Equity Implications of the Korean Urban Energy Policy*

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The importance of gas as the major source of fuel energy has recently been on the rise, reducing the traditional dependence on coal and coal briquets significantly. Accordingly, how to distribute government incentives among alternative sources of energy becomes an important policy issue. While admitting that the decision will be ultimately swayed by political considerations, this paper suggests that there are several policy criteria which, if properly adopted, would help rationalize energy policy-making. The author argues that in addition to the traditional criteria such as efficiency and equity, the uncertainties of the energy policy system and the consistency and continuity of the policy should be considered as substantive policy criteria as well. Among those, this paper focuses on the equity effects of gas and coal subsidies for various income groups. Evaluating the current distribution of government subsidies fairly equitable and favoring a greater reliance on gas as major source of energy in the future in light of its higher social benefits, this paper warns against the negative equity effects of gas subsidy for the lower income class, particularly when it is combined with the withdrawal or reduction of coal briquet subsidy currently available to them.

I. Introduction: Contexts, Goals, and Scope

The Korean government introduces 2 million tons of LNG (Liquified Natural Gas) annually into Korean urban areas. The government has seriously considered the next LNG project, and has planned large-scale of LPG (Liquified Petroleum Gas) importation. Once that occurs, the share of gas in the Korea economy will increase rapidly. More than half of the imported LNG will be used in the household and commercial sectors and for industrial fuel in urban areas, substituting mainly for coal briquets.[1] The new energy programs faced several problems at the initial phase of implementation, resulting in policy changes and delays. One of the critical issue in expanding gas demand involves the consumer price level or government subsidy.

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* Adapted from several sections of the author's Ph.D. dissertation, "Backward Mapping" Analysis of An Urban Energy Policy: A Fuel Subsidy to the Rich?, Harvard University, 1987.

1) The Ministry of Energy and Resources (MER), *Long-run Energy Prospects and Strategy for 2000s*, (Seoul, 1985), p. 44.

Concerning the expansion of gas demand, political games played by policy participants, such as politicians, national as well as local bureaucrats, and industrial representatives coming from different energy sectors will, to a large extent, determine the outcome of the policy. And, a large portion of the future policy development can be explained by examining the political games these interests play.

On the other hand, there may be several rational policy criteria which can be effectively employed in evaluating the urban energy policy implementation process. By analyzing the policy with these criteria, some formulative implementation strategies or concrete government role can be found. If these rational policy criteria are well incorporated in the policy modification process, the policy outcome seems to be more desirable than the outcome solely driven by the politics of the policy implementation.

These policy criteria may include traditional efficiency and equity. In addition to the two existing economic criteria, which seem to be extensively applicable, some criteria which are unique to the substantive policy—the energy and environmental policy in this case—must be incorporated. Two additional criteria can be chosen: the uncertainties of the energy policy system, and the consistency and continuity of the policy.[2)]

This paper deals with only one policy criteria, equity in energy use, and tries to analyze the present energy use and the effects of government involvement in the LNG program on the equity situation. The effects of gas and coal subsidies on the equity condition is main point.

II. Energy Policy and Equity Issues

1. Equity as a Policy Criterion

One dimension of evaluating the energy program involves equity in energy use. Equity is an ethical concept, with other ethical principles, such as utilitarianism, right, justice, denoting virtues such as "fairness," "impartiality," and "social justice."[3)] As a policy criterion, equity has been not so extensively used as efficiency in the field of energy policy. While procedural equity refers to the fairness of the decision allocation process, substantive

2) For more detail, see Lee, D., *op. cit.*, pp. 7-19 and pp. 38-73.

3) For equity or justice as a policy criteria, see Rawls, J., *A Theory of Justice*, (Cambridge, MA; Harvard University Press, 1971); Ake, C., "Justice as Equity," *Philosophy and Public Affairs*, Vol. 5, No. 1, (Fall, 1975), pp. 69-89; and Gianessi, L., H. Perkin, and E. Wolff, "The Distributional Implications of National Air Pollution Damage Estimates," in T. Juster, (ed.), *The Distribution of Economic Well-Being*, (Cambridge, MA: NBER, 1977), pp. 201-232.

equity, which is our main concern here, conceptually represents the empirical distribution of costs and benefits resulting from policy choices to affected parties.

Inequities in the distribution of the economic impacts must be considered to ensure that specific groups of people are not bearing excessive costs for the benefit of others. Equity issue becomes a serious energy policy consideration, especially when there is a sharp price increase or new sources are introduced. Intertemporal equity in energy in energy decision-making deserves notice.[4] The existing income distributions and patterns of ownership strongly condition the use of energy resources and the introduction of new systems. At least one important concept of equity would maintain that relative proportion of income spent on energy should be equal across income groups.[5]

2. Equity and Energy Use

The equity issue, here, is mainly associated with the expenditure on purchase of energy, and the distribution of the costs of urban energy policy which will change the energy source mix through various policy measures. In relation to expenditure on energy purchases, the term "equity" can be used to cover three different but connected concerns: 1) the more equitable consumption of energy across income brackets; 2) the more equitable "distribution" of the share of energy expenditures across income brackets; and 3) the amelioration of difficulties in securing basic energy needs.

The first equity issue in energy consumption is related to several technical as well as policy matters. Forms of energy and the equipment needed in using a certain form of energy, determine technical efficiency. Any policy which affects the efficiency factor actually changes the existing equity in energy use. Direct energy use, by which we mean the total use of raw fuels and electricity including the energy required to generate and distribute electric power to end-users is closely related to the efficiency of appliances. Becauses the poor tend to have less efficient energy appliances, the inequity gets worse. In addition, when we included the indirect energy (direct energy plus the amount of energy required to manufacture and deliver that energy to the point of end-use), inequity of energy use seems much worse.[6] Large portions of high quality energy forms will be used in higher

4) LeBel, P., *Energy Economics and Technology*, (Baltimore: The Johns Hopkins University Press, 1982), p. 442; Landsberg, H., (ed.), *High Energy Costs: Assessing the Burden*, (Washington, D.C.: Resources for the Future, 1982), pp. xi-xv.

5) Kalma, J. and D. Crossley, "Inequities in Domestic Energy Use," *Energy Policy*, (Sep., 1982), pp. 233-243.

6) Newcombe, K., "Energy Use in Hong Kong," *Urban Ecology*, 1, (1987), pp. 179-205.

income households because they are cleaner, safer, and more convenient to use. The different mix of input fuels in the household sector by different income group may exacerbate the "relative poverty perception," especially among the urban poor.

The second issue of equitable distribution of energy expenditure can be studied referring to the energy used by the household sector and the relationship between energy expenditure and income. Energy expenditure rises with income, but not proportionately. The income of the household and the price of energy consumed are two major determinants of both the absolute level of expenditure and the proportion of income that energy expenditures account for.[7] Relative price structure and levels directly affect the burden of each income group. These become politically sensitive issues, especially when the government has strictly regulated energy prices. Because there are cross-subsidies among various consumers and producers, a government policy change will benefit certain groups with the costs being born by other groups. A large part of the effort involved in setting a new price system should spent on comparing it with the existing one for a sample of consumers, in order to estimate the effect on their bills.

Last, inequities related to the volume of energy consumption by lower income group is closely related to the "fuel poverty" issue. In this respect, energy policy, especially domestic fuel policy, is closely related to social policy. A fuel policy should pay special attention to the urban poor to guarantee them reasonably warm and well-lit homes. This is especially important when energy prices increase rapidly or a high quality fuel source is expected to be introduced on a large scale in a region. This view, it is acknowledged, sees energy as a social necessity: people have a right to energy for cooking, home heating, lighting, transportation, and other essential purposes. Because fuel energy, along with food, clothing, and shelter, is often described as a basic need, "fuel poverty" should be paid attention to when designing an energy policy.[8] Some energy sources are thought inherently inequitable or discriminatory. Some energy technologies, while reach of some income groups, may simply be too expensive in any sense for the poor to afford.[9] Not only do households in different incomes bracket consume different amounts of energy, but the input mix of energy forms also differs siginficantly.

There may be a number of direct or indirect policy tools which can contribute equitable

7) Pachauri, R., "Third World Energy Policies," *Energy Policy*, (Sep., 1983), pp. 217-224.
8) Ester, P., (ed.), *Consumer Behavior and Energy Policy*, (N.Y.: North-Holland, 1984), p. 327.
9) Lovins, A., *Soft Energy Paths: Toward a Desirable Peace*, (N.Y.: Harper and Row, 1977), pp. 34-72.

energy use. One of the main problems with such efforts is its tradeoff with with efficiency.[10] This is highly polical, but one of the important guidelines may be that equity consideration is a basic constraint to any energy policy which tries to improve efficiency.

Let us assume that because of market imperfections, the public simply consumes too much energy at the current market price and that therefore a general tax or price increase—income distribution effects aside—would be a proper policy. Now assume further that each of these policies, an energy tax or a higher energy price would hurt poor people. Does this combination of outcomes—a good energy policy that is costly to poor people—mean that the policy should not be adopted? The answer, even for one who is very concerned about the poor, has to be "not necessarily." We can do other things to help poor people and still have the advantages that go with the adoption of the energy plans.[11]

However, an opposite example can be introduced here. Let us assume the government believes that introduction of large scale gaseous fuels in urban areas is strategically important and potential social benefits can be realized only when private consumption increases rapidly. And assume further that efficient marginal pricing turns out to be expensive even for the rich, and the demand expansion is not able to be realized in short period of time. Then, can fuel subsidies for the rich be justified?

For these cases, we suggest that the present condition of the income distribution and equity in energy use can be a criterion for policy decisions. And, even if the foreseable inequity situation is not serious, new policy should be designed not to worsen the present condition, when it cannot improve economic efficiency considerably.

2. Equity Consideration in Environmental Quality Improvement

Urban energy policy is closely related to environmental policy because energy use raises problems of air and water pollution, and other hazards on human health and property damages. Any energy policy has income redistribution effects through environmental quality changes across income groups, regions, and economic functions. To the extent that urban fuel policy contributes to reducing pollutants, we can analyze the welfare distributional effects of energy pelicy. If air pollution damage is considered negative income, it is natural to investigate its effects on income distribution.

10) For this issue, see Okun, A., *Equality and Efficiency: The Big Tradeoff*, (Washington, D.C.: The Brookings Institution, 1975); Varian H., "Equity, Envy, and Efficiency," *Journal of Economic Theory*, 9, (1974), pp. 63-91.

11) Brannon, G., *Energy Taxes and Subsidies*, (Cambridge, MA: Ballinger Publishing Co., 1974), p. 143.

There are opposing arguments regarding the distribution of air pollution damages among individuals classified by income and race. Freeman and Zupan have found that poorer income groups are exposed to higher pollution levels.[12] In contrast, Gianessi and his associates found that air quality is distributed in a "pro-poor" manner.[13] The mean pollution damage gets larger as income gets higher. But the percentage of persons in the income class gets much larger as income gets lower, the total damages in the lower income groups get larger. Gianessi said, "of course, as a group the poor suffer more; but that is only because there are more of them."[14]

We can expect higher income groups to satisfy their relatively high demands for environmental quality by selecting sites with comparatively little air pollution, noise, and so on. Some of environmental programs are of primary value to people with resources with which to enjoy them. In contrast, the poor can be expected to occupy the less attractive parts of the metropolitan area in exchange for lower rents, such as near streets or factories. In fact, if differentials in environmental qualities are perfectly capitalized into differentials in property values and rents, economic reasoning would suggest that improved air quality in part of an urban area will make the land under that air more valuable and raise land prices. Empirical studies verify that, within metropolitan areas, property values do indeed reflect differences in environmental quality. On balance, programs for environmental improvement, including urban fuel substitution, are contended to promote the interests of higher-income groups more than those of the poor. Low-income families are likely to feel that basic needs, such as better food, fuel sources, and housing constitute more pressing concerns than cleaner air and water.

When the improvement is a pure public good, it must be available to everyone on equal terms. Nevertheless, the public-goods model suggests that the dollar value placed on these benefits will be greater among higher-income recipients. But, in a Tiebout world we can reach no such simple and categorical conclusion.[15] Because the poor and the rich inhabit

12) Freeman III, A., "Distribution of Environmental Quality," in Kneese, A., and B. Bower, (eds.), *Environmental Quality Analysis*, (Baltimore: Johns Hopkins Univ. Press), 1972; Zupan, J., *The Distribution of Air Quality in the New York Region*, (Baltimore: Johns Hopkins Univ. Press, 1973).

13) Gianessi, L., H. Perkin, and E. Wolff, "The Distributional Implications of National Air Pollution Damage Estimates," in Juster, T. (ed.), *The Distribution of Economic Well-Being*, (Cambridge, MA: NBER, 1977), pp. 201-232.

14) *Ibid.*, p. 212.

15) Baumal, W., and W. Oates, *The Theory of Environmental Policy: Externalities, Policy Outlays, and the Quality of Life*, (Englewood Cliffs, NJ: Prentice-Hall, Inc., 1979), pp. 202-205.

separate areas, it is possible to devise 1) programs whose benefits flow to both parties, 2) programs that primarily affect the poor alone, or 3) programs directed mainly to the wealthy. From all these programs, the possibility of greater monetary benefits to the poor seem very low.

On the costs side, the transitional costs—costs of adjusting from one state of environmental quality to another; and continuity costs—costs involved in maintaining over time a newly achieved environmental quality—will have different incidences. Theoretical as well as empirical studies suggest that, at least in the eyes of the poor themselves—and, it may very well be in fact, that the costs be much higher for the poor than they are for the wealthy, due to the former's weak employment position, and large share of energy and environmental expenditures relative to their income. They may well increase the degree of inequality in the distribution of real income; making somewhat regressive the incidence of the costs of environmental programs.

However, if a large portion of such programs are funded through general revenue expenditure, policy costs are borne by the rich through a progressive tax system. But the benefits of environmental improvement are enjoyed without any restriction, i.e., that are common property. On this ground some scholars argue that the urban energy modernization or environmental programs are pro-poor. Freeman believes that, on balance, the improvement could be pro-poor in the U.S. cities at least.[16]

Government has at its disposal a wealth of tools to offset any unfavorable income distribution effects of an energy policy. The problem is largely a political one of putting together two program elements. Various policy tools have been suggested: credits and technical fixes and subsidies; welfare payments and tax policies, including refundable tax credits and a tax on energy-using appliaces; and cost subsidies and adjustment assistance. What this suggests is the need for incorporating sensible redistributive provisions into environmental programs, both as a matter of justice and as a means to enhance their political feasibility. We should not, however, lose sight of the fact that the primary purpose of energy and environmental program is allocative.

In addition to the rich and poor perspective, equity issues of an energy policy can be further analyzed from the other perspectives: the economic functions, locations, and dwelling types (structure and design). Even though the analyses on these need different aspects and variables, the basic logic is virtually the same. Economic functions can include

16) Freeman, A., R. Haveman, and A. Kneese, *op. cit.*, pp. 143-144.

the "wages" and "profits," or several energy-related subsectors. Policy costs and benefits might be different between different dwelling residents. Especially where heating fuel is concerned, any government regulation may affect different dwellings quite differently. Finally, unequal environmental benefits can be distributed on different parts and groups in a city.

III. Analysis of Equity in Fuel Use: The Korean Urban Areas

1. Energy Use and Expenditures

In urban areas, households tend to spend a larger portion of their incomes on purchasing energy and water. As can be seen in the following table, urban households spend relatively more on purchasing fuel, light, and water than do rural households.

This seems to be the case especially if we take into account the fact that large usage of non-commercial fuels and water are more readily available in rural areas. Another important consideration is the fact that urban salary and wage-earning households spend smaller percentages of their expenditures on fuel, light, and water than do all total urban households.

According to 1985 energy survey,[17] an average rural household consumed 76.3% of the national average. Of them, about 10% is woodfuel, of which a large portion is not commercialized in the rural area. An average household in Seoul uses about 123% of the national average which translates into 1.6 times the energy used by a rural household. Even if we take into account the fact that the average climatic temperature is lower in the Seoul area than the rest of the country, if we consider the high fuel efficiency in urban areas, especially in Seoul, we can safely conclude that an average household in Seoul con-

〈**Table 1**〉 Expenditures on Fuel, Light, and Water (Unit: %)

	Rural Household	All Urban Household	Urban Salary/Wage Earning Household
1979	4.47	6.3	6.1
1980	4.71	7.7	7.4
1981	4.70	8.4	8.2
1982	4.24	8.1	7.7
1983	4.19	7.7	7.3
1984	4.20	7.5	7.2

(Source: Korea Statistical Year Book, 1984, 1985)

17) The Korea Institute of Energy and Resources (KIER), *The Sample Survey of the Household Energy Consumption in 1985*, (Seoul, 1986).

〈**Table 2**〉 Fuel Consumption By Dwelling Size
(Unit; Mcal/Pyung (about 36 ft²)/Year)

Size	10~14	15~19	20~29	30~39	40~49	50~59	60+
Annual Average Per Month	96.2 (100)	88.2 (100)	65.5 (100)	62.8 (100)	59.0 (100)	47.5 (100)	49.9 (100)
Winter Month Average	166.3 (173)	153.6 (174)	98.1 (150)	126.2 (201)	118.7 (201)	103.4 (218)	94.4 (189)

(Source: KIER, The Sample Survey of the Household Energy Consumption in 1985, (Seoul, 1986). Hereafter, quoted as The Household Energy Survey, 1986)

sumes much more energy than the average household in other regions. An average household in Seoul consumes disproportionately greater amount of high quality energy sources, such as electricity, diesel, bunker-C, and gaseous fuel. In the case of gaseous feul, a Seoul household consumes 5 times that of a rural household. In recent years, households in the Seoul area have spent their expenditures on household fuels and lighting six to seven percent of their consumption expenditure.[18] These figures do not include an energy-related expenditure on transportation. If we were to include expenditure on transportation, then the share of total consumption expenditure on energy will increase significantly.

Consider also the relative difference of energy consumption among houses of different size. First, smaller dwellings consume relatively greater amount of fuel per unit. Second, household consumes in winter months almost 2 times that of average month, especially in a large house. A dwelling of size larger than 60 Pyung(about 36ft²) consumes almost half of the fuel used in a small dwelling, say 10 Pyung. The above facts point to some policy implications: first, fuel supply security during the winter season is critical, which implies potential problems for peak/off-peak management; and second, poor residents of smaller dwellings spend relatively more on heat, implying that any fuel price increase will hurt them more severely.

2. Energy Expenditures by Imcome Group

The main distributional effect we care about is the division between the rich and poor. A practical way to identify the rich and poor is by total income. Most students of the equity of energy use believe that the correct measure of regressivity or progressivity is the ratio of an energy cost to income before taxes. The following table shows energy consumption patterns and energy-related expenditures by income group in 1985. Again, this table does not includes the transportation usage.

18) *Seoul Statistical Yearbook*, (Seoul, 1985).

〈**Table 3**〉 Energy Consumption by Income Group (Unit: Mcal, 1,000Won/Year)

Income	20—	20~30	30~40	40~50	50~60	60~80	80~100	100+
Energy (1,000)(A)	13,043 (100)	13,631 (105)	16,633 (128)	19,591 (150)	22,260 (171)	25,193 (193)	28,690 (220)	28,584 (219)
Won (10,000)(B)	225.3 (100)	247.9 (110)	297.5 (132)	373.6 (166)	430.6 (191)	529.6 (235)	597.8 (265)	722.1 (321)
Income Share	9.39	8.26	7.08	6.92	6.52	6.79	5.86	6.02
B/A (W/Mcal)	17.28	18.19	17.89	19.07	19.35	21.02	20.84	25.26

(Source: The Household Energy Survey, 1986)

A high income-family consumes almost twice the amount of fuel, cooking and heating fuel combined, than does a low income-family. The highest income family group expends more than three times that of the lowest income-family group. The shares of expenditure on fuel among income groups vary from 6.02 percent for high income group to 9.39 percent (1.54 times more) for low income group. The low coal briquet price seems helpful in reducing the burden of lower income families, for coal briquets account for a large portion of the total energy purchased. Accordingly, policies supporting the coal industry from the coal production stage to the coal briquet distribution stage certainly have worked toward ameliorating the inequality in fuel use.[19]

The following table shows the effects of the withdrawal of the coal subsidy programs on household expenditures.[20] The goals of the subsidy programs are to boost coal production, to protect the low income families, and to curb inflation. Although there are problems achieving those goals effectively,[21] the burden on lower income groups in purchasing fuels for cooking

〈**Table 4**〉 The Effects of Subsidy by Income Group (Unit: 1,000Won; %)

Monthly Income	100 or less	100~200	200~400	400~800	800 or more
Briquet Expenditure (Income Share)	9.24 (9.2)	9.44 (6.3)	12.41 (4.1)	13.80 (2.3)	14.12 (1.8)
Withdrawal of Subsidy (Income Share)	10.03 (10.0)	10.24 (6.8)	13.46 (4.5)	14.97 (2.5)	15.32 (1.9)
Burden Increased by Price Increase (Income Share)	0.78 (0.8)	0.80 (0.5)	1.05 (0.4)	1.17 (0.2)	1.20 (0.1)

Note: It is assumed that the market price will increase after the removal of the existing subsidies.

19) KIER, *A Study on the Coal Mining Promotion Policy and Fuel Investment Plan for the Private Sector*, KE-81P-18, (Seoul, 1981), pp. 249-306.

20) KIER, *A Study on Coal Industry and Coal Briquet Pricing*, KE-82-P-38, (Seoul, 1982), p. 78.

21) The present government promotion system has been analyzed as an ineffective tool in encouraging high-grade coal production, and because a large number of low income rural households are excluded from coal briquet use, coal subsidy programs cannot be justified solely on equity

and heating will significantly increase without such subsidy programs.

The last row, B/A row, in Table 3, means the price of fuel per 1,000Kcal. A higher unit price of fuel in higher income-families tells that they use high-quality fuel. There are inequalities of fuel grades by income groups. Even though we could not find any comprehensive data concerning the kinds of fuel used by income group in the Seoul area, the

〈**Table** 5〉 Fuel Use by Income Group (1985 National Data)
(Unit: Mcal; Income-10,000Won/Year; Won; %)

Income	Briq.	Keros.	Diesel	B-C	Propane	City-G	Elec.	Wood
20—	8,408	503	0	0	174	0	630	1,579
	(74.4)	(4.5)	—	—	(1.5)	—	(5.6)	(14.0)
	83,868	16,827	—	—	10,702	—	53,834	—
	(54.7)	(8.9)	—	—	(5.8)	—	(30.6)	—
20~30	11,072	439	0	0	338	33	771	484
	(84.3)	(3.3)	—	—	(2.6)	(0.3)	(5.9)	(3.7)
	110,171	14,677	—	—	20,829	1,637	65,865	—
	(53.9)	(7.0)	—	—	(8.4)	(1.9)	(28.8)	—
30~40	13,307	385	35	29	568	33	913	169
	(86.2)	(2.5)	(0.2)	(0.2)	(3.7)	(0.2)	(5.9)	(1.1)
	132,299	12,879	1,062	551.3	36,000	1,635	78,023	—
	(52.1)	(4.3)	(0.2)	(0.2)	(14.8)	(0.3)	(28.1)	—
40~50	14,996	271	170	476	462	78	990	47
	(84.3)	(1.5)	(1.0)	(2.7)	(4.3)	(0.4)	(5.6)	(0.3)
	149,111	9,057	5,200	8,944	46,969	3,914	84,576	—
	(48.7)	(2.5)	(1.2)	(4.4)	(15.5)	(1.7)	(26.1)	—
50~60	15,914	235	722	677	892	105	1,312	190
	(80.1)	(1.2)	(3.6)	(3.4)	(4.5)	(0.5)	(5.7)	(1.0)
	158,204	7,872	22,042	12,719	55,037	5,221	96,717	—
	(44.1)	(2.2)	(6.3)	(3.9)	(15.6)	(1.3)	(26.6)	—
60~80	16,387	212	991	2,518	884	255	1,228	43
	(72.8)	(0.9)	(4.4)	(11.2)	(3.9)	(1.1)	(5.5)	(0.2)
	162,866	7,083	30,258	47,306	54,477	12,760	10,496	—
	(39.3)	(1.7)	(6.1)	(10.7)	(14.2)	(3.0)	(25.0)	—
80~100	18,524	125	2,258	2,688	1,151	191	1,371	122
	(70.1)	(0.5)	(8.5)	(10.2)	(4.4)	(0.7)	(5.2)	(0.5)
	184,085	4,167	68,971	50,505	70,954	9,526	117,129	—
	(37.1)	(0.8)	(11.3)	(8.7)	(16.3)	(1.5)	(24.4)	—
100+	10,434	112	3,375	10,266	784	732	1,619	0
	(38.2)	(0.4)	(12.4)	(37.6)	(2.9)	(2.7)	(5.9)	—
	104,499	3,749	103,074	192,877	48,314	36,593	138,321	—
	(15.9)	(0.5)	(12.4)	(33.4)	(8.4)	(6.5)	(22.8)	—

Note: The top figure of each cell is heat value in Mcal and the figure in the parenthesis is the share of the fuel among the total fuel used by the income group. The third row represents the costs of purchasing the fuel of the cell and the figure in parenthesis of the last row of each cell show the share of costs needed in purchasing the fuel among the total fuel costs. (Source: The Household Energy Survey, 1986)

grounds (The East Asia and Pacific Regional Office, The World Bank, *Policy Issues in the Energy Sector (Korea)*, 1985, p.76).

above nation-wide data shows that there are significant differences in the kinds of fuel used by different income groups. Table 5 presents the quantity of fuel, share of each fuel among total amount of fuel, and expenditure on each fuel by income group. Because no woodfuel has been used in the Seoul area, the actual share of coal briquets and kerosene, especially in low income families, will be higher than the figures above.

Lower income-families draw a large portion of their fuel from coal briquets and kerosene. Higher income families, also, consume a large amount of coal briquets in absolute calorific value terms, but the share of briquets decreases as income rises. Therefore, the low coal briquet price due to coal subsidy programs also benefits the higher income families and the absolute amount of benefit increases with income. Oil products, including city-gas and bottled propane, are increasingly consumed by high income families.

One of the important questions in considering LNG policy is "Who uses what kind of fuel mix and why?" This question can be properly addressed by employing some econometric techniques, such as choice models utilizing logit or probit analysis. But data for a detailed analysis are not available at this time. Instead, we try to find a simple relationship between income level and gaseous fuel consumption level. Gaseous fuels have been mainly used for cooking in households. There must be various independent variables in determining the amount of gaseous fuel consumption in the household sector, such as income, prices of fuels, demographic variables, and so on. Most of the effects of sets of factors on energy expenditures can be explained by, accounted for, or reduced to two major factors: the income of the household and the price or type of energy consumed.[22] Our data were collected in 1985 (The Household Energy Survey), period in which there has been no major fuel price changes. We do not need to worry about the price change effects because the price has been already controlled in these data. We left out all other variables except income due to the limitation of the data editing system. The results of the regression analysis are below:

The coefficient of the income variable might be biased due to left-out variables. Left-out variables might include relative price structure of fuels, equipment, family size, age and sex of household head, employment status of household members, and behavioral variables. It is not easy to conjecture the direction of the bias due to left-out variables.[23] When we

22) Cooper, M., *op. cit.*, pp. 43-44.

23) The bias depends on two terms, namely the regression coefficient of the left-out variable in the true relation, and the comovements of the left-out variable with the included variable. For example, if income goes with family size and larger family consumes more energy, the above

City-gas

$$Y = -12.7 + 0.5I + \epsilon \qquad R^2 = 0.72$$
$$(10.1) \qquad (0.033) \qquad \text{D.F.} = 93$$

Bottled propane

$$Y = 21.2 + 0.66I + \epsilon \qquad R^2 = 0.67$$
$$(16.2) \qquad (0.055) \qquad \text{D.F.} = 94$$

Gaseous fuel total (city-gas and bottled propane)

$$Y = 11.6 + 1.1I + \epsilon \qquad R^2 = 0.91$$
$$(12.8) \qquad (0.042) \qquad \text{D.F.} = 93$$

Where, Y denotes the fuel in Mcal, I denotes income in 10,000Won, and ϵ is the error term. The figures in parentheses are standard errors of the variables and all are statistically significant at the 95% confidence level.

assume that the effects of the left-out variables are small, the above coefficients tell us that as income decrease by 10,000Won, households will reduce their city-gas consumption by about 0.5 Mcal, bottled propane by 0.66Mcal, and all gaseous fuel by 1.1Mcal. In Table 5, lower income groups use a "small" amount of bottled propane, because propane use does not need any capital investment and the rate is flat regardless of the volume they use. In the case of city-gas, however, the lower income families hardly consume it although the effects of income seem not so large. This seems to be the case, because there is a high initial capital cost needed in order to tap city-gas, i.e., internal pipeline costs. Of course, once they are connected to the city-gas system, they are able to use a moderate volume of gas; and it is economical compared to bottled propane.

3. Future Energy Use and the Equity Issue

The volume of city-gas used by lower income groups is very small. This is especially true because the data are collected from national base that includes the rural areas as well as small cities where no city-gas is available. However, even if we collect data on the Seoul area, the pattern of using the gaseous fuels by income groups does not seem significantly different. Any subsidies on coal briquets or kerosene appear to be spread over all the income groups, but subsidies on gaseous fuels, such as propane or city gas, are less widely dispersed. Especially, any subsidies on LNG can only benefit the consumers who tap city-gas. Even in the case of coal briquets, as mentioned above, the wealtheir income groups get more subsidy benefit because they consume large amounts of coal briquets. Fur-

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coefficient is overestimated. For the left-out variables, see Rao, P. and R. Miller, *Applied Econometrics*, (Belmont, CA: Wads-worth, 1971), pp. 29-34.

〈**Table 6**〉 Accumulated Share of Fuel Energy and Coal Briquet Expenditures by Income Group(1979) (Unit: Income-10,000Won; %)

Consumption Expenditure	Accumulated Percentage of:					
	Urban Areas			Seoul		
(in 10,000 Won)	# of HH	Fuel	Briq.	# of HH	Fuel	Briq.
— 3	0.1	0.02	0.02	0.1	0.03	0.02
3∼ 5	2.1	0.7	0.7	1.3	0.5	0.5
5∼ 7	7.4	3.5	3.5	5.7	2.5	2.6
7∼ 9	17.1	9.8	10.0	14.4	7.5	7.8
9∼11	28.4	17.8	18.3	24.8	14.3	15.0
11∼13	40.0	27.2	28.0	36.1	22.5	23.7
13∼15	50.4	36.7	37.9	46.6	31.6	33.2
15∼17	59.5	45.3	46.6	56.0	39.8	41.8
17∼19	67.2	52.7	54.3	64.0	47.4	49.8
19∼21	73.2	59.1	60.8	70.4	53.8	56.4
21∼23	78.2	64.9	66.7	75.5	59.6	62.4
23∼25	81.9	69.6	71.4	79.5	64.2	67.1
25∼30*	88.6	79.0	80.7	86.9	74.5	77.4
30∼35*	92.8	85.9	87.5	91.5	82.0	84.7
35∼40*	95.3	89.9	91.4	94.5	86.6	89.3
40+	100.0	100.0	100.0	100.0	100.0	100.0

Note: * Income brackets are different from the others
# of HH demotes the number of households in the region

thermore, in the case of gaseous fuels, only wealthier groups will benefit. In addition, if fuel subsidies on gaseous fuels are related to reduction of subsidies on coal, then lower income-families, who cannot use gaseous fuel anyway, will be especially hard hit. They must spend a large share of their expenditure income on purchasing cooking and heating fuels. Introduction of gas subsidy programs would not appear to be a desirable policy direction in this respect.

A study[24] has found expenditure patterns on fuel energy as a whole and specifically on coal briquets by income groups. The above table shows that inequality in briquet consumption is less serious than that in the total fuel consumption. Expenditures on fuels other than coal briquets, had put a relatively greater unequal burden on low income households. The equity problems implied by fuel consumption are more serious in the Seoul area than others. Total fuel energy expenditure in the Seoul area shows one of the most inequitable distribution of all urban areas. In the Seoul area, 40 percent of upper income-families consumed about

24) Hahm, H., *Policy Measures for the Private Fuel Supply/Demand*, (Seoul, 1980), p. 182,

〈**Table 7**〉 Inequality of Fuel Energy and City-gas Expenditure in Seoul and Urban Areas(1985) (Unit: Income-10,000Won; %)

Monthly Income (in 10,000 Won)	Accumulated Percentage of:						
	Urban Areas				Seoul		
	Income	#HH	Fuel	City-Gas	Income	#HH	Fuel
20~	1.1	2.7	1.8	0.0	0.5	1.4	0.7
20~30	6.7	13.1	10.1	3.3	1.3	3.3	1.8
30~40	26.9	40.2	33.6	11.9	13.8	24.1	15.6
40~50	49.2	63.5	56.1	29.6	29.2	43.9	32.2
50~60	72.1	83.1	77.7	49.4	48.9	64.7	52.3
60~80	88.8	94.3	91.2	77.1	67.6	80.2	70.7
80~100	94.9	97.5	95.9	83.0	83.3	90.3	84.3
100+	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Note: #HH denotes the number of households in the region
(Source: The Household Energy Survey, 1986)

56.40 percent of household fuel energy and 54.20 percent of coal briquets in monetary terms in 1979. In urban areas overall, 40 percent of upper income families consume about 54.31 percent of total fuels and 52.90 percent of coal briquets in monetary terms.[25] The nationwide income analysis found that upper 40 percent of the people held 67.74 percent of total income in 1976 in Korea.[26] Although direct comparison has limited utility, the figure can be used in discussing equity issue in energy use as a reference value.

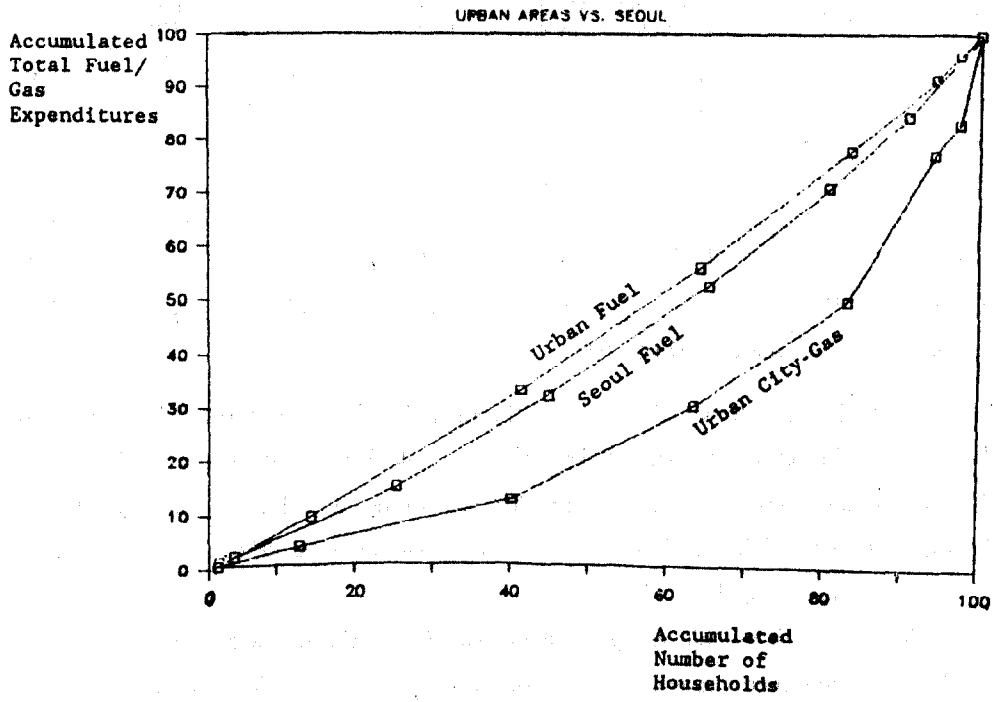
Based on the 1985 Household Energy Survey, we can find a similar pattern of inequality in energy use (see Table 7).[27] For all urban areas, 40 percent of upper income families consumed about 47.28 percent of total fuels in monetary terms in 1985. The inequality is serious for consuming city-gas in the urban areas: 40 percent of the upper income families consumed more than 70 percent of the total city-gas in 1985. In Seoul, 40 percent of the upper income families consumed about 52.24 percent of the total fuel in monetary terms. This means that there were some improvements in fuel consumption,

25) This situation is less serious compared to that of the United States. A study found that in 1972 the 40 percent of upper income groups in the U.S. purchased about 60.60 percent of direct fuel energy, i.e., electricity and gas, in 1972. It also found that the same group purchased 63.45 percent of total indirect energy. See Brannon, *op. cit.*, 1974, p.146.

26) Choo, H., *Income Distribution and Determining Factors in Korea (I)*, (Seoul, 1979), p.91.

27) The Survey used monthly income for categorizing income groups. Their sample consists of 228 households for Seoul and 836 for all the urban areas. This sample size seems rather small for representing income distribution and energy use by various categories. Although there are some difficulties in comparing the fuel expenditures of 1979 and 1985 due to the differences of data collection systems, it is still interesting to see the potential changes.

〈**Fig. 1**〉 Inequality in Fuel Energy and Briquet Expenditure in Seoul and Urban Areas



in terms of the absolute amount of fuel, in the urban areas including Seoul from 1979 to 1985. This seems to be resulted from the fact that the prices of high-grade fuels increased more quickly than those of coal briquets or kerosene during the period.[28]

When we draw a "Lorenz' curve" on the basis of the above data, we can see the overall pattern of fuel expenditure by income group more easily. Lower income groups, with their smaller share of income, spend disproportionally large resources on fuel expenditures. Lower income families pay a higher accumulated percentage of their income of fuel bills. Also, it is evident that lower income groups consume smaller amount of fuel in monetary terms. The inequity in fuel consumption appears the worst in the case of gaseous fuel.

When we look into average monthly consumption expenditure per household in Seoul, expenditures on cereals, such as rice, wheats, etc., education and recreation, and clothing and foot wear, are slightly larger than the expenditure on fuel and light. The following table shows consumption expenditure by major expenditure categories in the Seoul area for six years.

Fuel and light are the fourth largest expenditure item. It does not look like the expen-

28) The Ministry of Energy and Resources, *Energy Yearbook*, (Seoul, 1985), pp. 280-285.

〈**Table** 8〉 Share of Consumption Expenditures by Category (Unit: %)

Year	Cereal	Education and Recreation	Cloth Foot	Fuel Light	Medical Care	Transp-ortation	Meat
1979	13.2	10.1	9.8	5.8	6.2	5.8	5.1
1980	13.4	8.8	8.7	7.4	6.6	6.4	4.8
1981	13.1	9.2	7.9	8.1	6.7	6.3	4.9
1982	11.9	10.8	7.9	7.7	7.2	6.8	5.0
1983	10.2	11.0	7.8	7.2	7.3	6.5	5.3
1984	9.2	11.2	7.4	7.0	7.0	6.6	4.9
Average	11.8	10.2	8.3	7.2	6.7	6.4	5.0

(Source: Seoul Statistical Yearbook, 1985)

ditures on fuel and light will increase significantly in the near future since the income elasticity of fuel demand is usually less than a unit (between 0.51 and 0.77)[29] and the share of income going to energy consumption is already at a high level. Any increase in the share of fuel and light, if any, will reduce expenditures on other items which are also important in improving the quality of life.

The demand for household energy is more sensitive to the prices of the fuels when compared to the total energy consumption of the country. This implies that households have sacrificed other conveniences when fuel prices rise. For instance, people have often lowered their room temperatures below the comfortable level and this practice has been a common life-style response in Korea, especially during the winter season.

Next, we look at the possible change in expenditure patterns in the case of the lower income families beginning to use fair amount of gaseous fuel, substituting for solid fuels. Propane and city-gas are more expensive than coal briquets or kerosene, even after we consider the fuel efficiency. If we assume that lower income families consume gaseous fuel proportionately with their incomes, the share of fuel expenditure will increase sharply. Then, the existing equity situation will even worsen. In order to increase gaseous fuel demand, the government must lower the present prices, using several price-related policy tools. But the problem with these policy tools is that they cannot easily help the truly needy because the lower income families cannot significantly increase consumption of the gaseous fuels due to still high gas price and relatively cheaper coal briquet price. Only the wealthier families would enjoy low gas price and accordingly would increase their gas demand. If

29) KIER, *A Study on Energy Supply and Demand*, KE-82P-40, (Seoul, 1982), pp. 77-80.

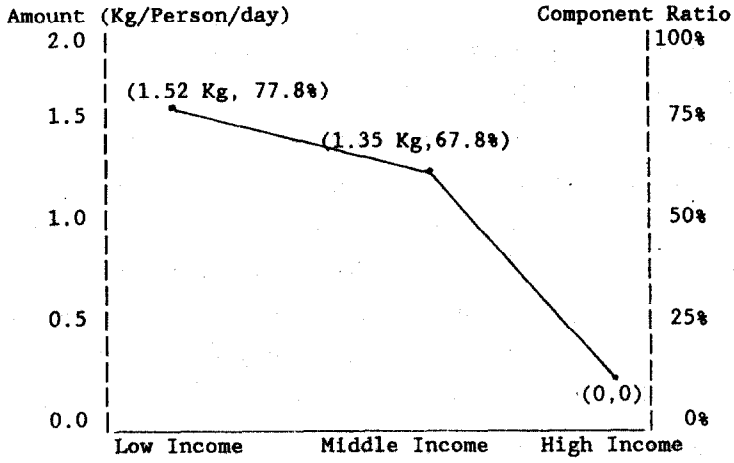
the government cut several subsidy programs related with the coal briquets, this would also damage the lower income families as anlayzed before. Substitution of large amount of subsidized solid fuels with subsidized gaseous fuel cannot help none except the rich. Also, the policy cannot help improve efficiency because the prices do not reflect real opportunity costs. The policy can satisfy, if any, only gas business interests, but this cannot be a proper policy objective.

4. The Social Cost Distribution of Fuel Use

However, the real social burden of urban energy policy is different from that suggested above. First of all, society will bear a large tax burden in order to subsidize various programs which range from the coal exploration to distribution of coal briquets. The funds come from part of the tax collected from the bunker-C related tax. The total subsidy amounted to about 69.7 billion Won in 1981. This accounts for about 10 percent of all coal briquets; and when we include the favorable tax clauses, the real subsidy will become much higher than 10 percent.

In addition to the price subsidy, there is another burden from society's point of view. The following graph shows the share of coal briquet ash among solid waste by income group in Seoul. Coal briquet ash accounts for 77.8 percent of total solid waste, which is 1.52 kg per person per day in low income bracket. The amount of ash seems very small upper income groups. But the majority of solid waste treatment costs are borne by middle

〈**Fig.** 2〉 Amount of Solid Waste by Income Group (1982)



(Source: The Graduate School of Environmental Studies, Seoul National University (GSES, SNU), A Study on Solid Waste Management, Seoul, 1983, p. 64)

among the and upper income families through various taxes and/or "tip" directly paid to the workers in the waste treatment business.[30] Large portion of waste disposal costs is borne by the local government in its general expenditures. Therefore, the households who do not switch to gas will not bear all the costs of coal briquet ash treatment. Because tax rates for low income families are disproportionately low, they are subsidized by rich families in this area.

Therefore, a significant portion of the real social costs of coal briquet use are borne by middle and upper income people. This rational analysis might imply that the distribution of the cost of existing fuel policy does not put a serious burden, in a relative sense, on the lower income people. In addition to the two sources of cross-subsidy (low price and solid waste), air pollution from the coal briquet use raises another kind of social costs. The argument for realizing coal briquet price is based on these facts. But the political implications of a coal price increase might have a different effect on the political actors. It is politically not easy to withdraw any policy tools which have been favorable for lower income families.

In addition to the analysis of fuel expenditure by income group, we must analyze the allocation of benefits and costs of a fuel switching policy among various households. Major benefits, including cleanliness, convenience, indoor pollution, etc., will be enjoyed by the households which have switched from solid or other low grade fuels to gaseous fuels. One of the major external benefits of this switch is reduced air pollution. The external benefits from reduced traffic congestion and water contamination seem very small. Of course, everyone, including the free riders who do not switch, will benefit from these externalities.

Geographical analysis of allocating benefits and costs requires a colossal amount of information. Because ambient air quality is determined by very complex processes, it is extremely hard to locate any air quality improvement benefits in a small area. Fuel switching alone cannot determine the air pollution level of a specific section of a region because industry- or transportation-related pollution sometimes more seriously affect the air pollution level of a small portion of a region. One of the most important factors which influence the air quality of a region is wind: wind direction and its strength affect the spread of "plum" beyond the site of the polluter. The average speed of wind in the Seoul area is estimated from 2.1 m/sec to 2.9 m/sec, with the high speed being most common in Spring and Winter, and the low speed in Fall and Summer. Across the four seasons, winds blow

30) GSES, SNU, *op. cit.*, pp. 180-203.

toward the East most of the time, and winds toward the Southeast occur a small portion of the time.[31] Mountains and other relevant topological factors play an important role also.

To the North of Seoul there are high mountains, and the Han River sweeps through the middle of the city toward the West. Air quality data show that the present pollution level is serious along the riverside, though relatively better on outskirts of Seoul. Because a large industrial site, the Guro Kongdan, is located on the Southwest side of Seoul, the general pollution level in the Seoul area, especially the East of the industrial site, is significantly higher due to the point sources of the industrial site. Therefore, the West-East corridor of Seoul would probably not benefit from a small level of fuel switching, except for indoor pollution improvement. The southern and northern areas, including other boundary areas, will be more or less benefited from fuel switching. Without any specific income data which is unavailable in Seoul we could not draw any conclusions regarding the allocation of air quality benefits by income groups.

Reports by the Office of Environment hint that the air pollution problems in the areas of Jongro and Yongsan-Kus, and parts of Guro, Sungdong, Youngdungpo, and Tongjak-Kus are serious. These areas have differing air pollution problems because different pollutants are involved. In 1985, the annual average level of sulfur oxides, 0.056 ppm, exceeded the standard, 0.05 ppm. Especially, densely populated resident areas, such as Sanggue, Mia, Bulgwang, Hongun, and Noryangjin-Dongs, show higher level of sulfur oxides due to extensive coal briquet use. Also, the levels of sulfur oxides in the areas near industrial sites, such as Yangnam, Hwoagok, and Chungdam-Dongs, exceed the average sulfur level.[32] The combinations of mobile and point sources in these areas vary greatly. Also, the effect of the Guro Kongdan is relatively high in these parts of Seoul. As winds come from the West and traffic volume in these parts remains at its present level, the real benefits of household fuel switching in these parts appear to be marginal.

The next issue of the allocation of costs and benefits of the policy involves distribution by economic functional category. Rapid expansion of the gas industry in Korea will require many professionals and skilled as well as unskilled laborers. Within the accelerated gas expansion scenario, people who hold these gas-related jobs will benefit. The gas-related, skilled manpower will grow, as evidenced by the establishment of many private anticipatory gas-related training institutions. The pipeline industry also is prospering from recent

31) The Office of Environment, *Impact of Pollution on Athletic Performance and Pollution Abatement Strategy*, (Seoul 1985), pp. 57-76.

32) The Office of Environment, *Environmental White Paper*, (Seoul, 1985).

increased demand. Demand will increase for gas-related equipment, such as gas ovens, gas boilers and so on, with potential benefits for such industries.

Within the accelerated gas demand scenario, the coal industry and petroleum industry will not grow as they would like. Even though the absolute demand for coal and petroleum product fuels will increase, these industries will not be able to enjoy the demand expansion they have enjoyed for a long time. Especially, domestic bunker-C is estimated to be surplus in the near future. Then the refineries will face a serious problem of adjusting configuration of their facilities. The government regulation of these energy industry often meant government protection. Subsidies, favorable tax treatments, credit allocation, loose safety regulations, and limited union activities in these industries—along with the licensing system—result in government protection of existing firms. But they must adapt strategically when they expect any policy change. The strategic movement will raise costs and the costs will be likely transferred eventually to the consumers.

IV. Concluding Remarks

The existing equity situation in energy use does not seem so serious. When we look into the real social cost side of fuel use, gas consumption will reduce the social burden while briquet use will increae the burden. In this sense, gas expansion program, including subsidies for gaseous fuels, can reduce general social burden to some extents.

However, we are reluctant to recommend general price subsidies for rapid gas demand expansion, especially when such policy tools are connected with the withdrawal of government coal subsidies. When the social benefits of gas demand expansion in a short period of time exceed the social costs by big margin, it seems to be justified that the gaseous fuel enjoy price subsidies, to a moderate extent. Even in this case, we recommand the government try to find ways to help the poor: targeting of the poor community or neighborhood and specific programs to help the truly needed require a lot of effort. But when the margin is dubious, this is true in this case, the policy revision process should be constrained by the equity consideration discussed above: only the rich, excluding almost all the poor, can exploit the gas subsidy, moreover when the briquet subsidies are withdrawn to expedite gas demand increase, the poor will bear additional burden in financial term.