Science for Environment Policy
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SPECIAL ISSUE

Air Quality and Emissions Trading

Issue 4 May 2008

Editorial

The new EU Directive on ambient air quality and cleaner air for Europe and the proposed amendments to the EU's Emissions Trading Scheme (ETS) will drive changes in EU contributions to harmful pollutants and greenhouse gases in the atmosphere. New targets have been set in the Air Quality directive to reduce exposure to fine particles and reduce risks to human health. In January 2008, the European Commission proposed a number of changes to improve and extend the EU's ETS to further reduce GHG emissions. The ETS is the major market-based policy used by the EU to effect climate change strategies.

This thematic issue reports recent advances in air quality and emissions trading research, focusing on progress in forecasting air quality, the impacts of air pollution on health, sources of emissions and extensions to the Emissions Trading Scheme.

Long-term research on the impact of air pollution on human health is an important contribution to the air quality and health debate (see: 'Long-term exposure to traffic pollution increases mortality' and 'Can air pollution affect unborn children in the womb?').

Policy makers face many challenges. One is the trade-off between emissions control and sustainable use of resources (see: 'Residential wood burning – a major cause of harmful pollution'). Regulations have driven technological developments to limit transport-related emissions, but new research shows there is another trade-off: between regulated and unregulated emissions (see: 'Is better regulation of ammonia emissions required?).

Three articles focus on using emissions trading to meet targets to reduce greenhouse gas emissions. An overview of the European Union's Emission Trading Scheme is given in 'The EU's emission trading scheme: progress so far'. The planned inclusion of aviation in the EU ETS raises difficult issues with regard to the allocation of permits (see: 'Allocating emission permits to European airlines'). The benefits to both developed and developing countries of using emissions trading schemes are explored in 'Pacific Rim countries could form emissions trading alliance'.

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Integrating air pollution and weather models improves air quality

Air quality forecasts have improved significantly over the last decade thanks to greater integration of air quality models and weather models, as air quality is greatly influenced by the weather. A new study discusses how advances in Chemical Transport Models can further improve predictions of air quality, play a greater role in managing the environment and highlight the relationship between urban, regional and global air pollution.

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Theme(s): Air quality

"Chemical Transport Models have led to significant improvements in air quality forecasts over the last decade."

Chemical Transport Models are an essential computational method used to predict air quality, which are closely aligned to weather prediction models. They also incorporate the complex reactions of pollution emissions, their dispersal in the atmosphere, the chemical transformations they undergo and their removal processes.

By combining advanced computing capabilities with remote sensing facilities, Chemical Transport Models can predict the distribution of urban pollutants in a column of air above a base less than a kilometre wide, and can profile pollution distributions around the world with a horizontal grid resolution of 50 to 100 kilometres. Chemical Transport Models are used to:

- interpret information from emissions observations
- model scenarios for reducing urban pollution levels
- design strategies to control emissions
- understand factors affecting climate change

Chemical Transport Models have led to significant improvements in air quality forecasts over the last decade. Real-time predictions of air quality now include forecasts of pollutants including ozone. Progress is continuing in the development of air quality predictions for fine particles such as $PM_{2.5}$. However, immense computational power is needed to run these models and a balance must be achieved between the complexity of the models and the cost of running these systems.

There are important differences between forecasting air quality and predicting the weather. For example, observations used in weather forecasting concentrate on adverse weather conditions, such as storms. As adverse air quality is often associated with benign weather conditions, additional observation systems are required.

Chemical Transport Models are currently used by a number initiatives, including the GEMS (The Global and regional Earth-system (Atmosphere) Monitoring using Satellite and *in situ* data) project[1] and the Global initiative GEOSS[2], (the Global Earth Observation System of Systems), which is embedded with the European strand, GMES[3], (Global Monitoring for Environment and Security). GEOSS has been set up to monitor and manage the Earth's environment. The GEMS project is part of the atmospheric theme in GMES and will provide new analysis and forecast products for GMES.

[1] See http://www.ecmwf.int/research/EU_projects/GEMS for information on the GEMS project.

[2] See http://www.earthobservations.org/geoss.shtml for information on GEOSS.

[3] GMES is supported by the European Commission's Sixth Framework Programme www.gmes.info.

Source: Carmichael, G.R., Sandu, A., Chai, T. *et al*. (2008). Predicting air quality: improvements through advanced methods to integrate models and measurements. *Journal of Computational Physics*. 227(7): 3540 – 3571.

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Can air pollution affect unborn children in the womb?

In recent years concern has been mounting over the possible health implications of unborn foetuses' exposure to air pollutants in the womb. Compared with adults, the unborn foetus and infant are especially vulnerable to environmental stresses. Spanish researchers are conducting an ongoing epidemiological study to investigate the effects that pollutants have on the health of pregnant women and their unborn children.

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"Air pollutants are thought to affect foetal growth, but there is a need for more conclusive evidence."

Poor air quality is a health hazard, and policy makers rely on epidemiological studies to establish the link between exposure to airborne dust particles and ill health. A wide range of sources including diesel vehicles, industrial processes and household boilers emit fine particles, $PM_{2.5}$, which contribute to the premature deaths of 350,000 people across the EU each year. Along with the coarser PM_{10}, these particles are among the most dangerous pollutants for human health. To reduce exposure, air quality standards for PM_{10} came into force in January 2005[1]. Legislation limiting $PM_{2.5}$ concentrations is introduced with the new EU air quality directive [2], with effect from 2010.

However, recent research suggests that it is important to identify the chemical, physical and biological properties of particulate matter (PM), as the adverse health effects of pollution are not only defined by the size and concentration of particles.

As part of the ongoing study, the researchers selected four monitoring sites across Valencia, Spain, to represent urban, metropolitan, suburban and rural areas. Air samples were taken between 2004 and 2005, at three different times during the participants' pregnancies. The data gathered will be used in the ongoing study to assess the impact of environmental pollutants during pregnancy and early in life[3]. Air pollutants are thought to affect foetal growth, but there is a need for more conclusive evidence.

The chemical composition and concentrations of two size fractions of particles, $PM_{2.5}$ and PM_{10}, were identified from organic, man-made and mineral sources. For man-made particulate matter, there was a clear gradient from urban to regional areas, suggesting that roughly half the air pollutants in cities have a local origin. For particulate matter of mineral origin, there was no such gradient. However, in winter these levels of $PM_{2.5}$ were higher in the cities and the researchers suggest this is caused by re-suspension of dust created by traffic. Central monitoring of air quality, however, may not adequately represent exposure to local pollutants, as emission concentrations vary greatly with distance from the source.

Foetuses and infants are particularly susceptible to the toxic effect of compounds that cause cancer, such as polycyclic aromatic hydrocarbons (PAHs). The study showed that the levels of fifteen PAHs, found in particulate matter, were similar to, or slightly higher than, levels reported from other Spanish sites but lower than in the rest of Europe.

[1] See http://ec.europa.eu/environment/air/quality/legislation/existing_leg.htm for details of the air quality Directive 1999/30/EC.

[2] See http://ec.europa.eu/environment/air/quality/legislation/directive.htm for more details.

[3] The INMA (Infancia y Medio Ambiente-'Environemnt and Childhood') project follows nearly 4000 pregnant mothers and their newborns across a network of research groups in Spain. See www.infanciaymedioambiente.org.

Source: Viana, M., Querol, X., Alastuey, A. *et al.* (2008). Characterising exposure to PM aerosols for an epidemiological study. *Atmospheric Environment*. 42: 1552-1568.

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Long-term exposure to traffic pollution increases mortality

Annually, air pollution is estimated to result in several hundred thousand premature deaths in Europe. According to a new study, long-term exposure to air pollution from traffic emissions is associated with higher rates of mortality than previously thought.

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"The results suggested that ill-health associated with exposure to $PM_{2.5}$ concentrations in cities might be higher than previously thought because a large part of the population is exposed to traffic-related pollution."

Chemical pollutants and fine particles can be inhaled and deposited in the respiratory system, causing ill health. This latest scientific evidence confirms that $PM_{2.5}$ is responsible for serious negative effects on human health, leading to a substantial loss of life.

The researchers calculated exposure to nitrogen dioxide, sulfur dioxide, PM2.5 and black smoke, formed from the incomplete combustion of fossil fuels, at the homes of 120,852 participants across the Netherlands. The participants were aged between 55 and 69, and their mortality was assessed over a 10-year period (1987-1996). Around 15 per cent of the participants died during this period and the cause of death was noted.

The findings show that long-term exposure to traffic-related air pollution is associated with an increase in risk of dying from respiratory-related conditions, such as lung cancer. These associations were most notable for exposure to nitrogen dioxide and black smoke. The researchers also suggest that the mortality risk related to black smoke exposure was increased in participants with lower education levels, particularly those who ate less fruit. It has been suggested that eating fruit may protect against oxidative stress, a key symptom of exposure to air pollution[1].

For the first time in Europe, a relative risk estimate for $PM_{2.5}$ was calculated. The results suggested that ill-health associated with exposure to $PM_{2.5}$ concentrations in cities might be higher than previously thought because a large part of the population is exposed to traffic-related pollution.

Reducing air pollution and risks to human health is a key priority of the sixth Environment Action Programme[2] (EAP), under which the Commission developed a Thematic Strategy on Air Pollution, which aims to cut annual premature deaths from air pollution-related diseases by half by 2020. Strategies include the control of emissions from traffic, improving fuel quality and promoting environmental protection requirements in the transport and energy sectors.

It is important to regulate emissions of fine particles, as they can pose a risk to human health, even in low quantities. The European Commission's new Air Quality Directive[3], adopted by Council on 14 April 2008, requires Member States to reduce exposure of $PM_{2.5}$ in urban areas by 20 per cent by 2020. Additionally, the Clean Air for Europe programme (EU CAFÉ)[4] has set new quality and monitoring requirements for these particles.

[1] http://www.isafruit.org An integrated project funded under Food Quality and Safety Thematic Priority of the European Commission's Sixth Framework Programme.

[2] http://ec.europa.eu/environment/newprg/index.htm Acting through EC legislation and through work at the wider international level in order to reduce cross-border pollution.

[3] http://ec.europa.eu/environment/air/quality/legislation/directive.htm The air pollution reduction rategy, launched September 2005.

[4] EU CAFE is a programme of technical analysis and policy development to underpin strategies on controlling air pollution. http://ec.europa.eu/environment/air/index_htm.

Source: Beelen, R. Hoek, G., van den Brandt, P.A. *et al.* (2008). Long-Term Effects of Traffic-Related Air Pollution on Mortality in a Dutch Cohort (NLCS-Air Study). *Environmental Health Perspectives.* 116: 196-202.

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Residential wood burning – a major cause of harmful pollution

In Northern Europe, wood-burning to heat homes in residential areas may be the main source of a number of harmful pollutants in local air, new research has shown. Restricting wood burning could reduce public health risks and help meet the requirements of the EU directive on air quality[1].

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"The main sources of the pollutants were found to be from wood burning and traffic emissions, but wood smoke was the biggest contributor of many organic compounds, including benzene, ethene and ethyne, all of which are known to be harmful to human health."

Recent studies indicate that wood combustion is an important contributor to air pollution, releasing fine particles and organic compounds as emissions. $PM_{2.5}$ and PM_{10} particles in particular are a recognised health hazard, contributing to respiratory disease. Many volatile organic compounds have toxic effects on human health and the environment. Benzene in particular, one of the main organic compounds emitted by wood-burning, has the potential to cause cancer.

Burning wood to heat homes is increasingly common in residential properties, particularly in Northern Europe. Wood burning stoves are becoming popular household additions and have been recommended as an energy source, because they use a renewable fuel resource. Finnish researchers have now identified the exact compounds released by wood combustion, and have measured the proportion of pollutants in the air produced by burning wood.

Measurements were taken during winter in a residential area of Finland, selected for its isolation from other major sources of air pollution, such as main roads and local power stations. Modelling techniques were used to match the chemical profile of pollutants to their source. For example, compounds in the atmosphere produced by car exhaust fumes could be separated from the same compounds released by the combustion of wood.

The main sources of the pollutants were found to be from wood burning and traffic emissions, but wood smoke was the biggest contributor of many organic compounds, including benzene, ethene and ethyne, all of which are known to be harmful to human health. Up to 70 per cent of benzene detected in the air was from wood smoke. When weather conditions, such as the wind speed and direction, were favourable, brief surges in the concentration of some organic pollutants were detected. Fluctuation of levels of benzene in the air also occurred in the same daily pattern as the levels of wood use.

The association between the levels of fine $PM_{2.5}$ and PM_{10}, and wood combustion in this study was less definite. But the study suggested that peaks detected in the levels of particles were linked to an increase in local wood burning. Another recent study comparing the origin of fine particles ($PM_{2.5}$) at a number of different sites in Europe found a link between biomass burning and increases in fine particulate matter in the winter. This study attributed 50-70 per cent of winter carbon pollution to biomass burning[2].

Previous research has already shown that wood smoke is detrimental to public health and this study has helped quantify the problem.

Source: Hellén, H., Hakola, H., Haaparanta, S. *et al*. (2008). Influence of residential wood combustion on local air quality. *Science of the Total Environmen*t. 393 (2-3): 283- 290.

[1] http://ec.europa.eu/environment/air/quality/legislation/directive.htm.

[2] The CARBOSOL Project: http://www.vein.hu/CARBOSOL/ received Euros 1,299,695 in funding from the Fifth Framework Programme's 'Energy, environment and sustainable development' thematic programme. This study was reported by *Science for Environment Policy* on 17th January 2008. http://ec.europa.eu/environment/integration/research/newsalert/chronological_en.html .

Intelligent transport systems help pinpoint air pollution

Road transport has become the largest source of environmental pollution in urban areas. New research conducted in Beijing has shown that better control of traffic can be achieved using intelligent transport systems, which integrate data from air quality monitoring stations, traffic monitoring stations and modelling techniques, to predict air quality. This approach could be used to identify areas for low emissions zones.

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"By showing when and where pollutants exceed targets, low emission zones could be created, by banning traffic from sensitive areas of the city, and providing extra public transport."

Italian researchers have conducted an air quality assessment, using Beijing as a case-study. Beijing is a city of 13.8 million people and the number of vehicles is expected to reach 3.5 million in 2008. A rapid rise in vehicle numbers has led to traffic jams, slow speeds, increased pollution (which fails to meet national air quality standards) and an average load on central roads of 90 per cent at peak periods. About 10-20 per cent of the vehicles are old and inefficient and produce 40-50 per cent of the traffic pollution. The authorities are, however, making efforts to enhance public transport, deter highly polluting, private vehicles from the roads and have introduced liquefied petroleum gas (LPG) buses, which have lower emissions than diesel vehicles..

The research investigated the association between urban traffic and air quality. Using a dynamic approach, the study integrated data from a number of sources in real-time to allow a more flexible framework.

The system used information from a network of air quality monitoring stations and integrated this with input from traffic monitoring stations, which measure traffic flow, type of vehicle and exhaust emissions. Input from a public transport management system was also included.

Some key advantages of this framework are:

- it gives real-time information, showing pollution dispersal rates
- it provides an automated assessment of transport-related air pollution
- it permits mobility management techniques to be tested, which are used to reduce pollution levels from traffic flow

This 'intelligent transport system' meant that it was possible to predict where air pollution would become concentrated, by tracking traffic flow. Also, by showing when and where pollutants exceed targets, low emission zones could be created, by banning traffic from sensitive areas of the city, and providing extra public transport.

In Europe, the GMES[1] (Global Monitoring for Environment and Security) initiative is preparing to use dynamic modelling, integrating data received from Earth observation satellites and ground based information, at regional scale across the EU, enabling effective nesting at local scales.

[1] GMES is supported by the European Commission's Sixth Framework Programme www.gmes.info.

Source: Costabile, F. and Allegrini, I. (2008). A new approach to link transport emissions and air quality: An intelligent transport system based on the control of traffic air pollution. *Environmental Modelling and Software.* 23(3): 258-267.

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Is better regulation of ammonia emissions required?

Road traffic is a major source of reactive nitrogen compounds (RNC). Engine combustion produces RNCs including: nitric oxide and nitrogen dioxide (which trigger the formation of ozone) and ammonia, which is classed as a reactive toxic pollutant. Swiss researchers used improved detection technologies to measure different RNCs in exhaust fumes and found that ammonia had the most substantial impact on air quality.

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"NOx emissions have been successfully lowered through fitting vehicles with catalytic converters, but there are currently no limits for ammonia emissions from light duty vehicles."

The European Union has established quality standards for about a dozen pollutants, and, since the late 1970s, overall air quality standards in the Community have improved. European countries have restricted the release of all RNCs under the Gothenburg protocol (United Nations Economic Commission for Europe (UN-ECE), 1999)[1] and the EU Directive 2001/81/EC (European Union (EU), 2001)[2] has set individual RNC emission ceilings for all EU member states and associated states like Switzerland.

The researchers measured different reactive nitrogen compounds in the tail-pipe emissions from 10 petrol Euro-3 cars (models of cars which meet European emissions standards for 2000-2001) and 10 Euro-4 cars (model year 2001-2004). These were chosen to represent the existing Swiss vehicle mix. They found that although the vehicles were within the limits of NOx emissions, levels of ammonia were unexpectedly high, between 40-80 mol per cent of the total RNC.

While current vehicle legislation puts a cap on the amount of total NOx that are released, it does not distinguish between NO and NO2. NOx emissions have been successfully lowered through fitting vehicles with catalytic converters, but there are currently no limits for ammonia emissions from light duty vehicles. Although not toxic to human health at ambient air concentrations, ammonia is a toxic gas that contributes to secondary aerosols and can have an adverse impact on the local environment. Furthermore, it is readily transported in the atmosphere, and can acidify land and surface waters, meaning its negative impacts can be felt in remote ecosystems. As yet there are no systems in place to provide accurate measurements of ammonia.

The research findings reflect the fact that there is a trade-off between NOx and ammonia emissions and highlight the need to measure ammonia accurately when judging urban air quality. This would allow a greater understanding of vehicle contributions and enable limits to be set for this important pollutant.

The research also suggests that levels of reactive nitrogen compounds are rising due to the current trend to replace petrol-fuelled cars with diesel-powered vehicles. Diesel cars are chosen because they provide better mileage than petrol cars. However, the permitted levels of reactive nitrogen compounds emitted from diesel vehicles are three times higher than those for petrol-fuelled cars.

[1] http://www.unece.org/env/lrtap/status/99multi_st.htm

[2] http://ec.europa.eu/environment/air/legis.htm

Source: Heeb, N.V., Saxer C.J., Forss, A., Brühlmann, S. (2008). Trends of NO-, NO2-, and NH3-emissions from gasoline-fueled Euro-3- to Euro-4-passenger cars. *Atmospheric Environment*. 42: 2543-2554.

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The EU's emissions trading scheme: progress so far

A recent report has assessed the first two years' of operation of the European Union's emissions trading scheme (ETS)[1]. Its implications for business and whether it has lived up to its promise as a cost-effective tool for reducing greenhouse gases were examined.

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"The report recommends using EU-wide benchmarks, such as output measurements and activity rates, as well as promoting predictability for investment purposes by mapping out future allocation rules."

The ETS is a central instrument for implementing the 1997 Kyoto Protocol[2] and is the world's first cross-border emissions trading system used to tackle emissions of greenhouse gases (GHG). Launched in 2005, the scheme covers almost 11,500 installations responsible for emitting about 45 per cent of the total CO_2 in the EU. It aims to reduce GHG emissions by 20 per cent by 2030 compared with 1990 levels. The first phase, from 2005-2007, is currently being reviewed. The second phase runs from 2008-2012.

A new report indicates that the cap-and-trade model of the ETS has advantages over using taxation or voluntary agreements to curb GHG emissions. It allows the most cost-effective ways for the reduction of emissions to be factored into business strategies, improving long-term predictability. It also minimises distortions to competition among industries in the EU by imposing an EU-wide carbon price. In addition, it offers environmental benefits by capping overall emissions levels.

Compromises made in adopting the ETS included allocating free allowances and leaving the process of allocation to the discretion of member states. During the first phase, teething problems included the short time allowed for adoption of the scheme, volatility in the carbon price and an increasing gap between gas and coal prices, which drove power plants to burn more coal, increasing emissions to a higher than expected level. In addition, small installations faced high administrative burdens. There was also an absence of verified baseline data on emissions, prior to 2005.

Fundamental issues that currently need to be addressed include constraining the inflated projections of emissions and centralising the allowance of emissions. A key point for assessing the success of the ETS is how far it encourages installations to make long-term investment decisions on new low-carbon technologies. Current allocation periods provide certainty for only three, and then five years. These are much shorter periods than normally associated with investment cycles.

Other concerns include allowing energy producers to pass on increased power prices while benefiting from 'free' allocations, resulting in windfall profits. There are also fears of non-EU producers being given a competitive advantage in energy-intensive industries such as aluminum.

It was suggested the current review should look at issues of complexity, distortions to competition and investment incentives. Member states would like more consistency on setting caps at the EU level and sector level. The report recommends using EU-wide benchmarks, such as output measurements and activity rates, as well as promoting predictability for investment purposes by mapping out future allocation rules.

[1] For more information on ETS see: http://ec.europa.eu/environment/climat/emission/review_en.htm.

[2] http://ec.europa.eu/environment/climat/emission/linking_en.htm.

Source: Egenhofer, C. (2007). The Making of the EU Emissions Trading Scheme: Status, Prospects and Implications for Business. *European Management Journal*. 25 (6): 453-463.

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Allocating emissions permits to European airlines

The European Commission plans to incorporate air travel into the European Union emissions trading scheme (ETS)[1] from 2012. Low-cost airlines would bear the greatest impact from the introduction of air transport emission permits, according to a new study.

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"The study recommends using a benchmark scheme based on two elements: landing and take off (LTO) cycles and per kilometre emissions."

Initially, the focus of the air transport ETS would be on emission levels of CO2 from aircraft engines. There is also growing interest in other types of emissions from aviation and the EU is likely to introduce a directive which sets standards for local air quality around airports.

The study looked at methods of allocating air transport emissions permits in Europe. The International Air Transport Association, (IATA), has set voluntary targets for airlines to improve fuel efficiency, including a 26 per cent improvement between 1990 and 2012. However, this could be seen as insufficient given that by 2005 British Airways had already increased fuel efficiency by 27 per cent. In all, airlines have achieved a 70 per cent improvement in the past 40 years. Today's aircraft have a fuel consumption similar to that of a modern compact car. However, in the longer term, improvements in efficiency and the reduction of CO_2 emissions are expected to slow, and with air traffic increasing by 4-5 per cent per year, emissions will increase significantly.

It is unlikely that a global aircraft engine emissions trading scheme can be introduced in the near future. European member states are, however, keen to see aviation included in the European Union's ETS. Such a scheme might initially apply only to flights between EU nations. These flights produce around 42 million tonnes of CO_2 compared with about 213 million tonnes for all flights to and from EU airports. Using information on aircraft and engine types from 2003/4, the study compared the potential impact on three different types of UK carriers: a network carrier (British Airways), a low-cost airline (easyJet) and a charter/leisure operation, (Britannia/Thomsonfly). The study considered three main allocation systems:

- grandfathering, which is based on free allocations derived from previous emission levels
- auctioning, with airlines bidding for the levels of CO_2 emissions they expect to produce
- benchmarking, which sets a baseline efficiency measure.

In all cases, the impact was greatest on the low cost carrier. The grandfathering approach penalised the faster growing low cost airline and favoured the network carrier, which could absorb costs on long-haul flights. EU network carriers would be at a slight disadvantage when compared with foreign hub carriers. The most costly alternative for airlines would be auctioning, and further evaluation would be needed on how the proceeds raised would be used. The study recommends using a benchmark scheme based on two elements: landing and take off (LTO) cycles and per kilometre emissions. Although more complex, this would avoid distortion and would not penalise smaller low-emission aircraft.

[1] To find out more about EU ETS, see: http://ec.europa.eu/environment/climat/emission/review_en.htm.

Source: Morrell, P. (2007). An evaluation of possible EU air transport emissions trading scheme allocation methods. *Energy Policy*. 35 (11): 5562-5570.

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Pacific Rim countries could form emissions trading alliance

With the first Kyoto Protocol[1] compliance period (2008-12) underway, countries are addressing ways to mitigate the effects of greenhouse gas emissions (GHG) on climate change. However, most developing countries have not made commitments to mitigation. A recent study suggests developing countries and industrialised nations can cooperate to tackle climate change through the use of emissions trading schemes.

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"A recent study suggests developing countries and industrialised nations can cooperate to tackle climate change through the use of emissions trading schemes."

The Pacific Rim is a significant area, containing 44 per cent of the world's population, consuming 61 per cent of the world's energy and producing 60 per cent of global GHG emissions in 2004. India and China, in particular, are major sources of GHG emissions. Developing countries have argued that the high costs of complying with emission caps would hinder their future economic development.

Investigating cooperation between industrialised and developing countries within the Pacific Rim[2] region, the study analysed the potential costs and savings to countries participating in emissions trading schemes in the year 2020. The analysis assumes that most industrialised countries would continue to comply with their current Kyoto protocol commitments and explores the implications of their access to low-cost mitigation options in developing countries through emission permit trading.

The suggested policy dealt with CO_2 emissions and covered all economic sectors in 31 countries and regions. It provides a structure for the granting and trading of emission permits among industrialised and developing countries within the region. Two methods of allocating emissions permits to developing countries were tested: either on a zero cost basis or on 90 per cent of baseline emissions. Options of trading with five American states, which have agreed to a cap-and-trade emissions scheme (although the US as a whole has not signed up to the Kyoto Protocol), were also included.

Research suggested that all Pacific Rim countries would gain, or be no worse off, from the exchange. Countries that purchased permits would avoid the high cost of mitigation expenditure, and permit-selling countries would use the revenues to offset the costs of implementing mitigation policies. There would be a transfer of monetary payments from relatively rich to relatively poor countries.

Such a trading scheme could mitigate up to 3.6 billion tonnes of CO_2 and would result in a trading price of between 1.88 and 5.55 US dollars per tonne of CO_2. All developing countries would be able to sell permits, and China could reap revenues of between 1.1 billion and 3 billion US dollars annually from exchanging permits. The Pacific Rim is a natural area of co-operation with a long history of international trade and financial treaties. Issues of financial intermediation, monitoring and enforcement need to be addressed. Existing financial intermediaries could bridge the lack of an institutional structure to govern the trading.

[1] http://unfccc.int/kyoto_protocol/background/items/3145.php

[2] Countries in the study included: the Asian Tigers (Taiwan, Singapore, South Korea and Hong Kong), Australia, New Zealand, Canada, Central and South American countries, China, Japan, Mexico, Russia, Southeast Asian countries and five States of Western USA (California, Oregon, Washington, Arizona and New Mexico).

Source: Rose, A and Wei, D. (2008). Greenhouse gas emissions trading among Pacific Rim countries: An analysis of policies to bring developing countries to the bargaining table. *Energy Policy*. 36 (4): 1420-1429.

A selection of articles on Air Quality from the *Science for Environment Policy* News Alert

Finer particles give more useful air quality data (3/4/08)

New air quality research indicates that measuring ultra-fine particles can distinguish between particles generated through human activities, such as combustion, and larger particles, which are more likely to arise from mechanical processes and natural sources. The smallest air particles are from combustion sources such as vehicles and power plants, and easily enter the body. However, air quality measurements today typically focus on larger particles .

Urban trees improve air quality (14/2/08)

Planting trees in urban areas could cut particulate pollution in cities by as much as a quarter, according to a new study. Small air particles, especially those less than 10μm in diameter (PM_{10}) pose a long-term threat to human health. These can originate from human activities, including exhaust fumes or smoke, or from natural causes, such as dust. The study shows that trees are particularly good at capturing PM_{10} on their leaf surfaces.

True cost of Athens' industry adds up (7/2/08)

Air quality research from Greece suggests that the cost of industrial air pollution in Athens alone may exceed 211 million Euros per year. Estimating the costs of pollution in terms of, for example, human health, ecosystems and biodiversity, has received growing attention amongst policy makers. Finding ways to place a monetary value on these factors is one way to account for these costs more easily. It may also make it easier to directly influence technological and policy decisions without changing the rules of the market.

Wood smoke major source of pollution in winter (17/1/08)

Over half of organic air pollution in Europe during winter comes not from fossil fuel burning, but from home fires, and burning of agricultural and garden waste products, according to new results published by the EU-funded CARBOSOL project. Restricting these sources of human-made emissions could cut pollution significantly, with immediate benefits to public health and a positive impact on climate change.

Trends in Air Pollutants Emission and Projections (13/12/07)

According to a recent report by the European Environment Agency, a number of countries in Europe have already succeeded in reducing their emissions of certain pollutants below the level of the pollutant-specific emission ceilings specified in the National Emission Ceilings Directive. In addition, some countries anticipate that they will achieve the necessary reduction before 2010.

Impacts of Post-2012 Climate Policies on Air Quality (06/12/07)

European researchers have recently analysed the potential air quality co-benefits from different European post-2012 climate policies in Nordic countries. The results suggest that stricter targets and a more ambitious climate change policy will contribute to reduced emissions of air pollutants. On the other hand, expanding the European emissions trading scheme to new sectors might result in a small increase in emissions of air pollutants. A key aspect will be the post-2012 participation of Russia and non-EU Eastern Europe countries in emission trading.

Distribution of Atmospheric Particulate Matter in the Urban Environment (29/11/07)

Researchers have monitored the concentrations of particulate matter, a major air pollutant, in two different urban environments. Focusing on polar organic compounds, one of the constituents of particulate matter, their results provide a better understanding of the emission sources and atmospheric processes influencing the concentrations and seasonal composition of particulate matter.

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A selection of articles on Emissions Trading from the *Science for Environment Policy* News Alert

Technology support combined with emissions trading best over long term (10/4/08)

Achieving long-term reductions in greenhouse gas (GHG) emissions is a growing priority, both nationally and internationally, as evidenced by the recent package of climate and energy proposals for Europe under discussion this year. But new research suggests that policies that lead to cost-effective GHG reductions in the short term may not be cost-effective over the long term.

A first look at how the EU emissions trading scheme is working (3/4/08)

The EU's emissions trading scheme (ETS) was introduced for a three-year trial period in 2005, and this initial analysis looks at how well it is working using data from the first two years of operation. The research concludes that both over-allocation and a reduction in CO_2 emissions occurred.

Impacts of the European Carbon Emissions Trade Directive on Industry (08/11/07)

A Finnish researcher recently investigated the economic impacts of the European emission trading scheme on energy intensive manufacturing industries. The results show that the total cost impacts remain below 2% of the production value for most industries in the Kyoto period. Nevertheless, this figure may rise considerably in the post-Kyoto phase assuming a more stringent emission reduction target.

How the EU Emission Trading Scheme impacts Competitiveness (31/05/07)

In the context of the highly debated EU Emission Trading Scheme, English researchers have investigated the economic impacts of this scheme on firms and consumers. They have shown that in addition to the reduction of greenhouse gas emissions, this scheme enables firms to increase their profits because they pass the costs of the scheme on to the consumer, leading to an increase in product prices.

Improving the Implementation of the Emission Trading Directive (10/05/07)

According to a recent report by the European Environment Agency on the implementation of the Emission Trading Directive, competitiveness issues due to the application of the directive are one of the concerns raised by Member States. The report concludes that further alignment of operating procedures of the Emissions Trading Scheme is still possible.

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