Tackling air pollution requires international cooperation

Scientific Assessment Report
of the UNECE Convention on Long-Range Transboundary Air Pollution

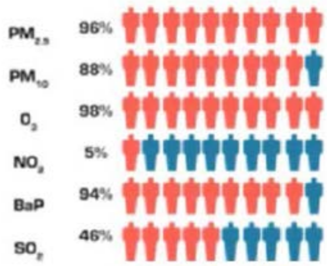
Summary for policy makers – draft 19 October 2015

1. More than 95% of the urban population in Europe is exposed to concentrations of fine particles (PM2.5) and ozone above the WHO guideline level. The current number of premature deaths associated with air pollution (nearly 600 000 within the UNECE region) is 10 times higher than the number of lethal traffic accidents. The costs of control are generally far less than the damage costs to health and environment. For industry the costs of absence from work due to air pollution only is higher than the cost of abatement measures.
2. International coordination of air pollution policy remains indispensable, as a substantial part of health and ecosystem impacts is caused by transboundary transport of pollutants. Effective reduction of the PM2.5 exposure of the urban population requires emission reductions of precursor emissions in a wider area: especially further reduction of ammonia is cost-effective.
3. While recovery of ecosystems from acidification is ongoing in some parts of Europe, excess deposition of nitrogen is currently a major cause of the loss of red list species. It stimulates dominant species such as grasses, bushes, algae and nettle. Reducing emissions of ammonia and nitrogen oxides is more cost effective than additional nature management to protect threatened species. There are many cost-effective ammonia measures within the agricultural sector, in particular for the largest 3% of livestock farms in Europe.
4. Current ozone concentrations reduce potential wood and crop production in Europe by up to 15%. Background concentrations of ozone, mercury and several persistent organic pollutants in Europe and North America are influenced significantly by emissions outside these continents. Reduction of background concentrations in Europe and North America therefore needs scientific and policy collaboration across the Northern Hemisphere, e.g. in order to identify cost-effective abatement options of precursor emissions of ozone (including methane).
5. Climate policy and air pollution policy cannot be seen separately. Energy savings and shifts in the energy mix have contributed to cleaner air and will continue to be important in the coming decades. However, promoting the use of biomass and biofuels could increase air pollution. Emission reduction of black carbon (e.g. from diesel and inefficient stoves) and methane can limit the speed of temperature increase in the next decades.
6. The net impact of abatement measures on national income and employment will be neutral as production of the technologies required, also create employment.
7. Ratification and implementation of CLRTAP protocols will enable an international level playing field for industries and prevent that countries competing with each other at the expense of environment and health within free trade zones.
8. Air pollution control is linked to several sustainable development targets, promoting e.g. healthy lives and well-being, sustainable energy, safe and sustainable cities and protection of ecosystems.

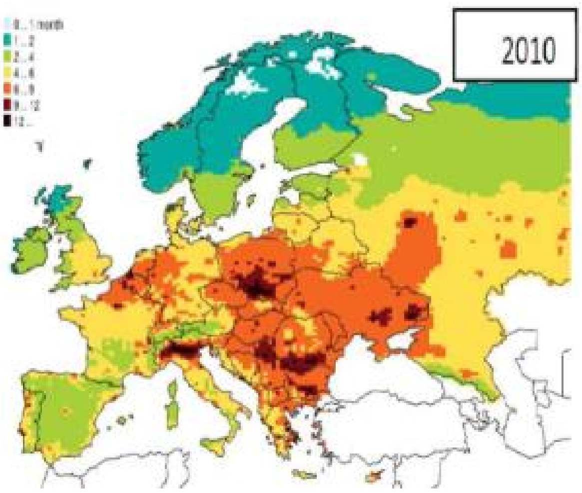
Air pollution causes damage to health and nature

Air pollution is still the number one environmental cause of premature deaths in Europe. A persistently high number of people are exposed to harmful pollutants in outdoor air, such as particulate matter (PM), ozone (O_3) and nitrogen dioxide (NO_2). Outdoor air pollution, particulate matter, one of its major components, and diesel engine exhaust have been classified as carcinogenic to humans by the International Agency for Research on Cancer. In 2014, the World Health Organization (WHO) published its latest estimates of the burden of disease related to ambient (outdoor) and household (indoor) air pollution. For 2012, 576,000 premature deaths were attributable to ambient air pollution and 118,500 premature deaths to household air pollution in the ECE region (including ECE member States in North America). The majority of these deaths were due to cardiovascular, cerebrovascular and respiratory diseases, as well as lung cancer.

The current number of premature deaths due to air pollution is 10 times higher than due to traffic accidents. The number of life years lost in Western Europe due to outdoor air pollution is twice as high as in North America (OECD, 2014).The number of life years lost in EECCA-countries (including West-Balkan) is 20% higher than in Western Europe (WHO, 2015). The average loss in life expectancy in Europe due to fine particles is estimated by IIASA to be about 5 months, but in several urban areas the loss of life expectancy is more than 12 months. In a recent public opinion survey air pollution was mentioned as the number one concern of the public (Eurobarometer, 2014).

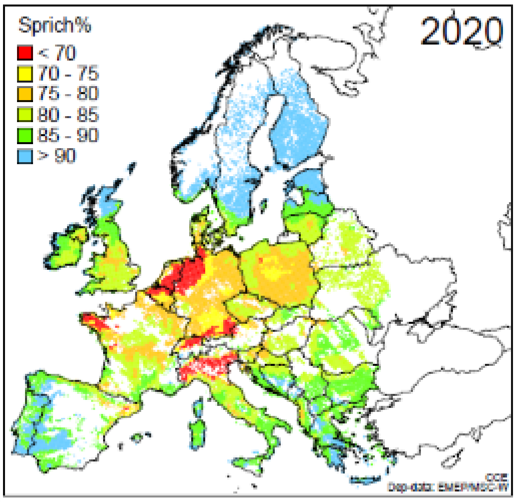


More than 95% of the EU population is living in areas above WHO air quality guideline levels of PM2.5 and ozone (O_3)



The loss in life expectancy due to PM2.5 in months per person is largest in the dark red areas

Air pollution also causes damage to nature. Deposition of sulphur and nitrogen leads to acidification of soils and waters and ecosystems in large areas of Europe and eastern North America have been affected. The major reduction of emissions of sulphur dioxide (SO_2) since its peak around 1980 has reduced depositions. In some parts recovery of forests and lakes is ongoing, although in many parts the acidification is continuing but at a much slower pace. Excess deposition of ammonia (NH_3) and nitrogen oxides changes the vegetation and many protected species are displaced by dominant species such as grasses, bushes and nettle. This may have a knock-on effect on butterflies, other insects and birds. Excess nitrogen deposition could lead to an increase of plants and insects that cause allergies or diseases and contributes to algae bloom in water ecosystems together with other sources of nitrogen pollution.



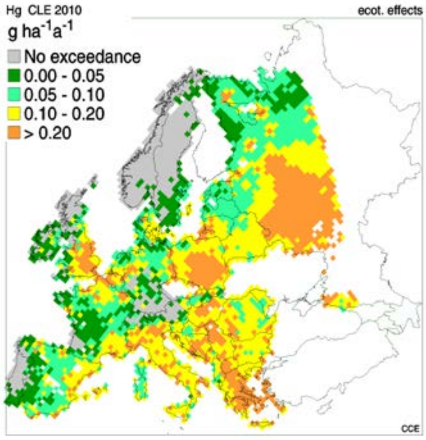
Red colors show areas where less than 70% of the plant species in grassland is protected against excess nitrogen deposition
Rare (red list) species are substituted by dominant species such as nettle

For the European UNECE region the total economic costs due to premature death are estimated at around €1 trillion (WHO, 2015). Costs of illness (e.g. hospitalisation and medicine use) due to air pollution are estimated to add 10% to this amount. In half of the UNECE countries the total health costs due to air pollution is more than 10% of GDP (WHO, 2015). Air pollution also has consequences for industry: it causes 5-10% of the absence from work due to sickness. For the EU28 it was estimated that the emission reductions proposed by the European Commission would lead to more cost-reductions for industry due to less sickness absence, than the costs of additional air pollution abatement measures (EC, Impact Assessment, 2013).

Up to 15% of the production of crops and wood in Europe is lost due to ground level ozone, depending on species sensitivity (source: ICP-Vegetation). The economic damage to wheat production alone in the European EMEP is already € 4.6 billion annually. Ozone could also affect future agricultural productivity due to decreased pollination. The damage from air pollution to materials and cultural heritage in Europe is estimated to be more than € 2 billion per year (Source: ICP-Materials).

Heavy metals and persistent organic pollutants are known for their toxicity and have adverse effects on human health and the environment (carcinogenicity, mutagenicity, reproduction toxicity, endocrine disruption, etc.). Due to accumulation of some toxics along food chains and in individuals even low environmental concentrations can lead to significant exposures over time.

Despite a decline in emission levels and the number of ‘hot spots’ close to industrial regions, long term risks for human health and the environment continue to exist in many UNECE countries. E.g. in a number of countries critical loads for mercury are still exceeded.



Critical load exceedance of mercury in 2010. Orange regions indicate regions with a high degree of accumulation in soil and ecosystems (source: /CCE)

Air pollution is more than a local problem

In several European cities a significant part of the concentrations of fine particles is caused by long-range transport and consists of ammonium-nitrate and ammonium-sulfate (so-called secondary particles that are formed in the air out of emissions of ammonia, sulphur and nitrogen oxides). Moreover it has become clear that ozone concentrations are to a large extent influenced by transboundary and even transcontinental transport of its precursors: NO_x, volatile organic compounds (VOC) and methane. Local actions alone will for many cities not be sufficient to meet WHO guideline levels. National and international co-ordinated actions will continue to be indispensable for reaching such a target. Even actions beyond the current CLRTAP mandate will be needed that could require new policy fora or legal instruments.

Smog episode over Paris, 18 March 2015. Transboundary fluxes contributed significantly to the PM concentrations and the high share of ammoniumnitrates.

Also for mercury and some persistent organic pollutants intercontinental transport is becoming an important issue. Many of the local hotspots have been tackled and the remaining challenge is to reduce the global background level. This global aspect has also been the reason for the foundation for the Stockholm Convention on Persistent Organic Pollutants and the Minamata Convention on Mercury.

Solutions are available

In the past much of the reduction of air pollution was the combined effect of end-of-pipe abatement measures and structural changes in the energy, transport and agricultural systems. Also in the future trends in air pollution will be closely related to developments in the use of fossil fuels and developments in transport and livestock. Future air quality could profit from climate and energy measures or an environmentally friendly agricultural policy. Sufficient technical measures are available to further reduce emissions from e.g. combustion installations, vehicles, ships and farms that would be needed to reach the WHO guideline levels for fine particles and ozone in most places in Europe and to avoid excess nitrogen in most European nature areas. For heavy metals and persistent organic pollutants, a variety of measures are available and coordination with other conventions and policy frameworks can provide opportunities for solutions. However, the geo-atmospheric cycling of POPs and mercury includes not only atmospheric transport and transformations but also interactions with the earth´s surface. Therefore, re-emissions and transport and circulation in aquatic and biological systems are important factors to be taken into account in finding long term solutions.

Socio-economic effects will be positive

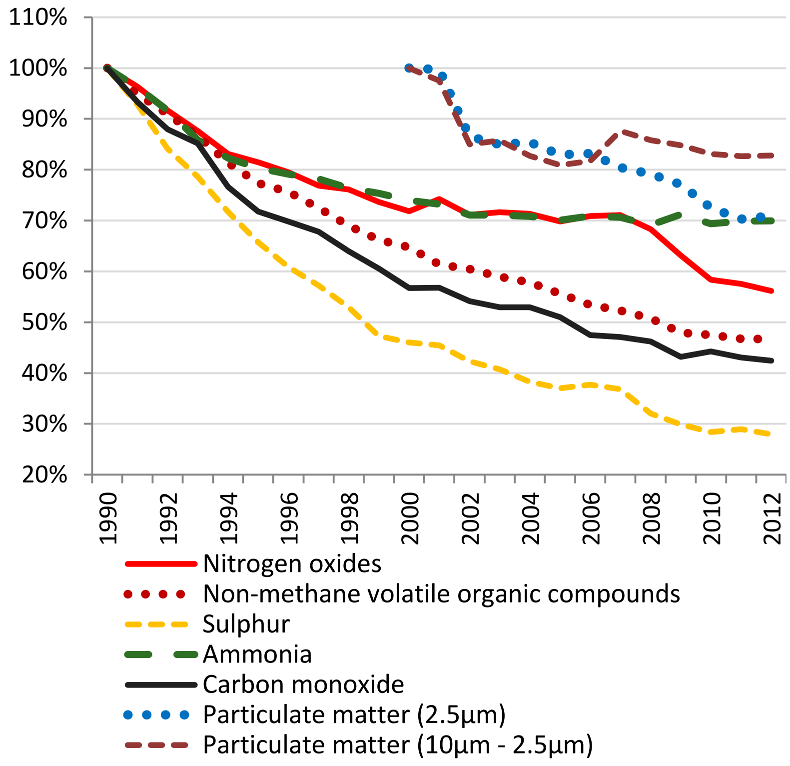
The direct costs of additional measures as proposed by the European Commission for EU-countries will be less than 0.01% of the European GDP. Economic models show that some sectors will lose jobs (e.g. the fossil fuel sector); but that other sectors will gain jobs (e.g. the building and equipment sectors). The total impact on employment will be negligible. In the long run environmental policy will favour the economy as it stimulates more efficient use of resources.

Some economic benefits of additional abatement measures for health, e.g. less absence due to sickness, will be felt immediately. On the longer run health benefits would increase GDP by up to 10% (WHO, 2015)

With an international co-operative approach each country would also benefit from reduced transboundary pollution. A larger market for clean technologies will reduce the costs of producing the required equipment and thus the abatement measures. Countries that move first expand their possibilities for a growing clean tech industry.

Learning from the past: the acidification case

The current challenges for reducing health effects from fine particles are comparable to the acidification of lakes and forest soils that was revealed in the 1970s. This acidification problem was successfully managed with an international co-operative approach (see text boxes on the acidification case, ‘common understanding of complexity’ and ‘A world avoided’).



Air pollution emissions in the ECE-region between 1990 and 2012 (excluding Canada and the United States of America). Sulphur has the steepest decline (Source: EMEP-Centre for Emission Inventories and Projections)

Substantial decrease of lead pollution was an important side-effect of the efforts to reduce nitrogen oxides emissions. The introduction of advanced cleaning technologies for gasoline cars required lead-free fuels. Lead pollution levels in the UNECE countries were reduced by almost 80% during period 1990-2012. The highest reduction rates took place in the beginning of the period, reaching 15-18% per year in a number of countries (e.g., Finland, Denmark, Germany, Spain, Norway etc.).

Air pollution as a global problem

Reductions of ozone precursors generated a reduction in peak ozone exposure since the 1990s. However the burden of disease from ozone is not restricted to exposure during occasional air pollution peaks, but also comes from longer-term exposure to ozone.. Background concentrations of ozone in Europe don’t show a significant downward trend. Concentrations in Europe and North America are for a substantial part the result of emissions in other parts of the Northern Hemisphere and reduction will require broader international co-ordination than the European or North American scale.

This is also the case for some persistent organic pollutants, e.g. HCB, dioxins and PCBs, and mercury, where measures within the CLRTAP-area will not be sufficient to significantly reduce concentrations: The LRTAP Convention is promoting scientific collaboration on the Northern Hemispheric scale through its Task Force on Hemispheric Transport of Air Pollution.

Also the LRTAP Convention seeks to increase synergies and cooperation with other international conventions, programs and policies (e.g. the Stockholm Convention, the

Minamata Convention and others, the Arctic Monitoring and Assessment Programme under the Arctic Council, and the regional sea conventions such as HELCOM and OSPAR).

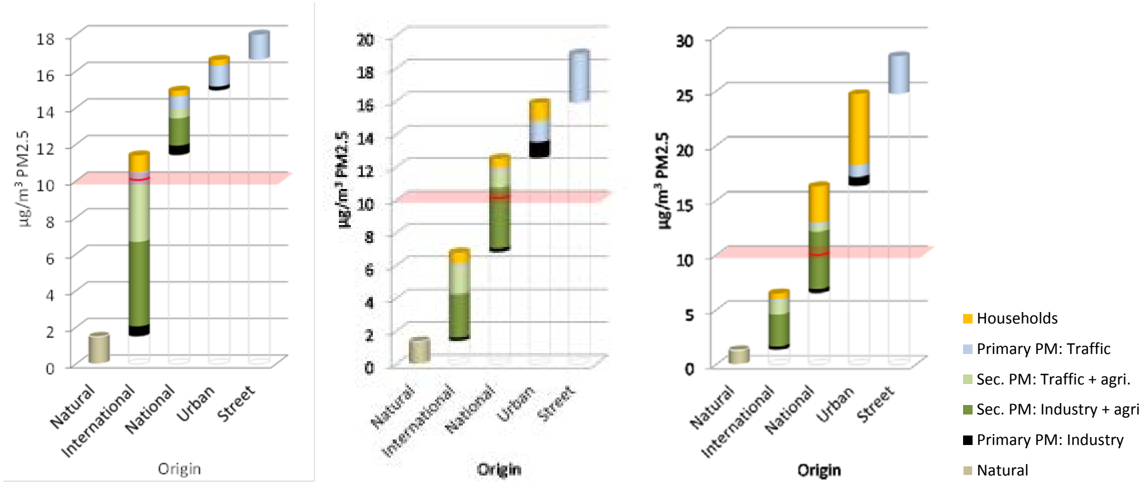
Actions at different levels

The air pollution policy agenda is currently dominated by public health concerns both in cities and in international policy fora. Monetised health damage exceeds estimates for other damage categories (such as crops and materials). Damage to ecosystems comes in addition, but is difficult to monetise. Abatement costs are significantly lower than the benefits from reduced damage. Episodes with high levels of pollution raise public concern, cause health complaints and make air pollution literally visible. Several local initiatives are taken to develop 'healthy' cities. But cities cannot reduce the air pollution levels down to the WHO guideline levels on their own, since sources outside the cities often contribute significantly to local air pollution concentrations, and may sometimes even be the dominating factor. Local air pollution risks are still a transboundary phenomenon in many cities of Europe. A reduction of exposure to fine particles (PM2.5) to the recommended concentrations will not only require local reductions of emissions of primary particulate matter in cities (such as black carbon), but also of precursor emissions of secondary particles in a much wider area: sulfur dioxide, nitrogen oxides (NO_x), ammonia (NH_3) and volatile organic compounds (VOC).

In several cities in Europe a major part of the concentrations of fine particles consist of secondary particles that are formed in the atmosphere during air pollution transport and are the result of emissions in other cities as well as rural areas. Ammonia is a crucial contributor to the formation of ammonium-sulfate and ammonium-nitrate, the most common secondary particles[1]. European wide emission reductions of these precursor emissions will be indispensable to meet the WHO guideline level for fine particles of 10 $\mu g/m^3$. Meeting this guideline level would reduce the average loss of life expectancy in Europe with almost 6 months compared to the 2005 situation. Besides these health benefits, better nature protection due to reduced deposition of nitrogen would be a co-benefit.

[11] The formation of secondary organic aerosols can become more important in the future when more biogenic aerosols are released from forests as a result of temperature increase.

Netherlands **Germany** **Poland**



In several countries local PM2.5 levels are strongly influenced by secondary particles (ammonium sulphate and ammonium nitrate) from transboundary sources (IIASA, TSAP12, 2014)

Actions at different levels to reduce air emissions

At the continental level:

- Make sure that vehicle emission standards work in reality
- Implement climate & energy targets
- Set emission standards for non-road mobile machinery, domestic stoves and installations for biomass burning
- Set ammonia emission standards for large cattle farms

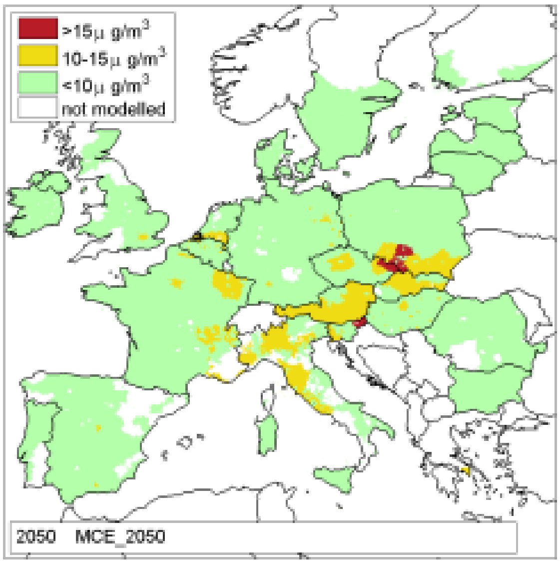
At the national level:

- Implement control on maintenance schemes for vehicles
- Stimulate scrapping of old vehicles and motorcycles
- Ratify and implement CLRTAP Protocols
- Implement climate and energy policies
- Enforce emission standards for farms and domestic stoves

At the local level:

- Implement low emission zones to encourage early scrapping of old vehicles
- Introduce speed limits on highways near urban areas
- Stimulate electric vehicles
- Improve infrastructure for public transport, cycling and walking (embed air pollution policy in healthy city designs)

Based on the proposed climate and energy measures in the context of the UN Framework Convention on Climate Change and implementation of technically available abatement measures, WHO guideline values for fine particles could become feasible in most parts in Europe in the coming decades.



Red and orange colors show regions where WHO guideline levels still will be exceeded in 2050 after implementation of climate and energy policies needed to meet the 2-degrees target of the UN-FCCC and an shift towards low-meat diets. Source: IIASA, 2014

Synergies

Air pollution policy is closely linked to climate and energy policy as well as to agricultural and biodiversity policies.

Most climate policy measures will contribute to cleaner air and have health and ecosystem benefits. Pollutants like SO_2, NO_x, VOC and PM2.5 result to a large extent from the use of fossil fuels. Like in the last decades, future changes in the fuel mix and measures to increase energy efficiency will in general not only lead to a reduction in emissions of carbon dioxide, but also of SO_2, NO_x, VOC and PM2.5. Also emissions of mercury and combustion-related POPs will go down when less coal is being used. In some cases climate measures could lead to more air pollution, without additional measures: wood stoves or the use of biofuels being the most prominent examples.

Air pollution also has a short term regional climate effect. Some pollutants act as cooling agents (e.g. sulphates and others giving white particles), while other contribute to warming (black particles, ozone and its precursors). To balance the climate impact of air pollution policy, sufficient attention should be paid to the abatement of black particles, e.g. from diesel cars. The Euro-6 standards include such an approach. The use of biofuels is also an example where air pollution and climate impacts need to be addressed together.

Current knowledge indicates that ozone concentrations will increase in a warmer climate. In order to avoid this, more efforts would be required to abate ozone precursors in the Northern Hemisphere: in addition to current policies to reduce emissions of NOx and volatile organic compounds, reduction of emissions of methane is most effective. This would require a co-ordinated policy that goes beyond the current domain of the LRTAP Convention and would also include major polluters in Asia. Particularly, future methane emissions controls are of major importance for controlling ozone concentrations in the next decades.

Future ammonia emissions are not linked to the future use of fossil fuels, but more to the development in livestock and diets. Current knowledge indicates that ammonia emissions will increase in a warmer climate. Ammonia related problems such as the exposure of the population to secondary particles and the loss of biodiversity in nature areas will remain the responsibility of air quality managers. Some measures to reduce ammonia emissions would imply financial benefits as they include a more efficient use of nutrients. The potential of technical options to reduce ammonia emissions is significant, but more limited than for SO_2 or NO_x. Non-technical options could include a reduction of livestock densities in and around sensitive nature areas, a reduction of food waste and stimulating low-meat diets. Diets that require less meat production will lead to less manure and less ammonia emissions.

The introduction of the catalytic converters in the 1990s also required a ban on the use of leaded petrol, which drastically reduced lead related health impacts. Reduction of primary emissions of fine particles could also have co-benefits in terms of less exposure of the population to some heavy metals and persistent organic pollutants.

Ratification

Ratification and implementation of LRTAP protocols would for many parties reduce health and environmental impacts in a more cost-effective way than with unilateral action. It would also enable a level playing field for industries, and prevent parties to compete with each other at the expense of environment and health. This can prove to be important in free trade negotiations, e.g. with EECCA countries or in settling disputes between governments and industries in the proposed Transatlantic Trade and Investments Partnerships (TTIP).

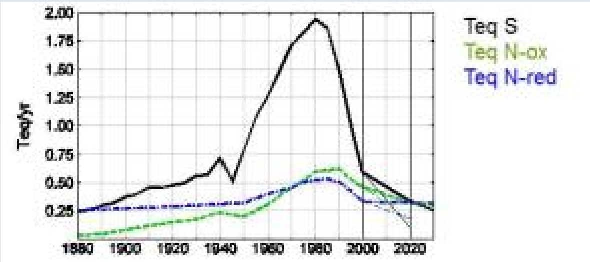
The LRTAP Convention offers a platform for mutual learning and finding solutions. The more parties ratify the protocols, the larger the scale of the market for cleaner technologies will become, and the lower the costs of such technologies. This offers advantages to all parties involved.

Towards sustainable development

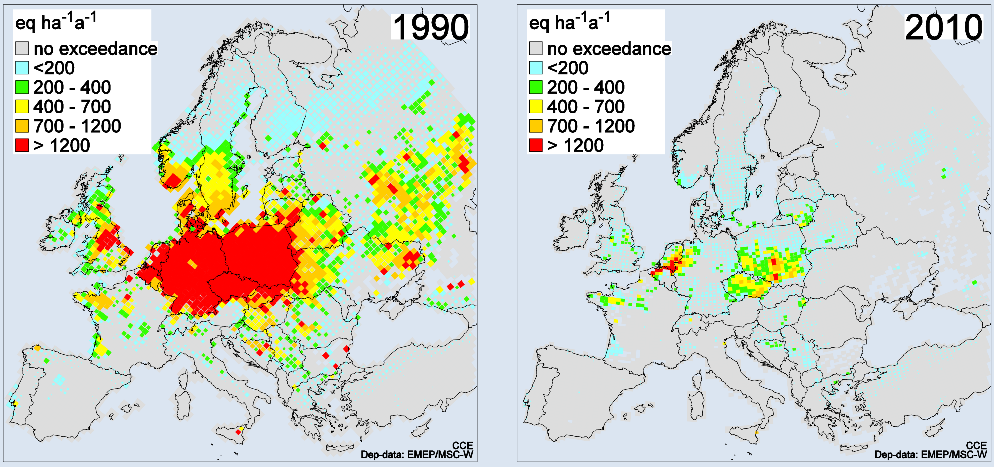
Air pollution is linked to several sustainable development indicators. WHO has identified air pollution as one of the top10 causes of the global burden of disease. Air pollution policy can significantly contribute to the sustainable development target to promote healthy lives and well-being in the world. Abatement of air pollution also contributes to other sustainable development goals e.g. ‘access to sustainable and modern energy’; ‘safe and sustainable cities’; as well as to ‘protect terrestrial ecosystems’.

Learning from the past: the acidification case

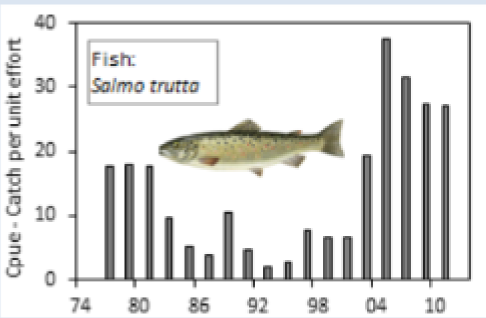
In the 1950s and 1960s local air pollution problems were mainly tackled by building higher stacks, thus diluting air pollution over a larger region. In the 1970s long-range impacts became visible: fish in Scandinavian lakes died due to increased acidification of the water. In the 1980s the acidification of forest soils was identified in large parts of Europe. These long-range impacts were the reason to start joint measurement and modelling efforts as well as policy negotiations under the Convention on Long-Range Transboundary Air Pollution. Over the years the mutual exchange of information between scientists and policy makers paid off in sharp emission reductions in all European countries, especially for sulphur dioxide (SO2).



Due to the strong decrease in emissions of sulphur in combination with a less pronounced decrease in emissions of nitrogen compounds, the deposition of acidifying compounds has been reduced to levels below the critical loads of acidity for forest soils in large parts of Europe. In areas with remaining exceedances of critical loads of acidity and with still progressing acidification, the deposition of acidifying compounds is increasingly dominated by nitrogen compounds.



Acidification of soils has stopped in most parts of Europe: area with exceedances of the critical loads of acidity decreased drastically between 1990 (left) and 2010 (right). Source: deposition data from MSC-W; critical loads data from the CCE)

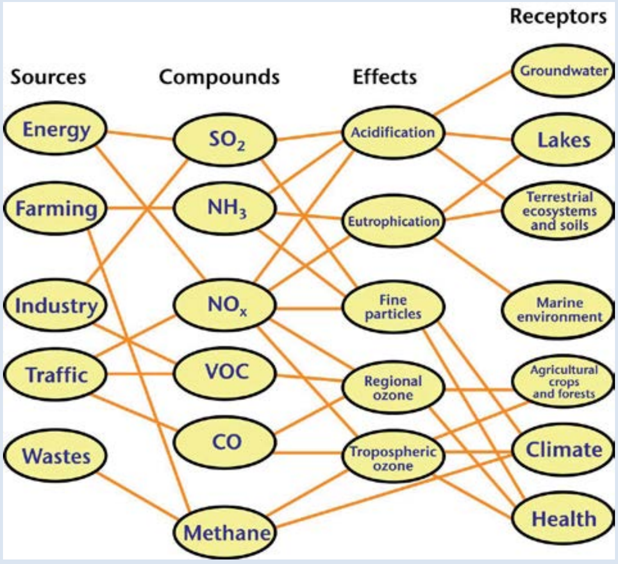


Fish is returning in Scandinavian lakes (Lake Saudlandsvatn, Norway) Source: Hesthagen et al. 2011 Sci Tot Env.

Common understanding of complexity

An important factor for success for air pollution abatement was the development of a common knowledge base including a scientific infrastructure aimed at joint monitoring and modelling programs. Moreover the frequent exchange of information with policy makers created mutual trust and learning. In contrast to the first technology and cost based protocols, in the 1990s an effect oriented approach was used in the second Sulphur Protocol, aiming at the most cost-effective way to reach acidification targets.

In the 1990s it was recognised that various air pollutants interact in the atmosphere, that they lead to combined impacts and that they often are caused by the same sources. This made a substance-by-substance approach less efficient and was the reason to develop a so-called multi-pollutant-multi-effect approach, including SO_2, NO_x, NH_3, VOC. The 1999 Gothenburg Protocol was the first protocol aimed at a cost-effective abatement of acidification, eutrophication and ground-level ozone impacts on human health and the environment. Later on the health impacts of fine particles were included in the analyses as well as the interactions with climate change.



(Revised from Grennfelt et al. 1994)

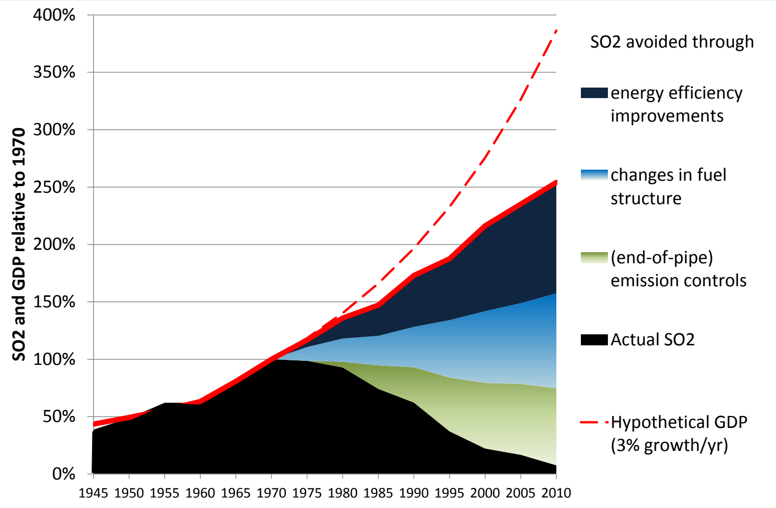
Over the past 40 years the LRTAP Convention has developed an extensive international network of scientists of various disciplines. Typical for the Convention is the frequent interaction between policy makers and scientists, which enabled a long term learning process, mutual trust and a common language. Joint measurement and modelling efforts created a common understanding of air pollution problems. The integrated assessment model GAINS played a central role in the communication between scientists and policy makers. It reflects the future expectations and the costs and impacts of policy options and enables to find the most cost-effective way to meet policy ambitions. The Task Force on Techno-Economic Issues assists the parties in exchanging knowledge on potential abatement measures.

With the Task Force on Hemispheric Transport of Air Pollution the scientific network is being extended across the Northern Hemisphere in order to compare models to assess the long range impacts of emission scenarios across the different continents: Europe, Asia and North America. This is a first step towards a co-ordinated approach to tackle hemispheric issues such as ozone and mercury.

Complexity is also enhanced due to the inevitable links between air pollution and climate change which increased the need for closer co-operation with climate experts of the UN-FCCC. Further co-operation on the issue of black carbon and other short lived climate pollutants is foreseen with UNEP, the Arctic Council and the Coalition on Clean Air and Climate.

A world avoided

The acidification case is even more impressive when we take into account the continued economic growth in the past decades. Without measures sulphur emissions would have more than doubled over the past 30 years, while in practice emissions decreased by more than 75%. Technological solutions such as flue gas desulphurization, low-sulphur fuels and catalytic converters in cars were applied and the costs became lower as more countries applied these cleaner technologies. Environmental measures contributed to one-third of the decoupling between production and consumption growth and the development of emissions. Energy policy and general technological progress also played a significant role in decoupling production and consumption growth from the development of emissions: coal was substituted by gas and non-fossil energy and products and production processes became more energy efficient. Also in the future air pollution trends will be influenced by both environmental measures and energy policy.



After 1980 actual SO_2-emissions in Western Europe did not increase at the same rate as GDP. Decoupling was the result of end-of-pipe abatement measures, changes in fuel mix and increased energy efficiency. Source: Rafaj et al, (2013) Climatic Change 24(3)477-504, (2014) Sc.Tot. Env. 414

If no decoupling of economic growth and air pollution trends would have occurred, the total exceedance of the critical loads for acidification in Europe would have been 30 times higher than the current exceedance. The total exceedance of the critical loads for nitrogen would have been 3 times higher. Average PM2.5 exposure would have reached levels that are currently measured in the Po-valley. Health impacts from PM-exposure would have been 3 times higher and 600.000 more people would have died prematurely. Compared to this hypothetical world avoided 12 months of average life expectancy has been gained. The health impacts from ozone would have been 70% higher and ozone damage to crops would have been 30% higher. Model studies suggest a strong influence of the rising hemispheric background on ozone impacts to crops.