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ENERGY CONSERVATION THROUGH TAXATION

by

Clark W. Bullard III

February 5, 1974
ENERGY CONSERVATION
THROUGH TAXATION

by

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This work was supported by a grant from the National Science Foundation.
ABSTRACT

The growth of energy productivity has slowed in recent years. This trend implies that energy demands will rise at increasing rates if economic growth is sustained. In turn, environmental, fiscal, and national security problems associated with growing energy demands may increase faster than our ability to cope with them.

To provide incentives for increasing energy productivity, an energy conservation tax is proposed. A linear model is used to estimate the impacts of such a tax on prices of final products. It is shown that an ad valorem tax could be more regressive than a specific tax based on energy units.
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1. INTRODUCTION

Energy demand is growing at an astounding rate. In turn, this growth creates problems in the areas of national security, balance of payments, and environment. As a result, a variety of legislative and regulatory measures have been suggested to control the growth in energy demand and to solve the problems it creates.

The purpose of this report is to suggest that a tax be levied on all types of energy at the point of consumption to encourage conservation and to raise revenue needed to solve energy-related problems. The rationale for the tax, its economic impact, and methods of implementation will be discussed.

1.1 Increase Energy Use Efficiency

One purpose of an energy conservation tax is to conserve energy by promoting its efficient use. A rationale for promoting energy conservation stems from observations of widespread energy waste while technology for conserving it goes unused. [1]

It is time to recognize that energy, like labor and capital, can be considered a basic factor of production. Since it is a resource that is truly consumed and cannot be recycled, attention should be given to policies for increasing energy productivity. The GNP/energy ratio, which might be considered a gross measure of energy productivity, has increased steadily since the 1920's, but the rate of growth has diminished to nearly zero during the past two decades. (See fig. 1). Previous policies to increase labor productivity have increased energy use at the expense of labor. Automation, replacing retail clerks with packaging, and replacing night watchmen in the security lighting are cases where energy has been substituted for human labor. In the future, it will become necessary to examine both the labor and energy impacts of policies, and be mindful of the necessity of efficiently using both resources.

Current energy prices have not helped us avoid serious problems of national security, resource depletion, environmental degradation, and premature dependence on new fuels before adequate safety testing. We have been relatively unsuccessful in solving these problems, and energy conservation is certainly one component of their solution. An energy tax would work through the price structure to promote energy conservation while preserving freedom of choice. If properly designed, it might provide an
GNP-ENERGY RATIO
1920-1972

FIGURE 1. THE GNP/ENERGY RATIO
acceptable alternative to a mandatory allocation system.

1.2 Revenues

An energy tax would also produce revenues. The acceptability of the tax would depend to some extent on the purposes for which these funds would be used. If a portion of the funds are earmarked for research on clean and abundant or renewable energy sources, benefits would accrue to the largest energy users, those paying the most tax. If funds are directed toward research in energy conservation, and educating the public on energy conservation methods, citizens would be provided with the opportunity to reduce their energy tax burden. It may be necessary to devote some of the revenues to income redistribution, perhaps through income tax credits to low income families. Such a technique, using the federal income tax to shift most of the tax burden to "energy wastrels", has been suggested by Muller [2].

The amount of revenue produced by an energy tax will depend on a variety of factors, the tax rate, demand elasticity, and the extent of inter-product substitution brought about by the tax. These factors, which also influence impact on prices to consumers and hence the need for income redistribution, will be discussed in Section 2.

1.3 Tax Energy Consumption, Not Production

An energy conservation tax would be applied at the point of consumption, not at the mine as would be the case with a resource depletion tax. By taxing each unit of energy (Btu) as it is consumed, the tax is not distorted by the rate structure of the energy processing industries. That is, the tax would be level, and would not be diminished by "quantity discounts". The energy consumer would be provided a clear incentive to select the most efficient fuel for his particular use.

It is suggested that all types of energy be taxed equally, based on their Btu content. In particular, hydro and nuclear electricity should be taxed at the same rate as electricity produced from fossil fuels. While exempting these might slow the depletion of fossil fuels, it would not be without adverse side effects. The few remaining hydroelectric sites would become more economically attractive, possibly leading to the irreversible loss of resources such as Hell's Canyon and the Grand Canyon. Increasing the economic feasibility of nuclear fission would bring us closer to closing the deal on this "Faustian Bargain", perhaps with insufficient knowledge of all its implications [3]. Exempting any particular fuel would provide
incentives for increasing its consumption, thus changing an energy conservation tax to a fuel tax.

In this report, an energy tax will be viewed as a tool for controlling the growth of energy demand. Since uncontrolled growth would contribute to problems with environmental quality, balance of payments and national security, it is reasonable to expect the federal government to consider using this tool to protect the health, welfare, and security of the public.

To help the policymaker estimate the economic and other impacts of an energy tax, a model is developed in Section 2. Conclusions and recommendations are presented in Section 3. Calculations and detailed descriptions of the methods used are contained in the Appendices.
2. ESTIMATING IMPACTS OF AN ENERGY CONSERVATION TAX

Ideally, we would like to have full knowledge of the impacts of an energy tax before implementing it. To appreciate the difficulty of evaluating these impacts, we need only consider their possible scope. The tax may be absorbed from profits or passed on to purchasers, and could therefore affect the prices of virtually all goods and services. Predicting in advance the demand changes and product substitutions brought about by these price changes would be nearly impossible.

Some models can give a first approximation to the projected impacts if the tax under consideration is small, and if the expected response is likewise small. These might be used by policymakers imposing an energy tax incrementally, and estimating the impacts of each increase.

In this section, a linear model will be used to estimate the impacts of a 20¢ per million Btu energy tax. Direct impacts on the most energy intensive industries will be determined first, then the possible increases in consumer prices will be estimated. The figures shown here are for 1963, since that is the latest year for which data are available. The method could be applied to 1967 and 1971 data as soon as they are made available by the U.S. Department of Commerce.

2.1 Impact on Commercial and Industrial Users

Energy used in each of 360 sectors of the U.S. economy is known for the year 1963 [4]. Total dollar outputs are also known [6]. Assuming an energy tax rate of 20¢ per million Btu, the amount that would be levied on each sector can be calculated (Details in Appendix A). It is expressed as a percentage of the sector's total output in Table 1, where the 35 most energy intensive industries are ranked. The impact on all other sectors would be less than one percent. Furthermore, if in response to the tax industries implemented energy conservation measures, the impact would be further reduced.

2.2 Impact on Consumers

The individual consumer can be hit two ways by an energy tax. First, he would be assessed directly on his purchases of electricity, oil, and gas. Second, the prices of all goods and services may be increased if industries are able to pass some of their tax forward. An upper limit on the consumer's ultimate tax burden will be estimated below.
<table>
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<tr>
<td>9.</td>
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<td>15.</td>
<td>CHEM MINERAL MINING</td>
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To estimate impact, we will make use of existing information on the total energy intensity (Btu/dollar) of goods and services. These results were derived in part from an input-output study of the 1963 economy, and therefore reflect the national average interindustry relations at that time. Total energy intensity includes both the (direct) energy content of the product (in the case of fuels) and the (indirect) energy consumed in every sector of the economy to produce the outputs necessary to deliver a product to final demand. Using this energy intensity as an indicator of the potential price increases is equivalent to assuming that industries are able to pass 100% of the energy tax forward to purchasers, in the form of an across the board price increase.

Table 2 shows the maximum price increases possible under these assumptions. Methods for calculating these figures are described in Appendix A. In fact, if the tax is effective and increases energy productivity in the commercial and industrial sectors, these figures would be substantial over-estimates. Keep in mind also that these figures apply to producers' prices in 1963 dollars. Actually, the consumer would see a gasoline price increase of much less than 24%, because that rate applies only to the producers' price. Tax rates on the transportation and trade markups are substantially lower, and motor fuel taxes would be exempt from the energy tax.

Using 1963 data we find that the tax on direct purchases of energy by individuals would average $20.00 per person; the tax paid by commerce and industry to meet personal consumption demands would average $15.00 per person. If the latter tax were passed on to consumers, the total tax could average $35.00 per person. (See appendix B). Obviously, these figures are meant to be first approximations; they do not account for savings through energy conservation, and they neglect secondary impacts of changes in consumption patterns induced by the tax.

These estimates might be useful as a guide for designing an income redistribution program, if the impact on low-income families is deemed excessive. Figure 2 shows the direct and indirect energy impacts of purchases by families of different income levels [5]. The indirect tax, or that portion of it passed
<table>
<thead>
<tr>
<th>PRODUCT</th>
<th>BTU TAX $</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Refined Petroleum</td>
<td>23.7</td>
<td></td>
</tr>
<tr>
<td>Gas Utilities</td>
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<td>Electric Utilities</td>
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<td>Plastics</td>
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<td>Man-Made Fibers</td>
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<td>Paper Mills</td>
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<td>Air Transport</td>
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<tr>
<td>Insurance Carriers</td>
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<td></td>
</tr>
<tr>
<td>Misc. Professional Services</td>
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<td></td>
</tr>
<tr>
<td>Banking</td>
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<td></td>
</tr>
<tr>
<td>Doctors, Dentists</td>
<td>0.3</td>
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</table>
on to consumers, is almost linearly proportional to after-tax income. Since direct energy use tends to saturate as income increases, adjustments might be made solely on the direct tax. A flat per-capita income tax deduction might be the most straightforward method of adjustment [2]. The amount of the deduction could reflect the tax on a "subsistence level" of energy use, thereby easing the burden on low income families.

Note that some proposed methods of taxing energy might be more regressive than others. In particular, if energy is taxed at a percentage of its price (an ad valorem tax) rather than on its Btu content, residential consumers will pay more tax on a given amount of energy than commercial and industrial users. Moreover, due to the nature of prevailing utility rate structures, large residential users (high income families) would be taxed at an effectively lower rate than small users (low income families). This is illustrated by calculations in Appendix B.
FIGURE 2. ENERGY DEMANDS AND HOUSEHOLD INCOME
3. CONCLUSIONS AND RECOMMENDATIONS

The growth of energy productivity has slowed in recent years. This trend implies that energy demands will rise at increasing rates if economic growth is sustained. In turn, environmental, fiscal, and national security problems associated with growing energy demands may increase faster than our ability to cope with them.

To provide incentives for increasing energy productivity, an energy conservation tax is proposed. Since an immediate switch to the most energy-efficient technologies is impossible, it is suggested that the tax be imposed incrementally. This would permit measurement of demand elasticity and other impacts of each increase. The tax increases would be continued until the desired increases in energy efficiencies were achieved.

In this report, a linear model was used to estimate the impacts of an initial energy tax rate of 20 cents per million Btu. Results indicate that the impacts on prices might be relatively small (less than 4¢ per gallon of gasoline, less than one half cent per kwh of electricity). What if these rates are too low to induce substantial energy savings? If experience indicates that a much higher tax rate is required to realize significant energy conservation gains, questions of income redistribution will become progressively more important and a substantial fraction of the revenues may be needed for that purpose. (At the present rate of energy use, 20¢ per million Btu implies about $15 billion annually in tax revenues!)

Accompanying each increase in the energy tax by a corresponding adjustment in the federal income tax could compensate for regressive characteristics of energy taxation. Calculations for an initial rate of 20¢ per million Btu indicate that an income redistribution scheme might be based on consideration of the tax paid directly by consumers on their purchases of energy. Taxing energy on a Btu basis was shown to be less regressive than an ad valorem tax.

The energy conservation tax discussed in this report would apply equally to all types of energy, and would be levied at the point of consumption, not production. The numerical results and methods developed here could also be applied to tax policy alternatives involving differential rates on different fuels. Such policies might be considered as a means for shifting growth in energy demand to cleaner or more abundant fuels. Differential taxation might not conserve energy, however, if it provides incentives to shift to less
efficient fuels. An energy conservation tax (on all fuels), with a surtax on specific fuels might be used to achieve both objectives.
4. REFERENCES


APPENDIX A
Tax Impact Calculations

A.1 Estimation of Impact on Commercial and Industrial Users

From [4] we have the matrix $E$, elements of which $(E_{ij})$ represent the energy of type $i$ consumed in sector $j$. Dimensions of the matrix are $5 \times N$, where $N$ is the number of sectors in the economy (368 in the present work). From the same source, we have a $5 \times 5$ matrix $C$, where

$$C_{ik} = \frac{E_{ik}}{E_k} \quad i, j = 1, \ldots, 5 \quad \text{A.1(1)}$$

The denominator represents the total energy output of energy sector $k$. Elements of the matrix product, $(C E)_{ij}$, then represents the total energy of type $i$ allocated to the consumption of all types of energy by sector $j$. This technique is applicable only for $j$ not an energy sector. To avoid double counting, we calculate the total primary energy allocated to sector $j$'s energy consumption:

$$P_j = (C E)_{ij} + (C E)_{1j} + \frac{.184 H \ (CE)_{4j}}{3412} \quad \text{A.1(2)}$$

That is, it is the sum of the coal (1) allocation, crude oil and gas (2), and the fossil fuel equivalent of the hydro and nuclear electricity allocation. $H$ is the fossil fuel heat rate, and .184 is the fraction of 1963 electricity produced from hydro and nuclear sources.

For a tax rate of 20¢ per million Btu, the energy tax paid by sector $j$ is $$.20 \times 10^{-6} P_j$ dollars. Or, in terms of cents per dollar output,

$$\text{TAX}_j = \frac{.2 \times 10^{-6} P_j}{X_j} \times 100 \quad \text{A.1(3)}$$

where $X_j$ are the dollar outputs from [6].

The use of $C$ to allocate primary energy to the use of secondary fuels such as electricity, gas, and refined petroleum, implies that energy producing and processing industries will not pay the energy tax on their fuel inputs, but will pass it forward to energy consumers on a per Btu basis. Since the
efficiencies of energy processing installations are relatively easy to measure, this may not be too difficult to enforce.

A.2 Possible Impact on Prices of Goods and Services

From [4], we have the primary energy intensity, $e_j$ Btu/$ at 1963 producers' prices. This is the "indirect" energy intensity, and is known for the output of all sectors, including the energy sectors. If all energy taxes were passed on to purchasers, and eventually to final consumers, the price increases would be proportional to $E_j$. Adding the direct tax on fuel sales to final demand, we obtain the potential price impact, expressed in cents per dollar.

\[ I_j = 0.20 \times 10^{-6} (e_j + \sum_{i}^{N} \sum_{k=1}^{5} C_{ik} e_{kj}) \]  

where $e_{kj}$ is the energy of type $k$ sold to final demand, and the summation over $i$ follows that of eq. A.1(2). The values $e_{kj}$ are simply given by

\[ e_{kj} = E_{k \text{out}} - \sum_{n=1}^{N} E_{kn} \]  

where $N$ is the number of sectors in the economy.
In this section, an alternative taxing strategy, based on a rate proportional to the dollar value of energy, will be examined. First, a method for determining the energy value content of goods and services will be presented. Then potential price increases on selected items will be compared with those expected with the tax based on Btu content.


Data compiled by the U.S. Department of Commerce [6] for the national input-output tables shows explicitly the value of energy type i used by sector j to produce a dollar's worth of output. This value, $A_{ij}$, can be interpreted as a direct energy purchase coefficient. Since energy processing sectors do not consume all the energy they purchase, we define the matrix $\eta$ whose elements $\eta_{ij}$ represent the fraction (Btu/Btu) of fuel i purchased by sector j that is converted to energy output from energy sector j. The matrix is 5 by 368, and its elements are zero for all sectors except the following: it is unity for the conversion of crude oil and gas to refined petroleum and to processed natural gas; it is 0.327, the average thermal efficiency of fossil fueled electric utilities, for the conversion of fossil fuels to electricity [5]. The modified energy purchase coefficient can then be given by

$$C_{ij} = (1 - \eta_{ij}) A_{ij} \left[ \frac{\delta_{ej}}{1 - 0.184} \right]$$

where $\delta_{ej} = 1$ for j = electric utility sector and 0 otherwise

The term in brackets accounts for the fact that 18.4% of electricity in 1963 was produced from hydro and nuclear fuels. In effect, this computes a direct energy purchase coefficient which assigns a fossil fuel equivalent to hydro and nuclear electricity. We must use the total requirements matrix, $TR$, from the national input-output tables. An element $TR_{ij}$ represents the output required directly and indirectly from sector i to deliver one dollar's worth of output from sector j to final demand. Postmultiplying $\equiv$ by $TR$, and summing over the five energy sectors, we obtain the total energy value coefficients.
Energy value coefficients thus derived are listed in Table 3.

B.2 The Tax Rate for an Equivalent Ad Valorem Tax

The tax base divided by the sum of all taxable transactions gives the tax rate. First, the values of all taxable transactions must be summed. This is equal to the total output of the energy sectors, less the value of specifically exempt transactions. A term accounting for the equivalent fossil fuel inputs for hydro and nuclear electricity is also included. The taxable transactions in 1963 were

\[
V_j = \sum_{i=1}^{5} \sum_{k=1}^{N} C_{ik} T_{R_{ik}}
\]

B.1(1)

\[
\sum_{i=1}^{5} (T_{O_{ij}} - \sum_{j=1}^{E} n_{ij} T_{T_{ij}} + T_{T_{ij}} \left[ \delta_{ej} \right] \left[ 1 - .327 \right] ) = 52.13 \times 10^9
\]

B.2(1)

In the above expression, \( T_{O} \) is the vector of total outputs, and \( T_{T} \) is the matrix of total transactions, also from [6].

To compute a tax rate \( R \) comparable to a 20¢ per million Btu tax, we set revenues equal and solve

\[
R = \frac{0.2 \times 10^{-6} E_{TOT}}{52.13 \times 10^9}
\]

B.2(2)

where \( E_{TOT} \) is the 1963 U.S. energy consumption, \( 48.7 \times 10^{15} \) Btu. The resulting tax rate is 18.6 cents per dollar's worth of energy.
<table>
<thead>
<tr>
<th>PRODUCT</th>
<th>ENERGY CONTENT (Btu/$)</th>
<th>ENERGY VALUE CONTENT ($/$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Refined Petroleum</td>
<td>1146444</td>
<td>114.8</td>
</tr>
<tr>
<td>Gas Utilities</td>
<td>1125546</td>
<td>160.8</td>
</tr>
<tr>
<td>Electric Utilities</td>
<td>554921</td>
<td>123.4</td>
</tr>
<tr>
<td>Plastics</td>
<td>218097</td>
<td>13.2</td>
</tr>
<tr>
<td>Man-Made Fibers</td>
<td>202641</td>
<td>7.4</td>
</tr>
<tr>
<td>Paper Mills</td>
<td>177567</td>
<td>7.9</td>
</tr>
<tr>
<td>Air Transport</td>
<td>152363</td>
<td>12.0</td>
</tr>
<tr>
<td>Electric Utilities</td>
<td>136961</td>
<td>7.3</td>
</tr>
<tr>
<td>Water, Sanitary Services</td>
<td>116644</td>
<td>11.6</td>
</tr>
<tr>
<td>Metal Doors</td>
<td>109875</td>
<td>6.7</td>
</tr>
<tr>
<td>Cooking Oils</td>
<td>94195</td>
<td>7.1</td>
</tr>
<tr>
<td>Fabricated Metal Products</td>
<td>91977</td>
<td>5.8</td>
</tr>
<tr>
<td>Metal Household Furniture</td>
<td>91314</td>
<td>5.9</td>
</tr>
<tr>
<td>Knit Fabric Mills</td>
<td>88991</td>
<td>6.5</td>
</tr>
<tr>
<td>Toilet Preparations</td>
<td>85671</td>
<td>5.1</td>
</tr>
<tr>
<td>Blinds, Shades</td>
<td>81472</td>
<td>6.3</td>
</tr>
<tr>
<td>Floor Coverings</td>
<td>79323</td>
<td>5.8</td>
</tr>
<tr>
<td>House Furnishings</td>
<td>75853</td>
<td>5.3</td>
</tr>
<tr>
<td>Poultry, Eggs</td>
<td>75156</td>
<td>7.3</td>
</tr>
<tr>
<td>Electric Housewares</td>
<td>74042</td>
<td>5.6</td>
</tr>
<tr>
<td>Canned Fruit, Vegetables</td>
<td>72240</td>
<td>5.2</td>
</tr>
<tr>
<td>Motor Vehicles &amp; Parts</td>
<td>70003</td>
<td>5.9</td>
</tr>
<tr>
<td>Photographic Equipment</td>
<td>64718</td>
<td>3.8</td>
</tr>
<tr>
<td>Mattresses</td>
<td>63446</td>
<td>4.5</td>
</tr>
<tr>
<td>New Residential Construction</td>
<td>60218</td>
<td>4.5</td>
</tr>
<tr>
<td>Boat Building</td>
<td>60076</td>
<td>4.9</td>
</tr>
<tr>
<td>Food Preparation</td>
<td>58690</td>
<td>4.8</td>
</tr>
<tr>
<td>Soft Drinks</td>
<td>55142</td>
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<tr>
<td>Upholstered Household Furniture</td>
<td>51331</td>
<td>4.1</td>
</tr>
<tr>
<td>Cutlery</td>
<td>50021</td>
<td>4.0</td>
</tr>
<tr>
<td>Apparel, Purchased Materials</td>
<td>45905</td>
<td>4.0</td>
</tr>
<tr>
<td>Alcoholic Beverages</td>
<td>43084</td>
<td>3.0</td>
</tr>
<tr>
<td>Hotels</td>
<td>40326</td>
<td>5.4</td>
</tr>
<tr>
<td>Hospitals</td>
<td>38364</td>
<td>5.4</td>
</tr>
<tr>
<td>Retail Trade</td>
<td>32710</td>
<td>4.4</td>
</tr>
<tr>
<td>Insurance Carriers</td>
<td>31423</td>
<td>4.4</td>
</tr>
<tr>
<td>Misc. Professional Services</td>
<td>26548</td>
<td>4.3</td>
</tr>
<tr>
<td>Banking</td>
<td>19202</td>
<td>2.5</td>
</tr>
<tr>
<td>Doctors, Dentists</td>
<td>15477</td>
<td>1.9</td>
</tr>
</tbody>
</table>
B.3 Potential Price Increases

B.3.1 Sales to total final demand. Under the same "worst case" assumptions used for the Btu tax, we calculate the potential price impacts in cents per dollar.

\[ I_j = RV_j \]  

These are presented in Table 4, and compared to corresponding increases possible with a Btu tax. The analysis assumes all taxes are passed on to purchasers in the form of an across the board price increase.

Note among the non-energy items that the Btu tax is higher than the value tax on most manufactured goods. This reflects the fact that industrial energy users pay relatively low energy prices compared to users in the service and trade sectors.

B.3.2 Energy Sales to Individuals. Reference [6] gives the personal consumption expenditures vector \( Y \), which is one component of total final demand. To compare the potential impact on consumers due to the two alternatives (Btu tax and ad valorem tax), we multiply the potential price increases by \( Y_j \) and sum over all goods and services.

This calculation is straightforward for the energy value tax. For the Btu tax, however, it embodies the implicit assumption that the average price of each fuel sold to individuals is equal to the price at which it is sold to governments, foreign markets, and the rest of final demand. For sales of coal to individuals, no specific price data were available, so the above method was used. (The error due to this approximation is small because little coal was sold directly to individuals.) For all other types of energy purchased by individuals, a different method was used.

First, the quantities (Btu) of fuels sold to individuals were obtained from ref. [7]. Then, using the overall energy sector efficiencies from ref. [14], the direct and indirect energy content of these purchases was calculated and multiplied by the tax rate.
TABLE 4. Possible Price Impacts
(Cents per dollar delivered to final demand, 1963 producers' prices)

<table>
<thead>
<tr>
<th>PRODUCT</th>
<th>Btu Tax</th>
<th>Value Tax</th>
</tr>
</thead>
<tbody>
<tr>
<td>REFINED PETROLEUM</td>
<td>23.7</td>
<td>22.0</td>
</tr>
<tr>
<td>GAS UTILITIES</td>
<td>23.2</td>
<td>30.8</td>
</tr>
<tr>
<td>ELECTRIC UTILITIES</td>
<td>11.5</td>
<td>23.7</td>
</tr>
<tr>
<td>PLASTICS</td>
<td>4.5</td>
<td>2.5</td>
</tr>
<tr>
<td>MAN-MADE FIBERS</td>
<td>4.2</td>
<td>1.4</td>
</tr>
<tr>
<td>PAPER MILLS</td>
<td>3.7</td>
<td>1.5</td>
</tr>
<tr>
<td>AIR TRANSPORT</td>
<td>3.1</td>
<td>2.3</td>
</tr>
<tr>
<td>METAL CANS</td>
<td>2.8</td>
<td>1.4</td>
</tr>
<tr>
<td>WATER, SANITARY SERVICES</td>
<td>2.4</td>
<td>2.2</td>
</tr>
<tr>
<td>METAL DOORS</td>
<td>2.3</td>
<td>1.2</td>
</tr>
<tr>
<td>COOKING OILS</td>
<td>1.9</td>
<td>1.4</td>
</tr>
<tr>
<td>FABRICATED PRODUCTS</td>
<td>1.9</td>
<td>1.1</td>
</tr>
<tr>
<td>METAL HOUSEHOLD FURNITURE</td>
<td>1.9</td>
<td>1.1</td>
</tr>
<tr>
<td>KNIT FABRIC MILLS</td>
<td>1.8</td>
<td>1.2</td>
</tr>
<tr>
<td>TOILET PREPARATIONS</td>
<td>1.8</td>
<td>1.0</td>
</tr>
<tr>
<td>BLINDS, SHADES</td>
<td>1.7</td>
<td>1.2</td>
</tr>
<tr>
<td>FLOOR COVERINGS</td>
<td>1.6</td>
<td>1.1</td>
</tr>
<tr>
<td>HOUSE FURNISHINGS</td>
<td>1.6</td>
<td>1.0</td>
</tr>
<tr>
<td>POULTRY, EGGS</td>
<td>1.6</td>
<td>1.4</td>
</tr>
<tr>
<td>ELECTRIC HOUSEWARES</td>
<td>1.5</td>
<td>1.1</td>
</tr>
<tr>
<td>CANNED FRUIT, VEGETABLES</td>
<td>1.5</td>
<td>1.0</td>
</tr>
<tr>
<td>MOTOR VEHICLES &amp; PARTS</td>
<td>1.4</td>
<td>1.1</td>
</tr>
<tr>
<td>PHOTOGRAPHIC EQUIPMENT</td>
<td>1.3</td>
<td>0.7</td>
</tr>
<tr>
<td>MATTRESSES</td>
<td>1.3</td>
<td>0.9</td>
</tr>
<tr>
<td>NEW RESIDENTIAL CONSTRUCTION</td>
<td>1.2</td>
<td>0.9</td>
</tr>
<tr>
<td>BOAT BUILDING</td>
<td>1.2</td>
<td>0.9</td>
</tr>
<tr>
<td>FOOD PREPARATIONS</td>
<td>1.2</td>
<td>0.9</td>
</tr>
<tr>
<td>SOFT DRINKS</td>
<td>1.1</td>
<td>0.9</td>
</tr>
<tr>
<td>UPHOLSTERED HOUSEHOLD FURNITURE</td>
<td>1.1</td>
<td>0.8</td>
</tr>
<tr>
<td>CUTLERY</td>
<td>1.0</td>
<td>0.8</td>
</tr>
<tr>
<td>APPAREL, PURCHASED MATERIALS</td>
<td>0.9</td>
<td>0.8</td>
</tr>
<tr>
<td>ALCOHOLIC BEVERAGES</td>
<td>0.9</td>
<td>0.6</td>
</tr>
<tr>
<td>HOTELS</td>
<td>0.8</td>
<td>1.0</td>
</tr>
<tr>
<td>HOTELS</td>
<td>0.8</td>
<td>1.0</td>
</tr>
<tr>
<td>RETAIL TRADE</td>
<td>0.7</td>
<td>0.8</td>
</tr>
<tr>
<td>INSURANCE CARRIERS</td>
<td>0.6</td>
<td>0.8</td>
</tr>
<tr>
<td>MISC. PROFESSIONAL SERVICES</td>
<td>0.5</td>
<td>0.8</td>
</tr>
<tr>
<td>BANKING</td>
<td>0.4</td>
<td>0.5</td>
</tr>
<tr>
<td>DOCTORS, DENTISTS</td>
<td>0.3</td>
<td>0.4</td>
</tr>
</tbody>
</table>
For example, the purchases of electricity were divided by 0.258, the overall efficiency of the electric utility sector. This efficiency of 25.8% is considerably less than a power plant's thermal efficiency due to transmission losses and energy required to supply all inputs to this sector. The overall efficiencies of the refined petroleum and gas utilities sectors are 82.8% and 85.5% respectively.

Then the total revenues were calculated for each tax as shown above. The results are presented in Fig. 3. The revenues from government purchases, exports, and investment, which make up the balance of final demand, are also shown. Per capita figures can be calculated assuming a 1963 population of 189,197,000 [8].

The ad valorem tax could derive more revenue from individuals than the Btu tax. Revenue from consumption of non-energy items is about the same under each alternative. From Fig. 3, it appears that the ad valorem tax could have a more severe impact on low-income families since it derives a larger part of its revenue through direct energy purchases by individuals.
Government, Exports, Investment

Personal consumption (energy purchases)

Personal consumption (non-energy purchases)

Figure 3. Comparison of Tax Burden Under Alternative Tax Strategies.
Several sources were used to calculate the GNP/Energy ratio over the period 1920 - 1972. In areas where time periods overlapped, the sources agreed within about 2%. The reason for the discrepancy may be related to the fact that fuel wood was included in ref. [9] for 1920 - 1955 and was neglected in ref. [10] for 1947 - 1969. Because of the relatively close agreement, the use of fuel wood was neglected for this latter period. For 1970 - 1972 data from the Bureau of Mines [11] and Department of Commerce [12] were used. Results are presented in Table 5; the calculations are described below.

For 1920 - 1945, data were obtained for 5 year intervals from ref. [9]. They were expressed as indices, $n$, normalized to the year 1900. That is,

$$n_{1955} \equiv \frac{\text{Btu 1955}}{\text{Btu 1900}} \times \frac{\text{GNP 1955}}{\text{GNP 1900}}$$

The Energy/GNP ratio for 1955 from ref. [10] was 91,200 Btu/1958 dollar. Therefore, the ratios for the years between 1920 and 1945 were given by

$$\frac{\text{Energy/GNP}}{\text{y}} = \frac{91,200}{n_{1955}}$$

where $y$ is the year of interest.

For 1947 - 1969 ratios were taken directly from ref. [10]. The 1970 ratio given in [10] was based on preliminary data and therefore was not used.


All data from which these data are derived are recognized as "best estimates", and no error bounds are given. Therefore, one should not construe the figures in Table 5 to be as accurate as the number of digits might imply. The figures were derived to show a trend, and this trend is apparent from
<table>
<thead>
<tr>
<th>YEAR</th>
<th>$/MILLION BTU</th>
</tr>
</thead>
<tbody>
<tr>
<td>1920</td>
<td>6.70</td>
</tr>
<tr>
<td>1925</td>
<td>7.92</td>
</tr>
<tr>
<td>1930</td>
<td>7.86</td>
</tr>
<tr>
<td>1935</td>
<td>8.76</td>
</tr>
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<td>1940</td>
<td>9.40</td>
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<tr>
<td>1945</td>
<td>10.85</td>
</tr>
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<td>1947</td>
<td>9.43</td>
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<td>1948</td>
<td>9.52</td>
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<td>1949</td>
<td>10.26</td>
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<td>1950</td>
<td>10.41</td>
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<tr>
<td>1951</td>
<td>10.38</td>
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<td>1952</td>
<td>10.80</td>
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<td>1953</td>
<td>10.95</td>
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<td>1954</td>
<td>11.20</td>
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<td>1968</td>
<td>11.33</td>
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<tr>
<td>1969</td>
<td>11.05</td>
</tr>
<tr>
<td>1970</td>
<td>10.76</td>
</tr>
<tr>
<td>1971</td>
<td>10.85</td>
</tr>
<tr>
<td>1972</td>
<td>10.98</td>
</tr>
</tbody>
</table>
fig. 1. Clearly, when the severity of the winter in the U.S. population centers can affect annual energy consumption by several percent, we are justified in using these "best estimates" to observe the forest, not the trees.
The growth of energy productivity has slowed in recent years. This trend implies that energy demands will rise at increasing rates if economic growth is sustained. In turn, environmental, fiscal, and national security problems associated with growing energy demands may increase faster than our ability to cope with them.

To provide incentives for increasing energy productivity, an energy conservation tax is proposed. A linear model is used to estimate the impacts of such a tax on prices of final products. It is shown that an ad valorem tax could be more regressive than a specific tax based on energy units.