An integrated energy policy for Korea

The case of an energy importing country

Tai-Yoo Kim and Seung-Rae Kim

Economic theory defines a market failure when competitive markets cannot reach an equilibrium maximizing social welfare. One of its most typical examples has proved to be the energy market. Exhaustible energy resources provide the limits to economic growth, at least in the short term. Thus an energy policy for energy importing countries like Korea has been focused on minimizing the negative influences of external energy price shocks to the domestic economy. This study suggests one of the possible directions for an integrated energy policy which seeks to present a flow of policy rules which lead government policy to attain equilibrium, maximizing the national economic benefits by offsetting the market failure.

Keywords: Energy importing countries; Energy price shocks; Integrated energy policy

During the first and second oil crises, the world economy suffered a low growth, high inflation stagflation.¹ Exhaustible energy resources provided the limits to economic growth, at least in the short term. Thus, the energy policy of energy importing countries like Korea has been focused on minimizing the negative influences of external energy price shocks to the domestic economy.² The main structure of their energy policies is a tax on imported energy, a domestic energy price high enough to reduce the growth rate of energy consumption, subsidization to domestic energy, development of new energy sources, and compensation for those domestic sectors or groups of people damaged by this policy.³

Although there seems to be some consensus among policy makers in the energy importing countries, little work has yet been done to answer such questions as 'Is this type of energy policy right or wrong?' 'How can we decide the optimum level of an energy import tax, the domestic energy price level, and so on?' 'Who gains and who loses by this policy and how can we compensate for the negative effect on the energy related sectors in the economy?' This study suggests one of the possible directions by an integrated energy policy which can answer most of these questions.

Cost–benefit analysis of the energy sector

Because resource allocation by the market mechanism is accomplished by an equilibrium which considers only private costs and private benefits, in the case of those commodities which have an additional social cost due to externalities their efficient allocation by the market alone is impossible.⁴

To approximate the social cost requires a new mechanism to internalize it. From this viewpoint the Korean economy, with its high foreign fuel dependency, needs to consider policy making which internalizes not only pure consumer cost but the associated, potential external cost arising from energy imports.⁵ In our study, we designed a concept of energy shock in relation to the import premium, not in the narrow definitional sense of a static time-series of instantaneous events like a disruptive price rise,⁶ but in the broad definitional sense of a continuous time-series including a price anomaly. Then, by applying the associated value items of domestic energy compared with the social cost of imported energy, we calculate the social value items for the individual energy sectors.⁷

Comparing the social values of each energy sector by such social cost–benefit analyses, we de-
An integrated energy policy for Korea

Figure 1. Comparisons of the social value of each energy alternative.8

1.00

Imported energy

Import cost

EC + SC + RP + IS + RE

2.04

Coal production

Social value

ECc + CM

2.07

Alternative
development

energy
Social value

RE

2.22

Oil stockpiling
and safety fund

Social value

EC + IS + RE

1.79

Overseas energy
development

Social value

EC + SC + IS + RE

1.24

Figure 1. Comparisons of the social value of each energy alternative.8

*ECo = environmental cost of imported oil; ECc = environmental cost of domestic coal; SC = national security; RP = risk premium; IS = import substitution; RE = regional economy; CM = mine closure.


Fundamentals of an integrated energy policy in Korea

The general framework

In energy sector evaluation Korean energy markets are not cleared at the Pareto-efficient state, $E_1$, owing to the presence of such externalities as an import premium on imported energy; the benefit of domestic energy production from the insider’s viewpoint; and the environmental pollution cost of energy consumption. Therefore government intervention is needed to attain allocative efficiency and distributional equity of the energy resources.13 To achieve internalization of the externalities in the Korean energy sector, presented in Figure 2b, the energy-related policy instruments should be so executed as to shift the current state ($E_0$) to the desired state ($E_1$).14 In this study, we define an integrated energy policy (IEP) in Korea as synthesizing these energy-related policies.

An energy tax compensation policy in relation to the energy funding system should minimize its excess burden on the national economy and maximize the potential social benefit from subsidy or investment. In economic welfare theory, the standard Pigouvian approach to externalities is via corrective taxes and compensations which can be warranted on grounds of efficiency. Thus, the fundamental logic of our energy policy study is to construct the most efficient,
feasible energy tax system to alter the conditions for attaining Pareto optimality including the Korean energy sector. The IEP contains the following:

- import tariff/fee level or excise tax on imported energy (e.g., oil), PEI, and formation of an energy fund, REV, relevant to an optimal tax structure;

- domestic energy demand, \( E \), management through energy pricing/taxation, and reforms in the energy market organization/regulatory framework to reduce dependence on foreign resources and to meet national security requirements;

- oil stockpiling, \( \Delta E_S \), to cope with a sudden disruption of oil supply;

- overseas development of energy resources, \( \Delta E_F \), to raise self-sufficiency ratios of energy by the stable supply of foreign energy resources;

- reorganization of the energy supply-demand structure by promoting the development and the introduction of alternative energy sources, \( \Delta E_{SUB} \);

- ensuring economic efficiency, \( \Delta E_{EFF} \), in energy use through financing energy conservation, elimination of overconsumption and saving foreign exchange;

- preserving the environment, \( \Delta E_{ENV} \), by promoting investment in alternative/clean energy sources, LNG, and helping finance pollution control;

- export compensation, \( \Delta EX \), to minimize the excess burden arising from taxation due to all of the above; and

- meeting the basic needs of the poor and contributing to their real income/welfare, \( Y_L \), with development of special regions (particularly rural or remote areas) from subsidizing the domestic energy industry (e.g., anthracite coal).

These energy-related policies (IEP) are illustrated in diagrammatic form in Figure 3. As a result, IEP in the Korean economy could overcome the national economic burden of imported energy sources, providing a stable supply of energy, a reduced dependence on imported oil, and overall energy conservation. Moreover, despite the extra burden of IEP, this study shows that compensated export promotion and low-income energy consumer protection are attained through financial compensations and a shift in the tax burden among energy commodities.\(^{15}\)

Structure and methodologies of the model
Using our basic concept linking taxation on imported energy and financing the overall energy sectors to incorporate social value, we constructed the ‘integrated model’ to correct externality problems in the Korean energy sector. This model integrates the related-satellite modules with the energy supply mix dynamic optimization model, the staged energy taxation mix model, and the energy funds optimization model in a dynamic general equilibrium model of the Korean economy (KDGEM).\(^{16}\) For the purposes of our energy policy analysis, we first evaluate each energy sector using social cost-benefit analysis and investigate the energy-economy interactions.
with taxes and subsidies through the KDGEM simulation analysis. Then, we present the fund formation/allocation related to the energy fund system, energy pricing and taxation, and energy supply-demand management.

We especially consider composition at the tax levying stage to minimize the excess tax burden with respect to the fund formation for financing energy sectors, and the optimal allocation of the energy fund by the energy sectors. The capabilities of IEP analysis are empirically examined by means of simulation properties and policy responses on both energy and economy by varying the exogenous international environment.

Accordingly, we establish the limits of production/supply and subsidization of domestic energy, the effect of efficient pricing and tax systems on imported energy, and a more effective energy funds system incorporated into energy investment schedules.

Schemes for an integrated energy policy

The energy pricing policy

Government intervention in energy markets attempts an optimal supply-demand balance by altering the market structure. However, this is possible only on the condition that the pricing policy is rational. In such a price system, domestic energy prices should be determined at the level of imposed import premium cost, which insures against structural instability of the international oil market. Operationally, the proper objective is an energy tax added to the imported price. In addition, we estimate the contribution to the Korean economy of the complex social values of domestic energy. Thus, we derive a more general criterion for the disaggregate level energy sources included in domestic energy by using an extended general equilibrium model which attempts to examine the overall pervasive effects of the value balance of each energy source/energy business and the associated energy policy for the Korean economy as a whole.

The social utility of domestic energy (Figure 1), shows that alternative energy has an additional social value of 107% of the imported price and domestic coal 104%, which represent the upper limit of support appropriate for each energy sector.

On the other hand, the optimal domestic energy price level determined by the extended energy-economy model which contains the energy funds optimization model, yields 131% of the imported energy price (or 1.306/1.114 = 115% of the current domestic energy price). We consider two cases: exclusion of export compensation, and inclusion of export compensation, comparing the domestic energy price system of our extended KDGEM with the current actual price system; the results are shown in Figure 4.17
Excluding export compensation

<table>
<thead>
<tr>
<th>1.00</th>
<th>1.114</th>
<th>1.159</th>
</tr>
</thead>
<tbody>
<tr>
<td>Import cost</td>
<td>Current</td>
<td>Our study</td>
</tr>
</tbody>
</table>

Including export compensation

<table>
<thead>
<tr>
<th>1.00</th>
<th>1.220</th>
<th>1.306</th>
</tr>
</thead>
<tbody>
<tr>
<td>Import cost</td>
<td>Current</td>
<td>Our study</td>
</tr>
</tbody>
</table>

Figure 4. Comparisons among optimal domestic energy price, current price and imported price (imported energy price = 1.0).

The energy supply–demand policy

We next investigate the energy supply–demand management scheme determined by the optimal energy pricing policy noted above. Based on the variations of the domestic energy/economic environment due to our international oil scenario (maintaining 1991 constant price US$18/bbl) through KDGEM we evaluate the total social cost generated within the specific planning period. Then, we find the optimal supply–demand level minimizing total social cost. Using this, we also examine the relative proportion of domestic and imported energy in total supply–demand. The results are illustrated in Figure 5. The optimal supply–demand level of domestic energy (composed of anthracite, hydroelectric power, fire wood etc) is 392.5 trillion (10^{12}) BTUs in 1992 and 353.1 trillion BTUs in 1996. These are increased for comparison with the baseline government scenario by 5.7 trillion BTUs (311 thousand tons of domestic anthracite), and by 22.6 trillion BTUs (1242 thousand tons of domestic anthracite) respectively. In addition, the optimal supply–demand level of imported energy (oil, bituminous coal, LNG, uranium) is 3944.2 trillion BTUs in 1992 and 4838.1 trillion BTUs in 1996. These show the decrease in supply–demand compared with the baseline government scenario of 163.1 trillion BTUs and 530.9 trillion BTUs, respectively, due to the policy execution described in our study.

In conclusion, the desirable supply–demand mix of domestic/imported energy, which maximizes the net social benefit is controlled downward to 1.52% per year of total energy quantity during 1992–96, and in 1996 shows a decrease of 494.1 trillion BTUs.

The energy funds system

Energy funds formation. The funds system policy must be complex and inclusive to guarantee the security of the reserved funds for supplying the financial resources both for executing comprehensive energy resources policy and managing intra-

Figure 5. Optimal energy supply–demand path based on model analysis (1992–96).
An integrated energy policy for Korea

Table 1. Relative superiority of alternative tax systems according to oil price scenarios (1992–96).

<table>
<thead>
<tr>
<th>Oil price scenario</th>
<th>Taxation method</th>
<th>Total cumulative GNP loss (A)</th>
<th>Total tax revenue (B)</th>
<th>Tax efficiency (A/B)</th>
<th>Superiority a</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ascending phase</td>
<td>AVT</td>
<td>14656.63</td>
<td>4755.371</td>
<td>3.08</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>UNT</td>
<td>13457.56</td>
<td>4756.701</td>
<td>2.83</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>RPT</td>
<td>23468.71</td>
<td>5366.210</td>
<td>4.37</td>
<td>3</td>
</tr>
<tr>
<td>Descending phase</td>
<td>AVT</td>
<td>11788.17</td>
<td>4724.871</td>
<td>2.49</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>UNT</td>
<td>12366.41</td>
<td>5875.209</td>
<td>2.10</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>RPT</td>
<td>11496.32</td>
<td>7454.990</td>
<td>1.54</td>
<td>1</td>
</tr>
</tbody>
</table>

* Total cumulative GNP and total revenue are calculated as cumulative amounts over the five years of the study period (constant billion won in 1985).

a Assumes that the oil price in the ascending phase increases by an annual average 6%, in the descending phase decreases by an annual average 4%.

¢ This implied GNP loss per unit tax revenue which is the index introduced for comparison of economic superiority of tax system.


Energy optimal relative prices. Hence, the comprehensive energy policy described in this paper provides the optimal system for energy funds to maximize the national benefit and use it effectively.

Table 1 presents comparisons of three tax systems in reaction to international oil price scenarios. From this analysis we can determine that if the international oil price decreases, we must minimize the excess burden on the national economy by the taxation in the priority order of residual tax to reference oil price (RPT), unit tax (UNT), and last, ad valorem tax (AVT). If price increases, we must minimize the excess burden on the national economy by taxing in the reverse order. However, while the effects of the RPT system may vary slightly with the setting of the tax rate base of oil price, the UNT system can secure a comparatively stable tax revenue. Hence, the UNT system is the most effective alternative for taxation in the Korean economy, given that a long-run oil price rise is expected, irrespective of short-run oil price fluctuations.

On the other hand, if we divide the establishment of energy funds into two cases, inclusive and exclusive, according to tax levying stages and the optimal tax rate on the corresponding energy sources, it is desirable to divide total energy funds into the import oil stage and special consumption of oil in the ratio 66:34. For the tax rate, in the inclusive case this requires 8–9% at the importing stage of oil, 10% at the special consumption stage of oil, and in the exclusive case, 18–19% and 19.4% respectively. When we prepare the coal fund by taxing electric power, it is possible to share the preparation of the energy fund through taxing the electric power by 3–6%. This electric power taxation is comparable with the electric power tax level of 7.5% for the current coal fund executed in Germany. This taxation method assists domestic self-sufficiency to some extent in the future electric sources development.

Energy funds allocation. Energy funds allocation must be based on the size of the additional social benefit provided by the individual energy sector from the insider's viewpoint.

Domestic energy activity is classified into six subsectors in the model: coal industry promotion (B1), overseas resources development (B2), oil stockpiling (B3), energy conservation (B4), environmental protection (or imported LNG) (B5), and alternative energy development (B6); and then induced the national economic gain function which is comprised of the individual sector investment efficiency functions and another gain function to calculate optimal allocation proportions for each energy investment subsector. The investment efficiency function is combined with the contribution ratio of the quantity of secured energy to the GNP; and the quantity of energy security correlated with the investment of the individual energy sectors. The exogenous gain function is composed of economy-wide propagation effects due to increased production of coal, environmental improvement benefits from using natural gas, and the national benefits of the energy intensity improvement arising from investment in energy conservation. On the basis of the contribution of the individual energy sectors, results of the analysis of the investment maximizing effects of the optimal energy funds allocation under the budget constraint are summarized in Table 2.

The energy-related tax in the category of current
energy funds is aggregated and found to be 922.43 billion won. The allocation result under the government's current method is described as CASE(0). In comparison, CASE(1) from our model shows that the coal and environmental protection sectors have smaller allocation ratios. In the funds optimization model approach, CASE(2), the fund formation size increased 1.39 times, 15.9%, 11.4% respectively, compared to the current government method. Considering the compensation for export loss due to levying taxes on the energy sector, the energy funds formation size increases, as presented in CASE(1*) and CASE(2*), by 1.93 (22.0%/11.4%) times and 2.68 (30.6%/11.4%) of the current tax rate respectively.

For the five cases described in Table 2, we know that the policy execution of CASE(2*) is the optimizing proposal which internalizes market externalities and maximizes national economic benefits from the energy sector. Considering the size of optimal support for the domestic coal sector, analysis shows 353.82 billion won, which implies the need for more than the current government subsidy (ie 226.27 billion won), and shows almost the same level in comparison with 351.68 billion won for the subsidized domestic coal price to the international price level. Focusing on the investment amounts by energy sector, Figure 6 compares CASE(0), the current government proposal, and CASE(2) of the investment proposal using our approach.

**Economic impact simulation of integrated energy policy**

The overall economic effects can be classified into a general economic sector and an energy sector. Here we divide the general energy sector into gross national product (GNP), trade balance, and welfare levels for protecting energy sources for low income consumers. These are the major directions of economic policy. We also investigated the energy sector with special reference to reinforcement of domestic economic performance during an energy crisis by stabilizing energy supply and demand, a decline in degree of dependence on foreign energy, and a decrease in energy consumption by the imposition of an energy tax.

Examining the effects of the IEP with a higher energy price system, Table 3 shows that execution of this policy leads to an increase in the domestic energy price of about 15% compared with the current energy price system. Hence, it shows a decrease in total energy consumption by 494.1 trillion BTUs and a reduction by US$1.49 billion in payments for imported energy which means 3.8% reduction in the degree of foreign dependence. Compared with the lower energy price system of a free energy market without government intervention, maintaining the higher energy price system decreases total energy consumption by 1271.9 trillion BTUs, energy import payments by US$3.23 billion, and the degree of dependence on foreign energy by 5.3% respectively.

Adding social cost–benefit analysis to the energy sector and government investment yields the optimal energy funds system illustrated in Table 4 for the case of the baseline oil-price scenario. The result shows the energy funds policy for the energy sector potentially increases the GNP by 7.1% (2.6% in real GNP) by late 1996. Here, we can verify that the IEP follows the objectives of general economic policy. With regard to the energy sector, total
energy consumption decreases by 494.1 trillion BTUs and the degree of dependence on foreign energy decreases by about 4.25%. Thus, this effect contributes to the stabilization of energy supply-demand and reinforces potential national economic performance during an energy crisis as measured by the risk premium and national security cost of 382.6 billion won, which increases by 24.1%.

The decrease in exports caused by operating the energy funds system as the core of IEP leads to a decrease of about 1.78% (namely, 1181.7 billion won), but this can be compensated by funds raised from taxes. Furthermore, as a result of IEP from the viewpoint of reflecting the social value of domestic energy, there are effects due to protecting the energy source which low income consumers mainly use, about 308 billion won.

In a way, the KDGEM shows that the energy crisis leads to a 26–31 trillion won cumulative loss in GNP over some 20 years compared to no crises. Applying this to the Korean economy in 1990s, on the basis of the above analysis the simulated impact of an upcoming energy crisis like those of the past two, shows a 60–75 trillion won cumulative loss of gross national product.

Overall economic losses due to an energy crisis are greatly influenced by the scale of the national economy, its energy intensity, the relative weight of

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**Table 3. Energy demand management effects of the energy pricing policy (in late 1996).**

<table>
<thead>
<tr>
<th>Price system</th>
<th>Energy crisis performance (billion won)</th>
<th>Degree of dependence on foreign energy (%)</th>
<th>Total energy consumption (trillion BTUs)</th>
<th>Payments for imported energy (US$ billion)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower energy price (87)</td>
<td>-16 921</td>
<td>92.7</td>
<td>6 463.2</td>
<td>177.2</td>
</tr>
<tr>
<td>Current (100)</td>
<td>-15 863</td>
<td>91.2</td>
<td>5 699.7</td>
<td>159.8</td>
</tr>
<tr>
<td>Higher energy price (115)</td>
<td>-14 395</td>
<td>87.4</td>
<td>5 191.3</td>
<td>144.9</td>
</tr>
<tr>
<td>Effect 1</td>
<td>+2 526</td>
<td>-5.3</td>
<td>-1 271.9</td>
<td>-32.3</td>
</tr>
<tr>
<td>Effect 2</td>
<td>+1 468</td>
<td>-3.8</td>
<td>-508.4</td>
<td>-14.9</td>
</tr>
</tbody>
</table>

* Here, Effect 1 is the difference between the higher energy price system and the lower energy price system. Effect 2 measures the differences between the higher energy price system and the current system.

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Table 4. Economic impact policy simulation of energy funds system by the baseline oil price scenario (in late 1996 (1991 constant billion won, trillion BTUs).

<table>
<thead>
<tr>
<th>Policy System</th>
<th>Potential GNP level</th>
<th>Total export level</th>
<th>Welfare for low income consumer</th>
<th>Performance for energy crisis</th>
<th>Total energy consumed</th>
<th>Degree of dependence on foreign energy (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No tax-no aid</td>
<td>204 267</td>
<td>68 054</td>
<td>36 614</td>
<td>-1 692.3</td>
<td>6 463.2</td>
<td>92.7</td>
</tr>
<tr>
<td>Current tax-current aid</td>
<td>211 273</td>
<td>67 607</td>
<td>36 761</td>
<td>-1 586.3</td>
<td>5 699.7</td>
<td>91.2</td>
</tr>
<tr>
<td>Tax-no aid</td>
<td>201 855</td>
<td>66 425</td>
<td>35 172</td>
<td>-1 439.5</td>
<td>5 685.9</td>
<td>88.8</td>
</tr>
<tr>
<td>Tax-aid</td>
<td>226 280</td>
<td>67 067</td>
<td>37 069</td>
<td>-1 203.7</td>
<td>5 191.3</td>
<td>87.4</td>
</tr>
<tr>
<td>Policy effects (%)</td>
<td>15 006</td>
<td>1 181</td>
<td>308.0</td>
<td>(24.1)</td>
<td>(8.67)</td>
<td>(4.66)</td>
</tr>
</tbody>
</table>

* Here, the dynamic effects of the energy funds system are analysed in terms of existence and/or non-existence of this system (ie differences between the effects of the current tax-current aid policy and those of our tax-aid policy).

domestic energy, and the level of stockpiling or security of energy supply. If the IEP is fully executed before an energy crisis, economic performance in preparation for the crisis can be remarkably enhanced. Our study shows that the national economic cumulative losses in the case of an upcoming third energy crisis will be 42–53 trillion won, which can be decreased by about 30% in comparison with a crisis without IEP.

Therefore, our general equilibrium analysis in connection with social valuation and investment efficiency of the energy sector shows that if we impose an optimized tax on imported energy desirable effects will come about. Thus, the energy policy goal of contributing to a national economy through optimization of the energy sector can be attained.

Summary and conclusions

The integrated energy policy model used in this study seeks to present a flow of policy rules which lead government policy to attain equilibrium, maximizing the national economic benefits from offsetting market failure.

The fundamental principles of this policy analysis are as follows:

- Energy policy must focus on the social value of the energy sector based on national economic benefit–cost and must not be misled by a simple comparative advantage rule due to energy supply price.
- Energy policy must be formulated and executed along with energy sources or their related energy sectors as a link in the chain of a wholly integrated policy instead of as separate, individual policies.
- Energy policy must be designed consistent with the formulation of long-term energy policy as a link in the chain of a balanced national economic policy and the supply/distribution/consumption of energy.

Based on the principles above, the integrated energy policy (IEP) can be accomplished by effectively compensating several energy investment sectors, including the domestic energy industry. Energy funds raised by taxing imported energy are mainly considered with regard to the desirable level of domestic energy price, the optimal mix of domestic energy use, and an efficient plan for the formation and distribution of the energy fund. The analytic results show that the IEP in this study requires the energy fund formation to be greater than the current petroleum business fund, the domestic energy price to be higher than at present, that energy demand management of consumptive energy usage be reinforced, and the compensating level of domestic energy and various energy-related sectors be escalated.

Considering direct policy effects on the energy sector and the general economic sector and the long-term indirect/derived effects on the national economy, the IEP has tremendous effects including considerable shock buffering impact in terms of the preparation for future energy crises.

The authors wish to thank M. Rieber and anonymous reviewers.


In this broader definition, all points above the price regression line comprise energy shock and the height of price anomaly describes the size of the shocks. In reality, from 1949 to 1990 the results of the analysis of the international (real) oil prices shows a risk probability of energy shock of 23.8%. For details, see Tai-Yoo Kim, Seoul National University Research Institute of Engineering Science, A Guideline on the Energy Policy in Korea (II), Korea Coal Industry Promotion Board, 1992, pp 39-43.

The regional economic effects add the cost of the employment lost in the case of domestic coal industry closure and the loss due to the regional multiplier effect of the closure of those coal mines. The import substitution effects calculate the social opportunity cost of the payment reduction to imported energy by using domestic energy. There are two aspects of the cost to the society using imported energy: one is the risk premium effect, which considers the future possibility of a price rise of imported energy, and the other is the national security effect, which calculates the social cost of quantity shortfalls. The environmental cost calculates the social cost of productivity reduction arising from the energy-caused air pollution for each of energy sources by using the health effect discussed in L.B. Lave and E.P. Seskin, 'Air pollution and human health', Science, Vol 169, 1970, pp 723-733; E.J. Mishan, 'Evaluation of life and limb: a theoretical approach', Journal of Political Economy, Vol 79, 1971, pp 687-705; and S. Gerking and L.R. Stanley 'An economic analysis of pollution and health: the case of St. Louis', Review of Economics and Statistics, Vol 68, No 1, 1986, pp 115-121. For a complete discussion of the items presented above, see op cit, Ref 6, pp 331-366.

Besides, in the other items for evaluating domestic energy value, there are regional economic effects, substitution effects of the imports in the interindustry forward/backward linkage effects. In addition, low income consumers depend heavily on the coal usage, yielding an additional utility to the protection effects for low income consumers. However, we excluded these in our final summation.

Here, refers to those assumed to have been technologically feasible and developed: see op cit, Ref 6, pp 239-241.

See op cit, Ref 6, pp 241-243 for details.

Notice that this refers to energy resources such as oil: see op cit, Ref 6, pp 243-245.

See op cit, Ref 6, pp 363-364 for details.

Here, allocative efficiency implies allocating both within the energy markets as well as between the energy sector and the economy as a whole. We adopt distributional equity as meeting the environmental benefits of the oil special-consumption stage and that the tax amount is determined by the energy taxation mix model and subject to amount of energy formation.

The value is approximated in terms of the aggregate tax rates added on imported oil price (= 1.0 in 1991).

This implies no IEP, namely an invariant current government policy.


In our study, this means the steps when distilled oil products are used in the consumption sector.

Assumes that the scope of the electric power tax is equivalent to that of the oil special-consumption stage and that the tax amount is prepared for electric power-related support money for the supply and demand of coal is adequate.

The details of compositions of the efficiency and gain functions by the individual energy sectors are made up as follows: Social benefit through aid to coal is made up of direct effects which increase the effect of coal output on GNP and the national economic benefit increase due to stabilizing the energy supply base (i.e., a decrease in the degree of dependence on foreign energy). The benefit from aid to overseas oil exploitation is composed of supply stabilization and revenue from local partial selling of the oil. National economic benefit from oil stockpiling is made from potential gains to GNP by escalating economic performance during an energy crisis. Benefits from aid to energy conservation are due to a decrease in inputed energy demand through attaining efficiency-improvement at the first hand and potential GNP gains, which a decrease in energy consumption gives, by stabilizing the energy supply/demand at the second hand. Environmental protection (LNG) provides social benefit through a decrease in environmental pollution and a potential benefit through the substitution of an existing energy source (oil) by imported LNG. Alternative energy development yields social benefits from the substitution for an existing energy source (oil), and a potential GNP gain due to a stable supply for domestic energy consumption.

This value is the observable real GNP plus the potential GNP gain added from the secured quantity by domestic energy sector investment.