# The Integrated Environmental Strategies (IES) Cost-Benefit Analysis in Seoul, South Korea

## Background

The objective of the IES Program is to assess and quantify the environmental and public health benefits resulting from integrated measures to reduce greenhouse gases (GHGs) and local air pollutants. By analyzing and implementing integrated policies and measures, such as clean energy, energy efficiency, and public transportation, IES partners have an opportunity to make a positive impact on local air quality, public health, and the economy, while at the same time reducing GHGs at the global level. The IES Program seeks to enhance in-country capacity to conduct co-benefits analysis and assists with policy evaluation for integrated planning.

The IES-South Korea Program was initiated in 1999 as a collaboration among the U.S. Environmental Protection Agency (EPA), the Republic of Korea's Ministry of Environment, the Korea Environment Institute (KEI), and the National Renewable Energy Laboratory (NREL). The first project of the IES-South Korea Program (1999-2001) applied a bottom-up impact analysis to evaluate the benefits of integrated mitigation policies and measures in Seoul. The second project (2003-2007), which is overviewed in this fact sheet, evaluated the health and GHG impacts of the Seoul Air Quality Management Plan (SAQMP), compared those impacts to the expected health and GHG impacts of selected GHG reduction measures, and developed an alternate scenario of integrated measures to cost effectively attain local and global emission reduction targets.

KEI led the second IES-South Korea project, titled "Cost-Benefit Analysis of Integrated Environmental Strategies for Air Quality Improvement and Greenhouse Gas Emissions." Daejin University conducted the economic valuation and cost-benefit analyses. Kangwon University also collaborated on portions of the IES project by developing mitigation scenarios, performing air quality modeling, and identifying concentration-response functions for the health effects analysis.

## Objectives

The primary objective of the second IES-South Korea project was to deepen understanding among Korean policymakers and the research community of the advantages of an IES approach, the methodologies for conducting associated analyses, and the benefits of the measures analyzed. Specific goals included: 1) implementing a health benefits model for Seoul; 2) developing co-benefits analyses and evaluating the impacts of selected measures from the SAQMP and select GHG reduction measures; 3) developing an alternate suite of measures, identified through optimization analysis, that cost effectively meet GHG and local air pollution goals; 4) supporting integrated policymaking by the Ministry of Environment's Climate Change Team; 5) continuing cooperation with the national outreach campaign on air quality; and 6) continuing the presentation of IES results in national and international forums.

## Methodology

The Seoul metropolitan area, including Incheon and Kyonggi, represented the geographical scope of the study. Scientists studied the following GHGs and air pollutants: carbon dioxide ($CO_2$), methane ($CH_4$), sulfur oxides ($SO_x$), nitrogen oxides ($NO_x$), and particulate matter ($PM_{10}$). The sources of these GHGs and air pollutants were limited to fuel sources (energy industry combustion, nonindustrial combustion, manufacturing industry combustion, and mobile sources). The IES-South Korea team selected 2003 as the base year and 2014 as the year used for estimating scenario impacts. EPA's Models-3/Community Multiscale Air Quality (CMAQ) was used to measure air quality, and EPA's Environmental Benefits Mapping and Analysis Program (BenMAP) was used to


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calculate the expected impacts of the policies on health endpoints (morbidity and mortality).

The study considered four scenarios: a Business as Usual (BAU) scenario, the SAQMP scenario, a GHG Mitigation scenario, and an IES scenario. The SAQMP scenario focused on regulating industrial sources (e.g., total allowable emissions system, emission trading), area sources, onroad mobile sources, and nonroad mobile sources. The GHG scenario assumed a target GHG emission reduction of 10 percent by 2014 and included the most cost-effective measures to meet that target. The IES scenario included integrated measures determined to be the most cost-effective and to have the maximum possible spread and emission reduction potential. Examples of measures included in each scenario are displayed in Table 1.

Table 1: Examples of Policy Measures for Three Alternative Scenarios

| Scenario | Examples of Measures |
|---|---|
| SAQMP | Total allowable emission systems for $NO_x$, $SO_x$, and $PM_{10}$<br>Accelerated vehicle retirement program<br>Low emission vehicles<br>Expansion of district heating systems |
| GHG | Landfill gas for energy<br>Spread of low-$NO_x$ boilers<br>Promotion of compressed natural gas (CNG) intra-city buses<br>Expansion of district heating systems |
| IES | Spread of low-$NO_x$ boilers<br>Promotion of CNG intra-city buses<br>Expansion of district heating and cooling systems<br>Total allowable emissions systems for $NO_x$, $SO_x$, and $PM_{10}$<br>Accelerated vehicle retirement program |

## Findings

The emission reductions and associated economic benefits for each scenario, based on a cost-benefit analysis for estimated reductions in morbidity and mortality, are displayed in Table 2.

The following integrated measures were found to be the most cost-effective ways to reduce both air pollutants and GHG emissions: 1) increasing the use of low-$NO_x$ boilers; 2) promoting CNG intra-city bus operation; and 3) switching fuels in industrial facilities. Using integrated measures in the transportation sector was found to be particularly effective in reducing both GHG and air pollutant levels. The findings also indicate that cost savings (e.g., from reduced fuel costs) can offset the installation cost of GHG reduction measures, and that air quality improvement is closely related to the reduction in GHG emissions.

## Policy Results

While some current SAQMP measures, such as installing catalytic converters and employing desulfurization facilities, are retrofit technologies that will only reduce air pollutant levels, other measures, such as CNG intra-city bus operation and district heating and cooling systems, are integrated strategies that will reduce both air pollutants and GHG emissions. IES efforts have increased the interest in integrated strategies like these among researchers and policymakers in Korea. Research that includes additional GHGs and air pollutants, as well as studies that include geographic regions beyond Seoul, could reveal additional low-to-no-cost opportunities for integrated planning in South Korea.

Table 2: Projected Emission Reductions and Associated Economic Benefits for Three Alternative Scenarios in 2014

| | $NO_x$ (tons) | $SO_x$ (tons) | $PM_{10}$ (tons) | $CO_2$ (tons) | Net Economic Benefit (Won) From Reductions in Premature Mortality From Air Quality Improvements and GHG Emissions |
|---|---|---|---|---|---|
| SAQMP | 172,000 | 66,000 | 9,600 | 7,330,000 | 90–100 trillion |
| GHG | 3,000 | 13,500 | 2,800 | 10,340,000 | 130 trillion |
| IES | 172,600 | 41,600 | 10,400 | 10,640,000 | 147 trillion |

## For More Information

Visit the IES Web site at <www.epa.gov/ies> or e-mail <ies@epa.gov>.

Integrated Environmental Strategies

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