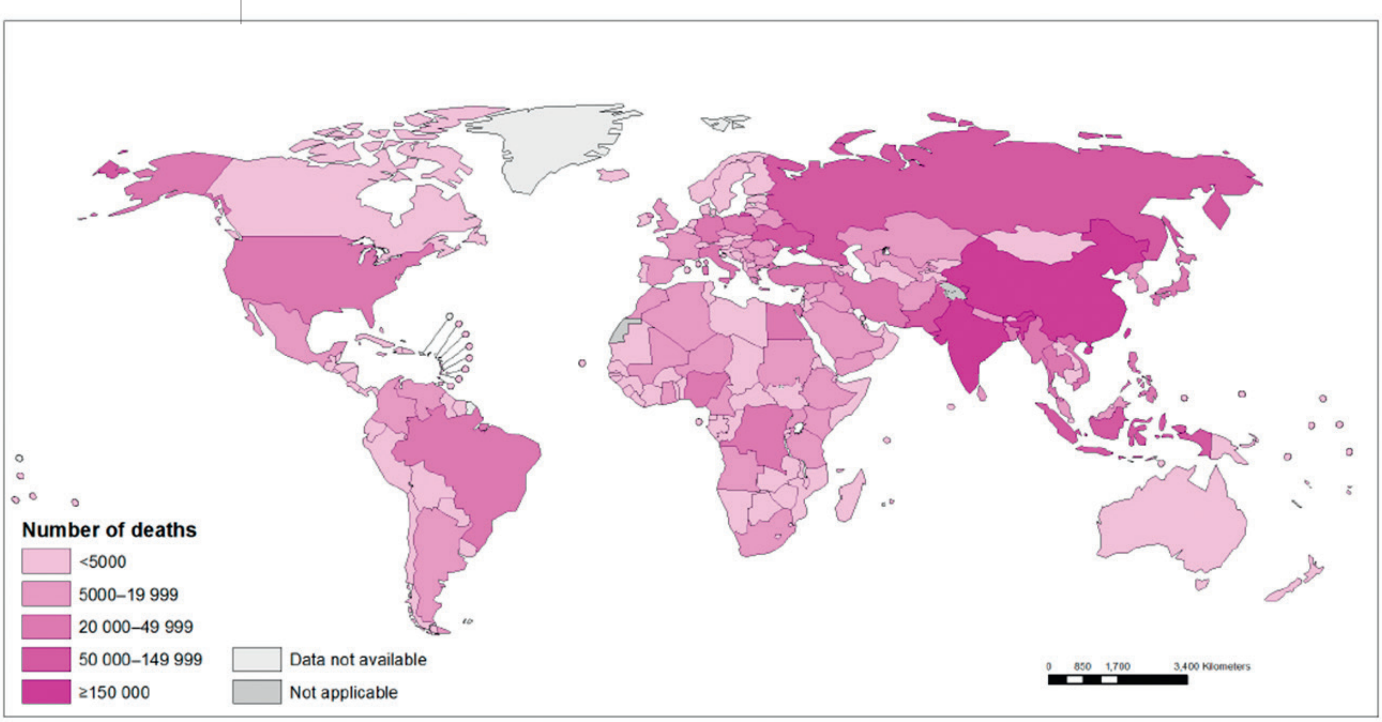
This translates into a decrease of life expectancy of more than eight months on average in Europe, and up to two years in the most polluted areas. Air pollution also causes significant damage to ecosystems and the environment. Ground level ozone (O_3), besides being harmful for human health, damages agricultural crops and vegetation. Nitrogen oxides (NO_X), sulfur dioxide (SO_2) and ammonia (NH_3) contribute to the acidification of soil, lakes and rivers, causing loss of biodiversity. NH_3 and NO_X also negatively impact upon water ecosystems by introducing excessive amounts of nutrients, in turn causing algal blooms and water hypoxia, a process known as "eutrophication."

On the other hand, as the recent Special Report of the Intergovernmental Panel on Climate Change (IPCC) "Global Warming of 1.5°C" (SR15) states, human activity is estimated to have already caused approximately 1.0°C of global warming above pre-industrial levels and global warming is likely to reach 1.5°C between 2030 and 2052 if it continues to increase at the current rate.

The SR15 also reports that impacts on natural and human systems from global warming have already been observed and that many land and ocean ecosystems, together with some of the services they provide, have already changed due to global warming. Sea levels have already risen by approx. 20 cm since pre-industrial times, Arctic sea ice continues to shrink, agricultural yields have already decreased in many parts of the world, and heath waves and extreme events are becoming more and more frequent in many parts of the world.

Atmosphere in the Anthropocene

Atmospheric pollution and climate warming both result from changes in chemical composition of the atmosphere due to anthropogenic activities. In fact,



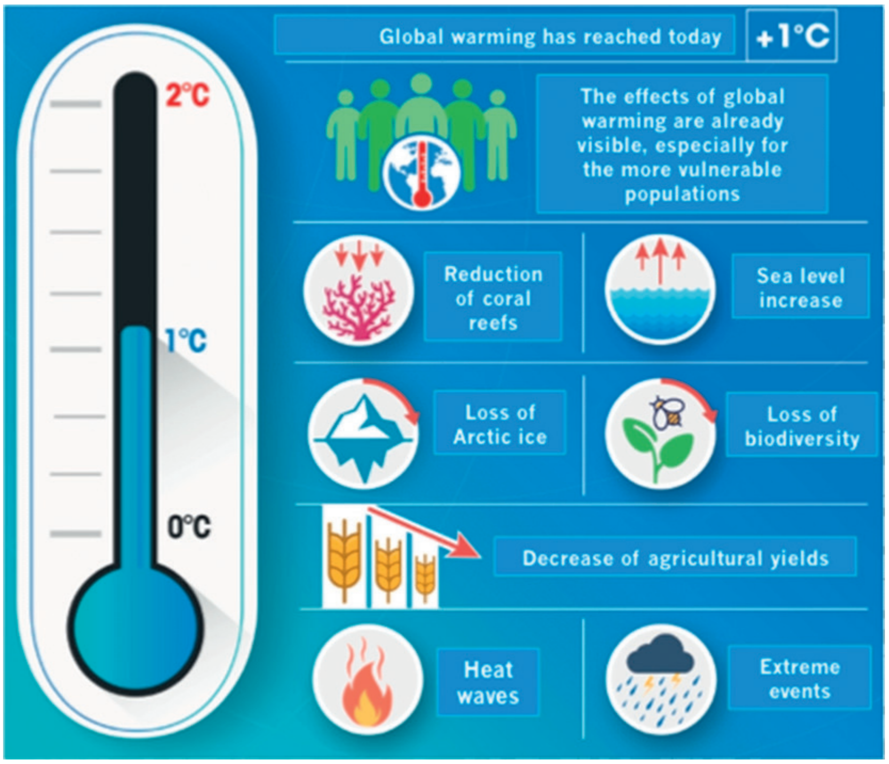
The boundaries and names shown and the designations used on this map do not imply the expression of any opinion whatsoever on the part of the World Health Organization concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. Dotted and dashed lines on maps represent approximate border lines for which there may not yet be full agreement.

Data Source: World Health Organization
Map Production: Information Evidence and Research (IER)
World Health Organization

World Health Organization

WHO

Deaths attributable to ambient air pollution in 2012, by country, as reported by the WTO.



GRAPHICS BY CMCC FROM THE IPCC SPECIAL REPORT SR15

Effects of global warming that are already being observed.

anthropogenic activities of all sorts (energy production, transportation, industry, agriculture, waste management) are responsible for the emission of gaseous and particulate pollutants that modify the atmospheric composition. Such changes are, in turn, responsible for the degradation of air quality at the regional/local scale as well as for the warming of the climate.

Over the past millennia of human history, the environmental changes induced by man have been negligible, given the small number of people on the planet and the very limited technologies available. Today, the magnitude, the spatial scale and the speed of the environmental changes induced by our societies have reached an unprecedented level, never before experienced in human history. The environmental processes induced by anthropogenic activities equal, and sometime exceed, the natural ones, their spatial extent extends at this point to the global scale and the speed at which the environmental changes proceed is on the order of years to decades, compared to a temporal scale of millennia that is typical of natural changes.

Some simple numbers provide a clue as to the causes of the recent environmental changes occurring at the global level:

- the global population more than doubled over the second half of the past century,
- cereal production tripled over the same period,
- energy production quadrupled,
- global production of goods increased five times.

In view of all theis evidence, the Nobel Laureate Paul Crutzen and the biologist Eugene Stoermer recently proposed that the Holocene, the geologic era that began ca. 12,000 years ago at the end of the last glaciation, should be seen as concluded and that the Earth should be viewed as having entered a new geologic era, called the Anthropocene, in recognition of the overwhelming role of mankind in the geology and the ecology of the planet.

Over six billion people now live on the planet, all of them with such fundamental needs as clean water, food, health, mobility, etc. The way in which these needs are met determine the environmental consequences at the global level (see Table 1). Most of the accelerated economic activity and energy consumption over the past decades have occurred in the developed parts of the world, but the new economies (e.g. China,

> Recent research has shown that there are opportunities for "win–win" scenarios that benefit both air quality and climate, while there are also measures that would benefit only one or the other ("win-lose" scenarios).

TABLE 1
Schematic representation of the anthropogenic activities responsible for the global environmental changes in different compartments of the Earth System and the individual and societal needs that induce these changes. Human needs are, in turn, also a function of social factors as the market, institutions, legislation, political systems and cultural values typical of each society

Compartment	Anthropogenic activities	Individual and societal needs determining global environmental changes
Terrestrial ecosystems	Deforestation, agriculture, land management	Food, recreational activities, shelter
Atmosphere	Fossil fuel combustion, land use change, industrial activities, waste management	Mobility, food, production of goods
Water	Water management, waste management	Water for human consumption, agricultural activities, industrial needs
Marine and coastal ecosystems	Land management, fishing, waste management, urbanization	Food, recreational activities, shelter
Biodiversity	Destruction of natural habitats, introduction of allochthonous species	Food, recreational activities, shelter

India, etc.) are now also having an increasing impact on the global environment and on atmospheric composition change.

Air quality and climate

Air pollution and climate change are, therefore, two intimately interconnected environmental issues. However, these two environmental challenges are still generally viewed as separate problems, dealt with by different research communities and within different policy frameworks. Indeed, many mitigation options offer possibilities to improve air quality and mitigate climate change but, at the same time, mitigation options that may provide benefits to one aspect are worsening the situation in the other. Therefore, coordinated action taking into account the air quality-climate linkages is urgently required.

In fact, it is not possible to unambiguously separate anthropogenic emissions into two distinct groups – atmospheric pollutants vs climate-forcing species (see the Table 2) – and moreover many of the same sources inject both climate-forcing species and air pollutants into the atmosphere. One straightforward example is the tailpipe of our car, which simultaneously emits CO_2 (a climate forcer), NO_X (an air pollutant) and PM (both a pollutant and a climate forcer).

Synergies and trade-offs

It has become clear through recent research that there are opportunities for "win–win" scenarios that would benefit both air quality and climate, while there are also measures that would benefit only one or the other ("win-lose" scenarios).

TABLE 2
Pollutant properties and climate effects of the main atmospheric trace compounds deriving from anthropogenic activities.

Compound	Pollution effect(s)	Climate effect
Carbon dioxide (CO_2)	Ocean acidification, affects photosynthesis	Long-lived climate forcer (warming)
Methane (CH_4)	Precursor of tropospheric ozone	Medium-lived climate forcer (warming)
Ozone (O_3)	Health and vegetation damages	Short-lived climate forcer (warming)
Sulfur dioxide (SO_2)	Health damages, ecosystem acidification	Precursor of PM sulfate (cooling)
Nitrogen oxides (NO_X)	Health damages, precursor of tropospheric ozone, ecosystem acidification, water eutrophication	Precursor of PM nitrate (cooling)
Ammonia (NH_3)	Ecosystem acidification, water eutrophication	Precursor of PM ammonium (cooling)
Particulate matter (PM)	Health damages	*Either cooling or warming
Volatile organic compounds (VOC)	Health damages, precursors of tropospheric ozone	Precursor of tropospheric ozone (warming)

*PM can, depending on particle composition, either absorb or scatter solar radiation, thus warming or cooling the climate.

DR. MARIA CRISTINA FACCHINI

Dr. Maria Cristina Facchini
is Director of the Institute of Atmospheric Sciences and Climate, National Research Council, in Bologna, Italy. She studies the interactions between climate and air pollution, physical and chemical processes in multiphase atmospheric systems (aerosols and clouds) and their effects on atmospheric composition and climate change.

The vast majority of climate change mitigation options will, at the same time, promote health and sustainable development. Win-win solutions are represented, for example, by placing a price on CO_2 emissions or by removing subsidies on fossil fuels. Also promoting greater use of renewables for electricity and household energy brings both air quality and air quality benefits.

One example of a win-lose solution, on the other hand, can be found in the incentives assigned by some countries to substituting wood burning for the use of fossil fuels (gas, oil) in household heating, on the basis that biomass burning can be considered carbon-neutral, since trees accumulate the same amount of CO_2 that is released when wood is burned. This may represent an advantage in terms of climate mitigation, but does not take into account the large emissions of soot particles and other gaseous species during wood combustion, which are extremely harmful for human health.

A schematic summary of synergies and trade-offs between air quality and climate change is represented in Fig. 1, where the upper-right and the lower-left quadrants represent win-lose policy options that benefit one aspect but that are detrimental for the other (air quality and climate, respectively, in the two cases), while only the upper-right quadrant represents win-win measures that mitigate both air quality and climate warming. The lower-left quadrant should, of course, not be considered since it clearly implies disadvantages for both climate change and air quality.

Emission abatement strategies are frequently intended only in terms of technological measures, such as any end-of-pipe technologies. Equally important are, however, the behavioral measures for which active citizen involvement is key (commuting habits, energy choices, waste disposal, dietary habits, etc.). To pursue individual behavioral changes of this type, social acceptability is key – there therefore needs to be reliable information provided to citizens, in addition to proper policy actions that favor the desired changes of lifestyles.

MARIA CRISTINA FACCHINI

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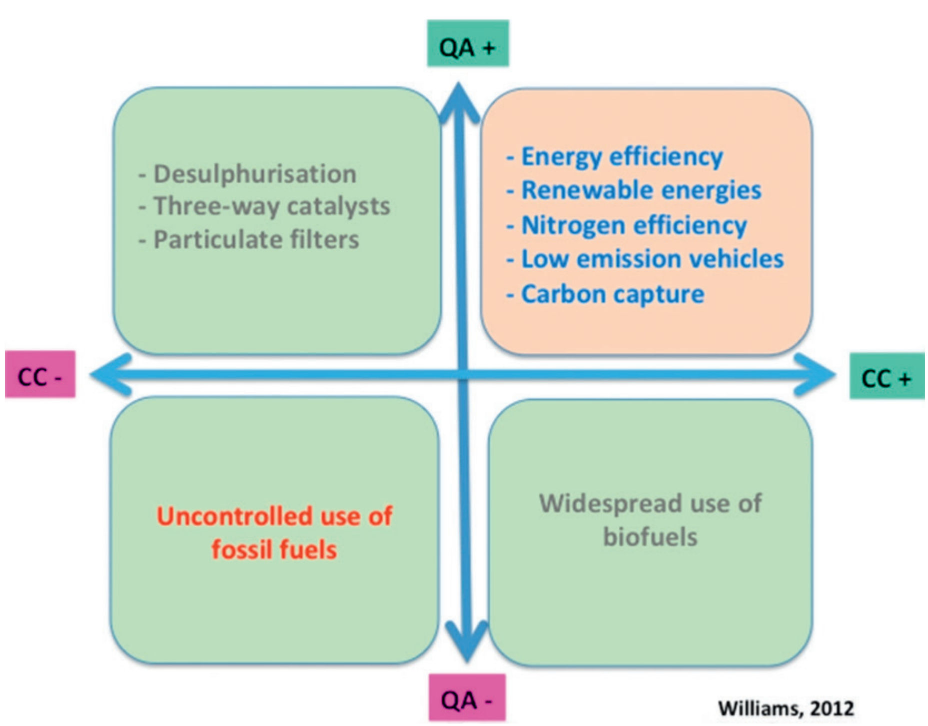

Schematic representation of synergies and trade-offs from policies and technologies that address climate change and air quality.