

Cost Benefit Analysis of Air Pollution Abatement Options in the Ger Area, Ulaanbaatar, and Health Benefits Using Contingent Valuation

O. Enkhtsolmon, T. Matsumoto, and Erkhembayar Tseven

Abstract—We conducted a cost-benefit analysis of air pollution abatement options that considered income level by region in a residential sector of a ger area in Ulaanbaatar, Mongolia. The study selected three feasible measures, taking into account direct benefits (fuel savings), health benefits and investment costs. The net present value of the abatement combined options and the reduction of total suspended particulate (TSP) emissions during the investment timeframe were estimated. We also conducted double-bounded dichotomous contingent (DBDC) valuation surveys with 373 respondents to gather data on air pollution awareness and willingness to pay (WTP) for protection of health from air pollution. To assess the unit costs of health benefits, we relied on the willingness-to-pay study carried out as part of the CVM study, which derived a value of WTP of US\$20.30, which is the value placed on protection of health from air pollution.

As for the results, the air pollution abatement combined option can be seen to reduce emissions approximately 50 percent in Ulaanbaatar over 7 years.

Index Terms—Air pollution, cost-benefit analysis, contingent valuation, Ulaanbaatar.

I. INTRODUCTION

Ulaanbaatar faces an air pollution problem, particularly during the winter months, and the pollution has several negative effects on human health. Currently, 60 percent of Ulaanbaatar's population lives in the ger¹ areas, and the proportion is growing. Ger area heating systems burn continuously during the winter season and their contribution to the overall air pollution level then reaches 70 percent and more in the ger areas and up to 60 percent in the city center. The residents of these areas use coal-fired stoves for both heating and cooking. Because ger area residents have no access to the district heating system, they have to depend on their own heating systems. The average households consumed about 4 t of raw coal and 3.18 t of wood during the heating season. Particulate matter PM_{10} and $PM_{2.5}$ concentrations in

Ulaanbaatar are 3 to 6 times greater than Mongolian air quality standards (AQS), and annual average concentrations are $75 - 150 \mu\text{g}/\text{m}^3$ and $150 - 250 \mu\text{g}/\text{m}^3$, which is 7 to 15 times higher than the WHO standard ratio, and these are among the highest measured values recorded in any world capital (Table I, Table II).

TABLE I: ANNUAL AVERAGE PM CONCENTRATION OF ULAANBAATAR 2008.06-2009.05 [1]

Location	PM10 ($\mu\text{g}/\text{m}^3$)	PM2.5 ($\mu\text{g}/\text{m}^3$)	Exceedance ratio to AQS	
			Mongolia	WHO
Central city areas	150-250	75-150	3-6	7-15
Ger areas	250-700	200-350	7-14	17-35

TABLE II: MONGOLIAN AIR QUALITY STANDARDS AND WHO AIR QUALITY STANDARDS [2]

Pollutant		Average time	Mongolia AQS value ($\mu\text{g}/\text{m}^3$)	WHO AQS value ($\mu\text{g}/\text{m}^3$)
Sulfur dioxide	SO_2	10 mins	500	500
		20 mins	450	
		24 hours	20	20
		1 year	10	
Ozone	O_3	8 hours	100	100
Particulate matter	PM_{10}	24 hours	100	50
		1 year	50	20
Particulate matter	$PM_{2.5}$	24 hours	50	25
		1 year	25	10

We conducted cost-benefit analysis (CBA) for the air pollution abatement combined options. This study targeted air pollutant abatement options for the major source of coal fired stoves in the ger area, Ulaanbaatar.

II. METHODS

We conducted a cost-benefit analysis of air pollution abatement options in a residential sector of the ger area considering income level by region. The combined various abatement options included relocation of ger area households into apartments, using electric heaters instead of coal stoves, and installing central heating systems.

We also conducted a double-bounded dichotomous choice (DBDC) contingent valuation (CV) survey with 373 respondents in October 2014 and collected complete information on air pollution awareness and respondents willingness to pay for protection of health from Air pollution. The survey was designed to collect data from a representative sample of respondents which living in the ger area and the apartment area in the Ulaanbaatar.

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¹Traditional *gers* are nomadic felt tents with wooden lattice substructures, used by Mongolian nomads for centuries. The *ger* was an ideal living solution for nomads for so long because it is mobile, light-weight, and portable, making it well suited for easy moving.

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