Executive summary

Air pollution is one of the most serious environmental risks, particularly in big cities and highly populated areas. Previous work by the World Health Organisation (WHO) and others has demonstrated the alarming consequences of outdoor and indoor air pollution for human health, especially a large number of pollution-induced premature deaths. Projections of the global economic consequences of future air pollution have however been entirely lacking.

This report provides a comprehensive assessment of the regional and global economic consequences of outdoor air pollution in the coming decades. While both outdoor and indoor air pollution are currently responsible for serious health impacts and economic consequences, economic growth in the coming decades will lead to a deterioration of outdoor air quality in particular. For this reason, the present report focuses on the future economic consequences of *outdoor* air pollution.

The report addresses the impacts of outdoor air pollution on mortality, morbidity (illness), and changes in crop yields as caused by high concentrations of particulate matter ($PM_{2.5}$) and ground level ozone. Other impacts, such as those on ecosystem services, buildings or visibility, and the direct health impacts of nitrogen dioxide (NO_2), have not been quantified owing to insufficient reliable data at the global scale. The projections of the consequences of outdoor air pollution reflect the future biophysical impacts and economic costs of air pollution in the absence of additional policies. The projections thus quantify the costs of inaction, the benchmark against which the benefits of additional policy action can be evaluated.

The analysis covers the period 2015-2060 and presents the projected economic consequences of outdoor air pollution for different types of costs. First, the market costs of outdoor air pollution, focusing on labour productivity, health care expenditures and changes in crop yields, are assessed with a multi-regional, multi-sectoral dynamic general equilibrium model. The modelling approach links economic activity to emissions of air pollutants, concentrations, biophysical impacts and feedback effects from these impacts on the economy. Second, the non-market health impacts of outdoor air pollution (mortality and morbidity) are assessed and monetised. These monetised non-market impacts do not reflect actual costs to the economy, but are obtained using results from studies that directly value the individual willingness-to-pay for reducing health risks.

Inevitably, uncertainties concerning the economic projections, the quantification of the biophysical impacts of outdoor air pollution, and the evaluation of costs mean that the results need to be interpreted with due caution. However, this report provides for the first time projections of the regional and global magnitude of the economic consequences of one of the most severe environmental challenges.

Key messages

Increasing economic activity and energy demand will lead to a significant increase in global emissions of air pollutants to 2060 in the absence of more stringent policies. This is based on projections obtained from the OECD's ENV-Linkages model, which includes pollutants such as sulphur dioxide (SO_2), nitrous oxides (NO_x), and black carbon (BC). Despite a partial decoupling of economic activity and air pollutant emissions in some areas, emissions are projected to grow particularly rapidly in regions with higher economic growth or with increasing shares of energy and energy-intensive sectors (especially coal-based electricity generation), such as South and South East Asia and the Sub-Saharan Africa regions. Thanks to more stringent policies, emissions from OECD countries tend to be stable or to decline in the short and medium run, then flatten out or increase again as the effects of the current policies fade.

Rising emissions of air pollutants are projected to lead to increasing concentrations of particulate matter ($PM_{2.5}$) and ground level ozone. In many places, concentrations of $PM_{2.5}$ and ozone are already well above the levels recommended by the WHO Air quality guidelines. Population-weighted average $PM_{2.5}$ concentrations are already high and rapidly rising in South and East Asia, especially the People's Republic of China (henceforth "China") and India. In large parts of North America, Europe and Africa, $PM_{2.5}$ concentrations from anthropogenic sources are also high but are not projected to rise as quickly. Ozone concentrations are particularly high in Korea, the Middle East and the Mediterranean, but they also exceed air quality guidelines in many other OECD and non-OECD regions. These areas are the most polluted at present and remain so in the projections for the coming decades. High average population-weighted concentrations mean that in many areas – and especially in large cities – air pollution is permanently above recommended levels; furthermore, for several days per year, they may reach levels that are extremely dangerous for human health.

The most dangerous consequences from outdoor air pollution are related to the number of premature deaths. This report projects an increase in the number of premature deaths due to outdoor air pollution from approximately 3 million people in 2010, in line with the latest Global Burden of Disease estimates, to 6-9 million annually in 2060, in the absence of more stringent policies. By 2060, a large number of deaths are projected to take place in densely populated regions with high concentrations of $PM_{2.5}$ and ozone (especially China and India) and in regions with aging populations, such as China and Eastern Europe. The projected mortality effects of $PM_{2.5}$ exposure are much larger than those of ozone.

In addition, increasing concentrations of $PM_{2.5}$ and ozone are projected to lead to substantially more cases of illness. This will imply more hospital admissions, additional health expenditures, a high number of lost working days and limitations to normal daily activities. It is projected that the air pollution-related healthcare costs will increase from USD 21 billion (using constant 2010 USD and PPP exchange rates) in 2015 to USD 176 billion in 2060, reflecting both a large number of additional cases of illness due to air pollution, and a projected increase in the healthcare costs per illness. By 2060, the annual number of lost working days, which affects labour productivity, are projected to reach 3.7 billion (currently around 1.2 billion) for the world.

The market costs of air pollution, flowing from reduced labour productivity, additional health expenditures and crop yield losses, are projected to lead to global annual economic costs of 1% of global gross domestic product (GDP) by 2060. The projected GDP losses are especially large in China (–2.6%), the Caspian region (–3.1%) and Eastern Europe

(Non-OECD EU –2.7% and Other Europe –2.0%), where air pollution impacts lead to a reduction in capital accumulation and a slowdown in economic growth.

In addition to the market costs, the report also presents projections of non-market costs associated with increased mortality and morbidity due to outdoor air pollution. These non-market costs (also referred to as welfare costs) differ from market costs in that they are based on people's expressed willingness to pay to reduce health risks and do not represent an actual cost to the economy. They provide a useful indication for policy makers of the importance of the health impacts of outdoor air pollution.

The annual global welfare costs associated with the premature deaths from outdoor air pollution, calculated using estimates of the individual willingness-to-pay to reduce the risk of premature death, are projected to rise from USD 3 trillion in 2015 to USD 18-25 trillion in 2060. In addition, the annual global welfare costs associated with pain and suffering from illness are projected to be around USD 2.2 trillion by 2060, up from around USD 300 billion in 2015, based on results from studies valuating the willingness-to-pay to reduce health risks. In per capita terms, the average global welfare costs from mortality and morbidity are projected to increase from less than USD 500 per person in 2015 to around USD 2 100-2 800 in 2060.

The potential economic consequences of both the market and non-market impacts of outdoor air pollution are very significant and underscore the need for strong policy action. Policies to limit air pollution emissions would lead to an improvement in air quality, reduce risks of very severe impacts, as well as generate considerable climate co-benefits. However, as both the sources of air pollutant emissions and the consequences of outdoor air pollution on human health and the economy are very unequally distributed across different regions, policies that reduce pollution levels and protect vulnerable groups of the population from the worst health impacts must be at the heart of an optimal policy mix.