CI&CEQ

Available on line at
Association of the Chemical Engineers AChE
www.ache.org.rs/CICEQ

Chemical Industry & Chemical Engineering Quarterly 16 (3) 281–286 (2010) CI&CEQ

BJARNE SIVERTSEN
ALENA BARTONOVA

Norwegian Institute for Air Research (NILU), P.O. Box 100, 2027 Kjeller, Norway

PROFESSIONAL PAPER

DOI 10.2298/CICEQ091214046S

CO-BENEFIT AND CO-CONTROL STUDIES IN NORWAY*

In both developing and industrialized countries, abatement of air pollution and mitigation of climate change have generally been treated separately. Co-benefits of air quality and climate change related policies are often addressed on national or supra-national level, to document that costs of policies are acceptable, especially when ancillary benefits are considered. On local or regional level, the focus until now has been mainly on air quality management, not considering benefits for climate change mitigation. Today's air quality management requires integrated and coordinated measures where urban air quality planning includes also greenhouse gas (GHG) emissions and climate change issues. The tools available for investigating scenarios for reducing local impacts and health effect improvements can also be used to investigate cost effective actions aimed at reducing GHG emissions. This approach would lead to identification of strategies that consider co-benefits of climate and local air quality measures, and would both improve the health of people and give climate benefits at best possible costs. Approaches based on an existing air quality management tool, prepared for co-benefit studies in Norway as well as plans for co-control projects in China are presented in this paper. These approaches have the potential to focus on issues not included in traditional air pollution abatement studies.

Key words: co-control; co-benefit; GHG emissions; air quality management.

In recent years, focus has shifted from local air pollution and its threat to health and environment, toward global threats due to greenhouse gas (GHG) emissions and their impact on climate. In both developing and industrialized countries, abatement of air pollution and mitigation of climate change have generally been treated separately. There are, however, large benefits in considering the control options together; such approaches would mostly lead to increased health and/or climate benefits and decreased costs.

As global warming has recently taken most of the focus in the political decision processes, local and regional challenges seem to have been set aside. The issue of co-benefits is on global scale often raised from the point of view of arguing for greater total benefits from climate change policies [1]. Nemet and co-authors [2] comprehensively review studies that look at co-benefits of climate change mitigation, poining out that there are important benefits, but also important barriers for the inclusion of air quality in climate policies. Increasingly however, the contributions of air quality management to climate change mitigation are recognized. The matter is treated in an integrated manner by the European Environment Agency [3]. The Intergovernmental Panel on Climate Change (IPCC) [4] states in its fourth assessment report that "integrating air pollution abatement and climate change mitigation policies offers potentially large cost reductions compared to treating those policies in isolation". The United Kingdom (UK) Department of Environment, Food and Rural Affairs (DEFRA) [5] provides a comprehensive and practical overview of UK climate and air quality commitments, benefits of combining both policies (targeting mainly the transport and energy sectors, but also agriculture sectors), and gives examples of local policies formulated with both political agendas in mind.

In research, the physical/chemical linkages between air quality and climate change are being increasingly well understood. Models show that with

Correspondening author: B. Sivertsen, Norwegian Institute for Air Research (NILU), P.O. Box 100, 2027 Kjeller, Norway.
E-mail: bs@nilu.no
*Part of this paper was presented at the Scientific Meeting Particulate Matter: Research and Management, 2nd Webiopatr Workshop, Mokra Gora, Serbia, 31 August-2 September, 2009.
Paper received: 14 December, 2009
Paper revised: 15 August, 2010
Paper accepted: 16 August, 2010

several climate change scenarios, more stringent control measures will be needed in most areas to meet the air quality standard for ozone, while the effects on particulate matter are less easy to predict [6]. Empirical studies are looking into the links between climate change and urban air quality for specific locations and areas [7]. On the side of effects, a recent review by Ebi and McGregor [8] summarizes research on health impacts related to ozone, particulate matter and health impacts, while Dietz and Atkinson [9] are looking into acceptance of practical policy implementations, considering issues such as how difference in temporal and regional scale of climate change and air quality affect individual preferences.

In this complex situation, there is a need for tools for practitioners of urban air quality management that would allow, at the same time, an assessment of contribution of local measures to global change mitigation, and of measures to combat climate change contribution to local air quality. Nemet and co-authors [2] point out that "full consideration of air quality co-benefits in policy debates will require improved evaluation techniques for both the climatic benefits and the air quality benefits of climate policy". D'Avignon and co-authors [10] argue that such a tool is provided by local emission inventories. Emission inventories are at the heart of any integrated air quality management tool, but such a tool needs to tackle more elements of the full chain, emissions, air quality, environmental exposures, effects and societal impacts.

INVESTIGATING POSSIBLE CO-BENEFITS ON GLOBAL SCALE

The IPCC [4] recommends co-benefit thinking in climate change mitigation. Climate policy may generate air quality improvements in the OECD countries in the mid-term; whereas in developing countries these benefits may only prove to be significant in the long--term [11].

A recent comprehensive study has performed a cost-benefit analysis that combines the damages from global climate change and local air pollution [12]. Bollen and co-authors have complemented a global welfare optimization model of the energy-economy-environment model MERGE with pollutants other than greenhouse gases, and performed an integrated assessment of the long-term climate change mitigation and a short-term reduction of local air pollution. They demonstrate synergies in the two sets of policies that clearly support the recommendation of integrated approach, and they point out that overall, local air pollution policies bring more short-term benefits than climate change policies.

The integrated long-term cost-benefit approach balances the means to lower simultaneously the adverse impacts of climate change and air pollution and shows significant climate benefits only after 2050. In summary, these simulations and results from the literature review suggest that for countries giving priority to GHG mitigation, the local air pollution co-benefits provide an additional incentive by off-setting a proportion of the GHG mitigation costs.

These co-benefits could be larger than currently estimated since most estimates omit the possible co-effects of GHG mitigation on indoor air pollution, which is expected to be large in countries such as India and China [4].

LOCAL SCALE ASSESSMENTS: THE NILU PLANNING TOOL

The NILU planning tool AirQUIS (Figure 1) has been developed to handle a number of air pollution

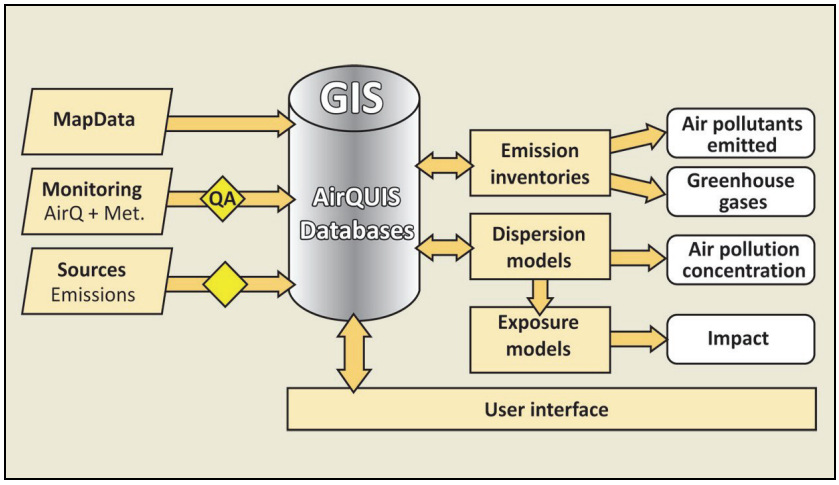

Figure 1. The NILU developed air quality planning tool; AirQUIS.

tasks and challenges common in local air quality management [13,14]. The modular system combines environmental monitoring, sophisticated modelling and advanced data presentations in one package. One module allows constructing emission inventories both for classical air pollutants and GHG from information about transport, fuel consumption, energy use and industry. The user can present and evaluate the current situation, undertake environmental planning, and evaluate local impacts such as health effects. The Geographic Information Systems (GIS) platform, on which the system is operated, provides easy access to the data and allows an accurate and easily understandable data presentation. The tool is routinely used by Norwegian authorities in environmental outlooks for assessment of population exposure to local air pollutants, and for defining air quality management strategies for urban areas. It also has numerous applications outside Norway.

Several studies evaluating different strategies were recently performed, looking at different geographic areas in and outside Norway [15-18].

NORWEGIAN STUDIES AND ACTIONS

In Norway, the background for measures to reduce air pollution and greenhouse gas emissions is to be found in several commitments. In addition to the need to comply with air quality directives, Norway undertakes to reduce global GHG emissions by the equivalent of 30% of its own 1990 emissions by 2020, and intends to cut the global emissions equivalent to 100% of its own emissions by 2030.

Measures to achieve these goals include moving from fossil based energy to increased use of bio fuels. This however may change the environmental challenges. While the GHG emissions will be reduced, emissions of particulate matter, nitrogen oxides and polyaromatic hydrocarbons may increase and give rise to more local air pollution as well as to more harmful pollution composition (for analysis, see *e.g.* Jacobson [19]), and increase exposures of human populations.

Scenarios Oslo

Studies have been performed in Oslo in order to evaluate population exposure for alternative scenarios identified to reduce the impacts of air pollution (Figure 2). The most important source of air pollutants in Oslo is road traffic, also an important source for greenhouse gas emissions.

Several actions were included in the evaluation of an optimal abatement strategy for Oslo. The possible actions and measures may be divided into 5 classes:

1. Measures that reduce the number of vehicle kilometers: concentrated development of public transport hub Home office, video conferencing, etc.

2. Measures that facilitate alternatives to car transport: public transport - better surface coverage, higher frequency, lower fares better arrangements for pedestrians and cyclists - walking and cycling routes "park and ride".

2. Measures to restrict car transport on selected routes / time periods travelers payment (time-differentiated road pricing), low emission zones, parking restrictions, parking pees, car-free zones, fuel tax costs of workplace, parking moved to the user maximum speed of the road network is set at 60 km/h.

3. Cleaner wood burning.

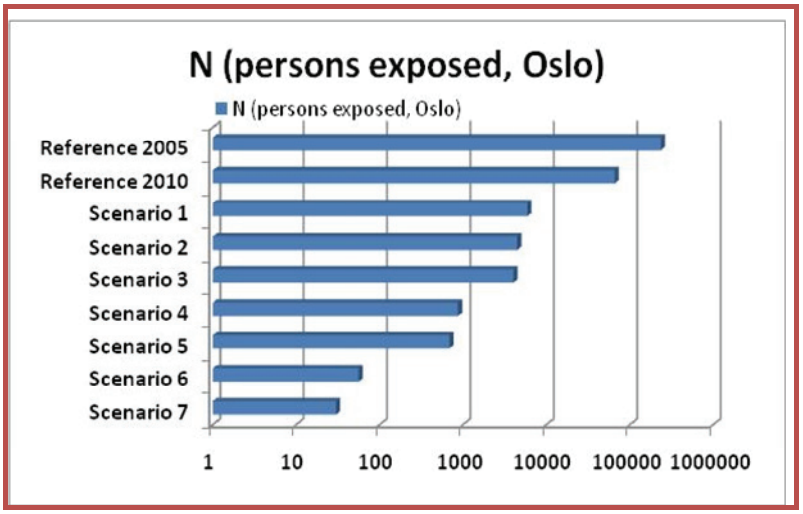

Figure 2. The number of people exposed to the 8th highest daily grid value of PM_{10} ($\mu g/m^3$) exceeding 50 $\mu g/m^3$ (national target). Reference year 2005 and 2010 have been compared to seven different scenarios for reducing PM_{10} exposures.

4. Measures that reduce harbor emissions.

Local impact of these actions was modeled in Oslo, and at the same time, their potential for CO_2 emission reductions relative to the baseline emission estimate was discussed [20]. Results showed that there are considerable co-benefits in implementing measures which will reduce the number of kilometres driven. Also the introduction of low emission zones and measures for reducing ship emissions in the harbor of Oslo will give effects both on the local scale and on climate change issues.

Norwegian climate policy and carbon capture

The Norwegian Government is committed to develop carbon capture and storage (CCS) technologies, and hopefully contribute to make this technology commercially viable at a global scale. Carbon capture and storage programmes are already being undertaken in Western Norway, as well as elsewhere, with potential for negative effects depending on technologies used[21,22].

The consumption of energy for the CO_2 capture process has been a hot issue debated lately, especially considering the emissions from the production of this energy. Further it is known that there will be a number of different substances produced within the process. Some of these will probably be cleaned and taken out as liquid or solid waste; others will follow the CO_2 stream for deposition or be emitted to air. After release, some of these products will enter into photochemical processes and additional components will be formed.

An evaluation of the potential impact on health and the environment from a CO_2 capture plant should be mandatory. An evaluation should at least look into a theoretical exercise for establishing possible effects on local air quality, nitrogen deposition, or, of the different types and quantities of, *e.g.*, amine emissions, for amine-based processes. The need for collecting emission data and knowledge of health and environmental impacts of these emissions should be a requirement in the emission permit for the capture plants.

CO-CONTROL AND CO-BENEFIT PROJECTS CHINA

A new project was proposed for China in collaboration between Norwegian institutions and Clean Air Initiative Asia, developing a programme for co-control. The project places a strong emphasis on assisting Chinese institutions in building technical capacity and expertise, specifically on the co-control of air quality, energy and climate change. In this way it will be easier for China to reduce local air pollution and contribute to greenhouse gas reductions. This is fully in line with Norwegian priorities for development cooperation, which has climate change and environmental protection as its cornerstones.

The proposed project is a national level project, with demonstration of co-control policies concentrated on cities in Western China, while a training component will cover the national, provincial and local levels. The objectives of the project are:

– To provide policy guidance and advice on integrated control of air pollution and GHG emissions in the 12^{th} and 13^{th} 5 year periods (FYP).

– To demonstrate the viability of the co-control approach in addressing environmental challenges related to air quality and energy management at the regional and local level.

– To enhance the capacity of the Ministry of Environmental Protection (MEP) and other related institutions, at national, regional and local level to formulate and carry out simultaneous cuts in air pollution and GHG emissions in the 12^{th} and 13^{th} five year periods.

The objectives will be achieved through three main project components:

1. National level policy analysis, suggestions and support on co-control.

2. Demonstration and pilot cases of integrated air quality management (AQM) and co-control at the urban level, in selected cities in Western China.

3. Capacity building for integrated AQM and co--control at national, regional and local level, with an emphasis on Western China Provinces.

NILU also participated in studies in China related to cost effectiveness in the city of Guangzhou (Figure 3) [23].

A cost-benefit study was undertaken in three cities in the province of Shanxi, China. Comparisons of cost-benefits were performed for various identified control actions in order to reduce SO_2 and total suspended particulate matter (TSP) exposure and health impacts in the three cities. The project was implemented through the cooperation between Chinese and Norwegian experts in order to develop a “Master Plan against Air Pollution in Shanxi Province” [24].

The modeling exercise conducted through the Sino-Norwegian project provides a unique opportunity to understand impacts of city level pollution abatement tools in one of China’s most energy intensive cities. The cost-benefit analysis is quite unique given that the health economics approaches are relevant in order to evaluating the cost/benefit of interventions. Despite the sparse, inconsistent, and sometimes questionable nature of the Chinese health data, the

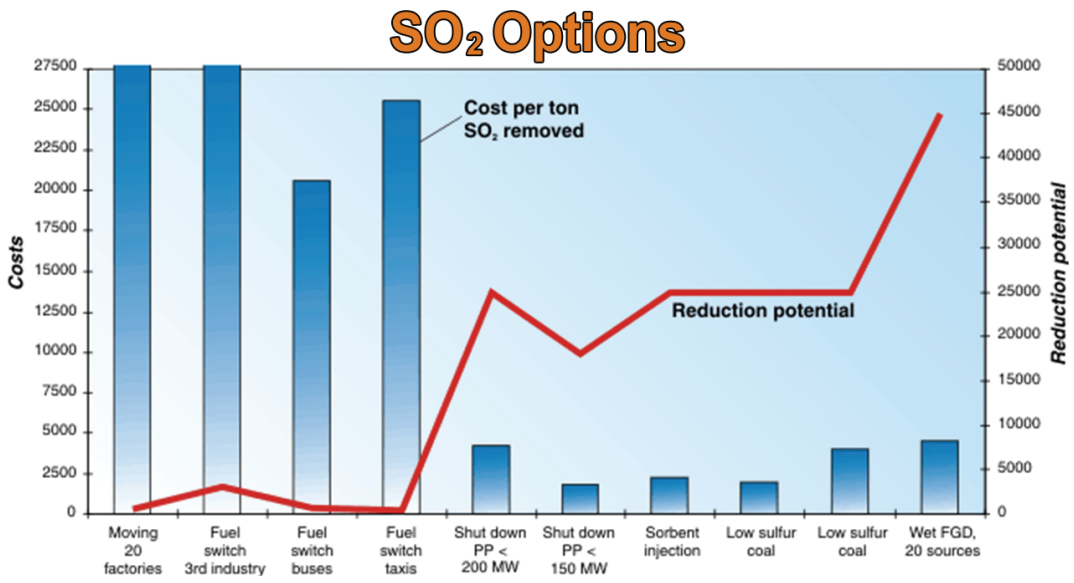

Figure 1. Ten mitigation actions identified in order to reduce the SO_2 concentrations in Guangzhou summarized the cost of actions relative to the reduced potential for SO_2 exposure in the city.

study has been successful in finding alternative data sources and comparing data with other international databases [23].

The studies in Shanxi have shown that there are actions where the cost of implementing these actions are less than the cost-estimated benefits gained in improved health effects in the population.

The scenario-based and pollution sources-oriented health benefit evaluation of air pollution in the city of Taiyuan in Shanxi province have proven very useful. Even though selection of optimal control scenarios for Taiyuan requires further cost-benefit analysis, this study does provide decision-makers with evidence about not only the significance of control that prevent environmental pollution, but also provides an indications of what measures are most effective [25].

RECOMMENDATIONS AND AREAS OF FURTHER DEVELOPMENT

Clearly, an integrated approach to development of measures leading to fulfilment of climate change and air pollution policies will provide benefits on local and global scale, and in short as well as long term horizon. A number of emission reduction options for GHG have co-benefits for air pollution, and a number of air pollution combating measures also provide significant climate change related benefits. It is important to identify those measures and their combinations that lead to a win-win situation, but due to the complexity of the issues involved, this task is not a simple one. Efficient tools that would help in this endeavour already exist. Further development is needed in order to continue the work related to integrated assessment, co-benefit studies and co-ordination of climate change and local air pollution issues. Some of these issues are:

- Exposure-response on human health.
- Local and regional influence of aerosols on climate forcing and weather patterns.
- Development and application of combined integrated assessment at various scales

This requires competence on:

- Emission inventories, air quality and atmospheric science.
- Climate and pollution policies.
- Integrated assessment modelling, including cost effectiveness / optimisation of abatement measures.

The issues presented in this paper are important issues in order to improve the tools for integrated assessments, and this work will continue in Norway and elsewhere.

REFERENCES

[1] D. Burtraw, D. Krupnick, K. Palmer, A. Paul, M. Toman, C. Bloyd, J. Environ. Manag. **83**(1) (2007) 115-130

[2] G.F. Nemet, T. Holloway, P. Meier, Environ. Res. Lett. **5** (2010) 014007-014016

[3] EEA Technical Report 4/2006. European Environment Agency, Copenhagen, 2006

[4] Climate Change 2007, Intergovernmental panel on climate change, Geneva, Switzerland, 2007, http://www.ipcc.ch/publications_and_data/ar4/syr/en/contents.html (accessed 1.8.2010)

[5] DEFRA, Air pollution: Action in a Changing Climate, 2010, http://www.defra.gov.uk/environment/quality/air//airquality/strategy/documents/air-pollution.PDF (accessed 1.8.2010)

[6] D.J. Jacob, D.A. Winner, Atmos. Environ. **43**(1) (2009) 51-64

[7] M. Athanassiadou, J. Baker, D. Carruthers, W. Colins, S. Girnary, D. Hassel, M. Horta, C. Johnson, K. Johnson, C. Jopnes, D. Thomson, N. Trought, C. Witham, Atmos. Environ. **44**(15) (2010) 1877-1886

[8] K. Ebi, G. McGregor, Environ. Health Perspect. **116** (2008) 1449-1544

[9] S. Dietz, G. Atkinson, Land Economics **86**(3) (2010) 423–443

[10] A. D'Avignon, F. Azevedo Carloni, E. Lebre la Rovere, C.B.Schmidt Dubeux, Energy Policy **38** (2010) 4838–4847

[11] Organisation for Economic Co-operation and Development, Paris, 2008

[12] J.C. Bollen, B. van der Zvaan, C. Brunk, H. Eerens, Resource and Energy Economics **31** (2009) 161-181

[13] L.H. Slørdal, H. McInnes, T. Krognes, Information Technologies in Environmental Engineering **1** (2008) 40-47

[14] AirQUIS 2007, www.airquis.no (accessed 1.8.2010)

[15] B. Sivertsen, T. Bøhler, Proceedings. Paris, Marie de Paris, Environment. Fourth theme, paper D6, p. 44-45 NILU, Kjeller (NILU F 4/2000), 2000

[16] B. Sivertsen, A. Dudek, NILU, Kjeller (NILU F 20/2007), 2007

[17] B. Sivertsen, NILU Kjeller (NILU OR 52/2007, 2007

[18] B. Sivertsen, NILU Kjeller (NILU F49/2008, 2008

[19] M.Z. Jacobson, Energy Environ. Sci. **2** (2009) 148-173

[20] Ø. Dalen, K.S. Amundsen, Report prepared for Norwegian Public Roads Administration, Municipality of Oslo and Municipality of Bærum. Sandvika, Edition: 03/2010-05-07. Asplan Viak, Oslo, 2010

[21] J. Blamey, E.J. Anthony, J. Wang, P.S. Fennell, Prog. Energy Comb. Sci. **36** (2010) 260-279

[22] J. Koornneef, A. Ramirez, T. van Harmelen, A. van Horssen, W. Turkenburg, A. Faaij, Atmos. Environ. **44** (2010) 1369-1385

[23] 2001NORAD Project CHN 013. NILU Kjeller (NILU OR 17/2000), S. Larssen, Ed., 2001

[24] Shanxi Province, ECON-Report no. 2005-076. ECON, Oslo, 2005

[25] D. Zhang, K. Aunan, H.M. Seip, S.Larssen, J., Liu Energy Policy **38**(1) (2009) 491-502.

BJARNE SIVERTSEN
ALENA BARTONOVA

Norwegian Institute for Air Research (NILU), P.O. Box 100, 2027 Kjeller, Norway

STRUČNI RAD

STUDIJE ZAJEDNIČKE KORISTI I KONTROLE U NORVEŠKOJ

I u zemljama u razvoju i u industrijalizovanim zemljama, smanjenje aerozagadjenja i ublažavanje klimatskih promena do sada su generalno tretirani odvojeno. Zajednička korist u vezi politika kvaliteta vazduha i klimatskih promena često je razmatrana na nacionalnom i nad-nacionalnom nivou, da bi se dokumentovalo da su troškovi sprovodjenja politike prihvatljivi, posebno kada se posmatraju prateće koristi. Do sada je na lokalnom ili na regionalnom nivou usmerenje bilo na upravljanju kvalitetom vazduha i nisu se uzimali u obzir koristi od ublažavanja klimatskih promena. Danas upravljanje kvalitetom vazduha zahteva inegralne i koordinisane mere gde planiranje kvaliteta vazduha u urbanim sredinama uključuje i pitanja efekta gasova staklene bašte i klimatskih promena. Za utvrđivanje cene efektivne akcije u cilju smanjenja emisije gasova staklene bašte dostupni su alati za proučavanje scenarija za smanjenje lokalnog uticaja i poboljšanje zdravstvenih efekata. Ovaj pristup vodi ka identifikaciji strategija koje razmatraju zajedničku korist od mera za klimatske i za lokalne mere kvaliteta vazduha, što će oboje dovesti do poboljšnja zdravlja ljudi i doprineti koristima za klimu uz najbolju moguću cenu. U ovom radu prikazani su pristupi koji se baziraju na postojećim alatima za upravljanje kvalitetom vazduha, primenjenim za studije zajedničke koristi u Norveškoj, kao i za planove projekata zajedničke kontrole u Kini. Ovi pristupi imaju potencijal da se usmere na pitanja koja nisu bila uključena u tradicionalne studije mera za smanjenje aerozagadjenja.

Ključne reči: zajenička kontrola; zajednička korist; GHG emisije; upravljanje kvalitetom vazduha.