DEVELOPING RISK-BASED PRIORITIES FOR REDUCING AIR POLLUTION IN URBAN SETTINGS IN UKRAINE

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ABSTRACT

Ukraine, when part of the former Soviet Union, was responsible for about 25% of its overall industrial production. This aging industrial infrastructure continues to emit enormous volumes of air and water pollution and wastes. The National Report on the State of Environment in Ukraine 1999 (Ukraine MEP, 2000) shows significant air pollution. There are numerous emissions that have been associated with developmental effects, chronic long-term health effects, and cancer. Ukraine also has been identified as a major source of transboundary air pollution for the eastern Mediterranean region. Ukraine's Environment Ministry is not currently able to strategically target high priority emissions and lacks the resources to address all these problems. For these reasons the US Environmental Protection Agency set up a partnership with Ukraine's Ministry of Environmental Protection to strengthen its capacity to set environmental priorities through the use of comparative environmental risk assessment and economic analysis – the Capacity Building Project. The project is also addressing improvements in the efficiency and effectiveness of the use of its National Environmental Protection Fund. The project consists of a series of workshops with Ukrainian Ministry officials in comparative risk assessment of air pollutant emissions in several heavily industrialized oblasts; cost-benefit and cost-effectiveness analysis; and environmental finance. Pilot risk assessment analyses have been completed. At the end of the Capacity Building Project it is expected that the use of the National Environmental Protection fund and the regional level oblast environmental protection funds will begin to target and identify the highest health and environmental risk emissions.

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INTRODUCTION

Ukraine, until recently, like the other countries of the Newly Independent States (NIS), and Central and Eastern Europe (CEE) operated with centrally planned economies. As they began to make the transition to a market economy and to build market institutions in the late 1980's and early 1990's, their economies came under severe pressure for a number of reasons. After a significant economic adjustment period, a gradual but slow economic recovery started first in the CEE countries and subsequently in the NIS countries. Many of the main government concerns in this period were slow economic growth, associated rates of unemployment, inflation, and social problems. Environmental concerns seemed to be less pressing due to sharp production declines resulting in reduction of all types of pollution, even though it was clear that these reductions would prove temporary. Nonetheless, countries with transition economies face certain specific problems. Environmental benefits are rarely considered in the short or even in the medium term, and willingness to pay for environmental services generally is low.

In this context, the concept of strengthening the capacity of the Ukraine Ministry of Environmental Protection was formulated during discussions between the USEPA and the MEP during meetings of the Environmental Work Group under the US - Ukraine Bi-National Commission for Economic and Technical Cooperation. This Commission was established as part of the US foreign assistance program in Ukraine. Through this process MEP representatives strongly supported more cooperation with USEPA on projects that focus directly on building their own institutional capacity. As a result, MEP and USEPA agreed on developing an environmental program with a clear emphasis on strengthening MEP's core institutional abilities. This approach was viewed as a necessary long-term strategy to enable Ukraine to successfully manage its environmental problems.

Essential elements of the CBP include: a) sharing analytical tools used in the US; b) results from other countries' (e.g., EU Tacis, Denmark) technical assistance programs in Ukraine; c) the work of multi-lateral organizations such as the Organization of Economic Cooperation and Development (OECD); and d) other relevant international experience and tools from neighboring countries, particularly Russia and to a lesser extent, Poland.

USEPA and MEP initially developed a series of analytical objectives for the Capacity Building Project (CBP). It was agreed that MEP needed to more rigorously set its environmental priorities, and that the analytical basis for these priorities should be comparative risk assessment. Due to the magnitude of pollution, the number of the pollutants emitted, and the number of significant pollution sources, Ukraine is faced with an extremely difficult task, and with very difficult choices about which sources to address and how to address them. Risk assessment, which uses estimates of exposure to hazardous pollutants and then characterizes the risk such exposure may pose, can be used to rank the relative risk of different industrial emissions. Risk assessment can provide decision criteria for MEP's actions. These analyses should be performed by Ukrainian experts, whether inside or outside the government. Risk assessments can be carried out to varying degrees of detail depending on the type of information on exposure and hazard available. Ukrainian experts and officials can use the best data sources available to them, whether the sources are national or international. At the very least, simple screening analysis can begin to provide critical decision support to the Ministry and support the case for the importance of environmental protection.

Through the efforts of this program MEP should be able to set more effective risk-based priorities in regional and national level environmental policies and increase the efficiency and performance of its environmental investments. Additionally, the Ukrainian government will have more tools with which to meet its international environmental treaty obligations. Finally, as a result of its efforts, MEP should be able to more effectively argue the significant health and economic benefits of environmental protection to the Ukrainian Government.

A Brief Synopsis of Approaches to Air Pollution Risk Assessment and Regulation in the United States

The purpose of this section is not to create a template for Ukraine to copy, but to provide a glimpse of the US experience in dealing with air pollution, and the ongoing need for flexibility and the ability to change approaches. The original Clean Air Act was signed into law in 1963 and was considered to be the first modern environmental law enacted by the United States Congress. It was the Clean Air Act of 1970 (amended by Congress in 1975 and 1977), that formed the basis of federal pollution control and it used health-based national ambient air quality standards as its approach. The standards were to be met by application of control technology with cost and technological considerations to be subordinate to public health protection. All requirements were to be national with no facility having a competitive edge by having to meet less stringent controls. The EPA was responsible for carrying out the program (Clean Air Act: Law and Explanation, 1990, www.epa.gov/air/oaq_caa.html).

The EPA set two kinds of National Ambient Air Quality Standards (NAAQS) that specified acceptable concentrations of pollutants in outdoor air. Primary standards were set to protect human health while secondary ones were developed for plants and animals for six common pollutants (Criteria Pollutants). Lists of hazardous air pollutants (HAPs) were created (e.g., asbestos, beryllium, mercury, benzene) and regulations were developed to control sources of those pollutants. To limit pollution from mobile sources (e.g., cars) controls were placed on emissions (e.g., catalytic converters and use of unleaded gasoline). Thus, national standards were in effect for most major industries. The fifty States were assigned important roles in implementation. Both national and local authorities have responsibilities, cooperation has been a necessity, and there are checks and balances built into the system.

However, due to the ongoing difficulty in the attainment and setting of health-based air quality standards there have been further changes to the clean air laws. The 1990 Clean Air Act Amendments (CAAA) contained new and specific regulatory deadlines and actions to combat pollution. Almost all major cities in the United States did not meet the NAAQS for one or more pollutant with the most widespread problem being that of ozone. The 1990 CAAA imposed more stringent controls on automobiles for areas with greatest pollution. Emissions of the hazardous air pollutants were to be controlled through a technology standard. The HAPs were identified for control with a goal of 75% reduction within 10 years through use of maximum achievable control technology (MACT). Rules to control these pollutants under the original statute were often delayed while trying to produce enough evidence on risk to justify regulation. So the 1990 CAAA tried to define away the risk problem by identifying pollutants thought to pose a risk and then mandating the MACT standard. Yet, the 1990 CAAA did require risk assessments to determine whether further reductions would be needed. But a national scale assessment of HAPs concentrations in the air and their likely health risks had never been conducted. The overall health benefit of the MACT standards could not be easily ascertained. So it has not been possible to avoid the inevitable questions about the nature and scope of the health risks to be reduced.

The approaches taken to tackle the problem of understanding and targeting the risks posed by HAPs can be informative for other situations such as the Ukraine. Under the 1990 CAAA the HAPs include 188 specific pollutants and chemical groups, many of which are associated with adverse health outcomes including cancer, neurological, respiratory, reproductive, and developmental effects. Most known health effects of the HAPs are derived from animal and occupational studies with little information on potential health risks from chronic low level exposures to the public (USEPA, 1994; Leikauf et al., 1995). In contrast to Criteria pollutants, little monitoring data exist for the large number of HAPs listed. Their varied chemical nature and heterogeneous geographical distribution makes comprehensive monitoring exceedingly difficult. The USEPA has used a modeling approach to estimate long-term annual average outdoor emissions of the 188 HAPs originating from a myriad of sources (USEPA's Cumulative Exposure Project or "CEP"). Concentrations were estimated for every census tract in the continental United States for a base year of 1990 (Rosenbaum et al., 1999a; Rosenaum et al., 1999b). Modeled HAP concentrations were then compared with previously defined benchmark concentrations for cancer and non-cancer health effects (i.e., the 1/million extra risk for cancer level and the inhalation reference concentrations, [a level at which there is little probability of non-cancer effects]). Uses of the information included identification of pollutants that were ubiquitously high in several geographical locations, pollutants that may pose the greatest risk near population centers, and sources of such pollutants (Woodruff et al., 1998; Caldwell et al., 1998; Woodruff et al., 2000; Axelrad et al., 1999). This approach provides an estimate of health risks rather than measures of the frequency of disease occurrence. A use of the CEP approach has been applied to a more localized level for the state of California (Morello-Frosch et al., 2000) and is the basis of EPA's National Air Toxics Assessment (NATA).

The NATA is an ongoing effort, based on the approach used in the CEP, to track the risk posed through time. Goals of a national assessment are: i) to inform priorities for regulatory programs, ii) to assess progress toward national risk-based goals, iii) to inform efforts to allocate resources to further investigate (e.g. monitoring) problems on a broad or local scale and iv) to support prospective assessments of estimated benefits of air toxics programs (USEPA Science Advisory Board, 2000). The results of NATA are publicly available. EPA's extensive outreach efforts to communicate the results include a website that includes information about the assessment, frequently asked questions, results (data, maps, charts) and discussions on interpretation. Even with the best national assessments there will always be uncertainties. One of the largest sources of uncertainty will continue to center around the inventory of the facility emissions. These data will always be the best available, but uniformity will be lacking; some will be from actual measurements, but most will be based on some method of emission factors or mass balance from the sources themselves. But it is important to emphasize that well-understood, peer-reviewed methods and tools exist for the hazard and exposure analyses of risk assessment.

Russian Experience with Risk Assessment

Ukraine was a very significant industrial region of the former Soviet Union. Comprehensive regulation of air pollution in the Soviet Union was established in the late 1970's. The maximum allowable ambient concentration (MAC) was a key environmental quality standard that was established for more than 100 pollutants. These standards established maximum values for one-time concentrations and daily average concentrations. Introduced in 1969, MAC standards complied with medical requirements and were very strict. For example, the MAC for SO_2 was 0.05 mg/m^3, as compared to 0.26 mg/m^3 in the US[3]. Such strict standards were in actual practice unattainable. Based on the MAC values, Maximum Permissible Levels of Emissions (MPL) for enterprises (stationary sources of pollution) were established. Standards for concentrations of harmful substances in emissions from mobile sources were also set. However, in practice only automobile emissions of CO have been controlled. MAC standards were applied to both new and existing enterprises. However, the stringency of the standards was offset by the lack of compliance due to poor monitoring and enforcement. While calculated for the individual source, MPL does not take into account background ambient concentration of the pollutant from other sources. Therefore, real concentrations of harmful substances in the atmosphere exceeded MAC's significantly. In addition, MPL's were difficult to use because maximum allowed emissions were established for each source of emissions, that is, for each stack, rather than for the facility as a whole. There are companies which have hundreds of individual pollution sources, and the standards are set for each of them. Many companies were not and are still not able to reach the MPL emissions. Therefore following the introduction of these standards, temporary standards (TSP) were also introduced which have become the real emission control tools.

By the end of the 1980's this system almost collapsed. But then a system of pollution fees was introduced (Golub and Strukova, 1994; Kolstad and Golub, 1993). However, this system inherited the major weak point of the previous regulation system, which was the enormous number of regulated pollutants. Introduction of pollution fees helped to improve the monitoring system, but it is very difficult to judge whether or not it had a measurable environmental outcome. During the economic crisis of the early post-Soviet period the level of air pollution declined, while emission per unit of output increased (Golub and Strukova, 1994; Kolstad and Golub, 1993).

In 1996 the first health risk analysis study was conducted in Volgograd (Larson et al., 1999). The study was based on the risk assessment methods of, and training provided by the USEPA, and was led by the Harvard Institute for International Development and the USEPA. Risk analysis was considered important to identify priorities given the scarce resources available in countries in transition. The risk assessment was based on the existing air and water emissions inventory of the multiple sources in Volgograd. Concentrations in the air were estimated using a Russian air dispersion model. USEPA health-based benchmarks and slope factors were used as a starting point. Russian air dispersion models designed to estimate ambient concentrations focused on 20 minute and 24 hour concentrations, which were the bases for regulation in that country. For risk assessments the annual average concentration is needed. For the Volgograd study the results of calculations were adjusted by experts (Larson et al., 1999). In an assessment in Nizhnii Tagil there was an attempt to calibrate the US air dispersion model and calculate annual average concentrations directly. Although the Russian modeling methodology has limitations, the benefits include the availability of data to run the model, and general acceptance of the methods. The Volgograd risk assessment estimated that among hundreds of pollutants only one of them: PM_{10} was responsible for more than 90% of the estimated mortality risk. Among dozens of industrial enterprises, only two were responsible for the major share of the impact on public health. These analyses were then used to develop risk mitigation priorities, with significant

[3] More examples of MAC's for various substances can be found in Golub and Strukova (1994), page 168.

input from epidemiology. Results from other health risk assessments in Russia are described in Oniszhenko (2002) and Danilov-Danilian et al. (2003).

A very significant proportion of Soviet industrial development occurred in Ukraine. By analogy to this first generation of risk assessments in Russia, it is fairly reasonable to assume that significant human health risks result from industrial pollution there. In 1999 approximately 2% of total mortality in Russia and 8% of morbidity (seen mainly as respiratory illness) was likely due to environmental pollution (calculations based on Bobylev et al., 2000). It is likely that environmental pollution takes a similar toll on public health in Ukraine. Ukraine also has some factors that may exacerbate the situation; these being higher population density and a fuel mix that probably produces more pollution. To generate more rigorous estimates for Ukraine it is necessary to carry out risk assessments within that country.

METHODS

Applying Risk Assessment to Setting Environmental Priorities in Ukraine

The numerous industrial facilities and mobile sources in Ukraine release very significant amounts of criteria air pollutants or their precursors, heavy metals, volatile organic compounds, and persistent organic pollutants. These emissions are linked to increased risk of numerous health effects including respiratory ailments, cancer, developmental, and/or neurotoxic effects. The extent of the problems and the constraints of cost require as a first step the careful weighing of relative harm of the many industrial emissions. Then setting priorities for control of these emissions can begin as the effectiveness and cost of control is considered.

Because risk assessment is relatively new to Ukraine to achieve the ultimate goal of creating acceptance and use of risk requires Ukrainian officials and technical specialists to learn the concepts and practice of risk assessment on their own. Risk assessment, risk management and their practical policy application must occur in their own country and environmental context. To accomplish this CBP objectives include: 1) the conduct of pilot risk assessments and priority-setting activity within several oblasts to show the effectiveness and benefits of the methodology and its relevance to Ukrainian conditions; 2) using “learning by doing” approaches to help Ukrainian specialists to acquire practical skills in risk assessment, and thereby train a core group of Ukrainian risk assessors; 3) harmonize Ukraine's existing retrospective, epidemiological approaches with the prospective approach of risk assessment; and 4) introduce the use of risk assessment to project evaluation procedures for the National and Oblast Environmental Protection Funds.

To set priorities for reducing the emissions, they must be ranked by their potential to cause harm. Setting priorities requires that we try to generate the most important pieces of information that we can learn about potentially harmful emissions. Perhaps the most difficult and uncertain but important step in conducting a risk assessment is to define the extent and content of emissions. In order for the assessment to have the greatest validity for defining the nature and scope of the Ukrainian pollution problem, it is essential to gather data specific to the areas or regions to be assessed. The information on facility emissions must not only describe what is being emitted but also in what amounts. To do the exposure analysis, appropriate population data must also be gathered. Pollutant dispersion models are already available from a number of sources. Toxicological information on the pollutants is also readily available. Medical epidemiological data from Ukraine can clearly be useful to understand the effects of industrial emissions on human health. However, epidemiology studies are by their nature retrospective and attempt to identify associations of health conditions with past emissions. This is typically difficult as these past emissions are among many factors influencing health. In the context of prioritizing the control of pollution it is important to include risk assessment's forward-looking, prospective view and to estimate the reduction in adverse health effects resulting from the reduction of emissions.

RESULTS AND DISCUSSION

Phase 1 CBP Activities

The Capacity Building Project (CBP) began with an Inter-ministerial workshop (November, 2002). It was designed with two purposes: 1) to build understanding of the approach by illustrating many of the principles of modern environmental policy; and 2) to facilitate partnership and to exchange experience between the two governments and share best practices available in multilateral international institutions. The conference was organized by the NGO Counterpart International, a grantee of the USEPA, in close consultation with both the EPA and the MEP. Presenters included representatives of the US and Ukrainian governments, the OECD and the World Bank, as well as Ukrainian, US and international experts in the fields of risk assessment, environmental economics and environmental finance. Most participants were officials from the MEP, both from the national level and nearly all of the oblasts. Additionally, the Cabinet of Ministers, Ministries of Economy, Finance and Health also sent their representatives.

While some of the specific topics covered in the workshop were familiar to various participants, the incorporation and integration of these ideas and practices into building core institutional capacity as a system was new and challenging. Open, transparent goal setting by government is the ultimate basis for good governance and broader public support. The task for MEP and the Government of Ukraine is to develop the capability of incorporating these practices into their own specific context. The workshop led to the formation of a workgroup that included all of the participating ministries and led to the selection of two oblasts to host pilot assessments. After the introductory workshop we began a series of parallel workshops to 1) begin the comparative risk assessment case studies and 2) promote risk-based management of Ukraine's environmental protection funds.

The first workshop to begin the pilot risk assessment on the local level was held in heavily industrialized Zaporyzhzhia oblast. Participants were from the oblast level Environment and Health Ministries, staff from the City Council, and representatives from industrial enterprises and local academic institutions. Presentations on US practice of risk assessment and its adaptation in Russia preceded sessions specific to the prospective local comparative risk assessment. This first "hands-on" workshop led to several key findings. The first confirmed the Russian experience with MAC standards – 400 priority chemicals – but attainment had been reached for very few. With preliminary emissions data from three industrial enterprises, it was possible to demonstrate an updated version of Russian air dispersion models that have now been linked to US geographic information system technology. Ukrainian environmental health specialists already have in-depth knowledge of their worst contaminants, but they do not always have easy internet access to the latest information that is available from sources such as the USEPA or the World Health Organization. But finally, and equally important to all of the technical issues was that these workshops are required to develop the trust and conditions for trying new approaches like comparative risk assessment. This was an opportunity to promote the benefit of risk assessment methodology and its relevance and practicality to Ukrainian conditions and context for risk management.

As a result, more detailed emissions data were made available and initial comparative risk assessments in this oblast has been completed. The first pilot risk assessment project in Ukraine was implemented in Zaporyzhzhia city. It used to be one of the most polluted cities in Ukraine. The study covered only three industrial enterprises since environmental authorities were reluctant to conduct a comprehensive study before testing the method. Exposure was calculated only for two districts in Zaporyzhzhia:

- Zavodskoy district with a population of about 61,000;
- Ordjonikidze district with a population of about 106,000.

The study applied adjusted dose-response coefficient for PM_{10} equal to 0.5% per 10 $\mu g/m^3$, and for SO_2 equal to 0.6% per 10 $\mu g/m^3$ SO_2. Baseline mortality for Zaporyzhzhia city is 8.4 per 1000. The results are provided in Tables 1 and 2.

Table 1. Annual additional mortality from PM_{10}.

Receptor point	PM_{10} Annual concentration μg/m^3	PM_{10}		Additional mortality (cases/year/per 1,000,000)
		Individual risk	Additional mortality (cases/year)	
Zavodskoy	0.137	$8.4*10^{-4}$	51	836
Ordjonikidze	0.085	$5.2*10^{-4}$	55	518

Table 2. Annual additional mortality from SO_2.

Receptor point	SO_2 Annual concentration μg/m^3	SO_2		Additional mortality (cases/year/per 1,000,000)
		Individual risk	Additional mortality (cases/year)	
Zavodskoy	0.125	$9.2*10^{-4}$	56	915
Ordjonikidze	0.118	$8.6*10^{-4}$	92	864

The analysis demonstrates that a dominant fraction of health risk comes from conventional pollution such as PM_{10} and SO_2. The share of health risk from carcinogens was relatively smaller. The results are similar to those obtained in Russian cities (Larson et al., 1999).

This pilot study demonstrates that this method could be successfully implemented using local primary data and local air dispersion modeling capacity, which is a critical aspect of the analysis gaining acceptance and use.

Based on this work, economic valuation will be used to help direct resources to those control projects which yield environmental benefits at the least cost. The most important categories of goods and services provided by the environment that need to be valued are environmental health risks, natural resources, and environmental services and amenities including bio-diversity. Valuation methodologies and benefit estimates based on health and environmental risk analyses would be a more standard approach, and would optimize environmental policy by targeting a reduction in human health risk from decreased environmental pollution at the least cost. Health risk reduction will likely become the leading criterion for deciding on the limited number of pollution control projects that are likely to be feasible. A pilot risk management workshop based on these analyses will be held to develop the risk-based decision making process. We believe that based on this preliminary effort, authorities are likely to make available emissions data from the other major enterprises. At that point the risk assessments can be expanded, and we can also begin to better develop other endpoints and routes of exposure.

In addition to workshops on risk, a parallel series of workshops are addressing environmental finance. Like Russia, Ukraine levies pollution fees on emissions. These fees go into a group of national, oblast and municipal environmental protection funds. These funds are major for environmental finance in Ukraine. The CBP is also addressing improvement of the management of these funds. Officials involved in the management of the funds are examining a series of issues including: updating financial management techniques, and consolidation and harmonization of funds at the different governmental levels. Explicit linkages between the use of the funds and the priorities set through comparative risk assessment are being explored.

CONCLUSIONS

The USEPA – MEP Capacity Building Project is still in its early stages and has not yet achieved concrete environmental outcomes. However, Ukraine is a country with severe urban air quality problems. A fundamental choice has to be made in any environmental assistance project that is carried out there. Resources can be used for a specific environmental pollution control project. Or resources can be directed to assist Ukraine in developing sustainable strategies and capabilities to manage environmental problems on their own, over the long term, with acceptance of the current set of constraints. Ukraine's MEP requested assistance based on this second path. The CBP, as described in this paper, has been designed to support that path. We have started reporting and will continue to report on actual results as the CBP progresses.

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