SOURCES AND USES OF WOOD FOR ENERGY

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ABSTRACT

Today about 3.7%, or 2.7 quad (2.8 EJ). of energy in the United States comes from wood. This could potentially increase to 10 quad (l0.6 EJ) or about 13.5% of U.S. energy use. This amount of wood is readily available. Wood use is competitive with other fuels in some applications now, and will become more competitive as fossil fuel prices increase and environmental pollution from burning fossil fuels receives more attention. Development of wood energy is needed to insure our energy security.

Our production of energy from wood is now similar to the amounts we obtain from hydropower and nuclear power. The major wood energy users are the forest products industry and homeowners. We could increase use significantly, without depleting our timber resource by using material not now used, such as logging residues, manufacturing residues, land-clearing residues, urban wood residues, and wood from insect-, disease-, and fire-killed trees. Nationwide, we have an excess of wood growth in comparison to annual cut.

Although gradual or unexpected sharp increases in fossil fuel prices will increase wood energy use, we could obtain many benefits of wood energy use sooner if we continue to improve technology for producing and using wood-based fuels. With a modest research and development effort, use could increase from the current 2.7 quad (2.8 EJ) to 4.0 quad (4.2 EJ) by 1995. A strong commitment could lead to production of 6.0 quad (6.3 EJ) by 2000, and a sustainable 10 quad (10.6 EJ) by 2010. This contrasts with a U.S. Department of Energy projection of 3.8 quad (4.0 EJ) by 2005 in the recent Energy Security Report to the President. To more fully utilize wood we must overcome obstacles that include high cost of harvesting and collecting wood, lack of infrastructure for marketing wood fuel products, emphasis on nonwood fuels in research and subsidy programs, and failure to give due credit to environmental, national security, and economic benefits in use of wood fuels.

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INTRODUCTION

In 1987, wood was the sixth largest supplier of energy in the United States (behind oil, natural gas, coal, hydropower and nuclear power) and the second largest renewable energy source after hydropower. Most wood is consumed in the residential and industrial sectors of the economy. Commercial, institutional, and transportation sectors use small amounts. The transportation sector used only about 4 to **5** million gallons (15 to 19 million liters) of ethanol that came as a byproduct of paper making. In the residential sector, about 1 quad (1.06 exajoule (EJ)) of wood was consumed in 1984. This represented 11% of total residential energy consumed and saved $2.2 billion ($10^9$) in conventional fuel expenses. Residential fuelwood costs vary widely depending on location, land ownership, and amount of personal labor expended in harvesting and handling. However, for equivalent heating value, wood at $40 per ovendry ton ($44.09 per ovendry tonne) is about 38% of the cost of natural gas at $5.80 per ft^3 ($0.205/m^3). In the industrial sector, 1.7 quad (1.8 EJ) of wood was consumed in 1984, or about 7% of total industrial energy consumed (USDOE 1985).

Wood energy use may have decreased from 2.7 quad (2.8 EJ) since 1984. The Forest Service and U.S. Department of Energy estimate 1986 use at 2.5 and 2.66 quad (2.6 E and 2.8 EJ), respectively. We assume that the use of wood for energy remained fairly constant during the past few years, despite lower oil prices and less perceived urgency for developing fossil fuel alternatives.

The pulp and paper industry accounts for much of the industrial fuelwood use in the United States, and it has increased its consumption since 1984 in all categories, which include hogged wood, bark, and waste processing liquor. Self-generated and residue sources of energy accounted for 56.7% of total consumption of the pulp and paper industry during calendar year 1986 (API 1987). On the other hand residential use of wood fuel appears to have dropped. An indicator of reduced fuelwood use by homeowners is a recent decrease in amount of material harvested for self-use (mainly residential) from national forests (Figure 1). The decline in fuelwood harvest from national forests is due in part to increased charges for fuelwood. A comparison of wood and other fuel use in 1987, assuming that wood use remained constant since 1984, is shown in Figure 2. The U.S. Department of Energy estimates that consumption of wood for energy increased sharply between 1970 and 1984 (Figure 3).

SOURCES OF WOOD FUEL

Wood used for energy is derived largely from materials that are not suitable for other products. However, in some parts of the country unsplit roundwood for fuel sells at about the same price as pulpwood. Even though pulpwood material may be used for fuel in some areas, there is still much wood residue in our forests.

Of the estimated 18 billion cubic feet (509 million cubic meters) of roundwood timber harvested in the United States in 1986, 3.1 billion cubic feet (88 million cubic meters), the equivalent of 0.9 quad (0.95 EJ), was used for fuelwood (USDA 1988). Of this, only 26% came from material classified as growing stock, that is, main stem portions of live sawtimber trees and poletimber trees, meeting specified standards of quality or vigor.

Roundwood is increasingly harvested for energy by whole-tree chipping. This method is particularly appropriate for supplying wood to 10- to 50-.MW power plants. Wood-burning electric power plants that are currently operating or under construction could generate 2000 to 2500 MW and consume 20 to 25 million green tons (18 to 23 million green tonnes) or 10 to 12.5 million ovendry tons (9.1 to 11.3 million ovendry tonnes) of wood chips per year. In 1984, there were 14 whole-tree chippers operating in the forests of Georgia, producing 972,000 tons (882,000 tonnes) of chips for energy. New England is becoming a leader in chipping in the woods for energy, and California is not far behind.

Wood is also consumed for fuel at manufacturing plants, after it has been removed from the forest for other purposes. Most of this is in the form of residues from primary wood products manufacturing. Black liquor, or waste processing liquor from kraft pulping operations, produced 0.9 quad (0.95 EJ) of energy in 1986. At least another 0.39 quad (0.41 EJ) was obtained from wood in the form of sawdust, slabs, edgings, chips, and veneer clippings at lumber and plywood manufacturing plants in that year. In addition, bark used for fuel at pulp mills and lumber and plywood plants amounted to at least 0.3 quad (0.32 EJ) of energy in 1986.

In addition to the wood consumed in industrial plants and homes, comparatively small amounts were used in commercial and institutional buildings.

CONTINUED AVAILABILITY

In considering expanded use of wood for energy, whether we will have enough wood to supply our needs for wood and fiber products as well as for energy is a valid concern. Numerous examples of severe problems from overcutting forests have occurred in the past, and in many countries these problems are resurfacing today. However, much of our fuelwood comes from material. that otherwise would not be used. Unremoved forest residue can cause difficulties in fire, insect, and disease protection or occupy space that might be better used by young, vigorous trees. Nonetheless, we must be aware of environmental problems that would be exacerbated in harvesting more wood for energy.

More research on the relationship between wood removal and nutrient balance for different situations is necessary. If more wood is removed from the land instead of being left to decay, fewer nutrients will be recycled back to the soil. It is uncertain how much nutrient material may be removed safely before replenishment is necessary. Undoubtedly this will vary with soil types, stand growth characteristics, and climatic conditions.

Although better information on nutrient cycling is needed, we should not be hard pressed to supply energy from wood in the United States in the near term. Table 1 shows sources of wood that are not now used and could serve as sources of energy. Some of these reserve supplies are in remote areas and would be uneconomical to harvest for energy. However, as a rough estimate, perhaps half this material would be available at a cost **of** $45 per ovendry ton ($49.60 per ovendry tonne) or less.

NEED FOR EXPANDED USE OF WOOD FOR ENERGY

Consumption of an estimated 2.7 quad (2.8 EJ) of energy from wood in 1987 amounts to 3.4% of our total consumption including wood. This is somewhat less than the 3.9% from hydropower and 6.3% from nuclear power. The contribution from wood is not a major portion of our energy consumption, but it is significant and has the potential for growth.

Use of an additional 587 million ovendry tons (533 million ovendry tonnes) per year of wood for energy would supply 10.0 quad (10.6 EJ); if only half the residues are available economically, this amounts to 5.0 quad (5.3 EJ).

Having a substitute fuel is important in case imports are cut off end fossil fuel supplies are depleted, causing prices to rise. The urgency for supplying alternative forms of energy is less during a period of low and decreasing oil prices, as we have enjoyed since 1985. However, this is a situation that could change abruptly and cause crises similar to those in 1973 and 1979.

Problems that could develop from a new oil crisis are indicated by the record of oil prices since 1970 (Figure 4). After the first oil crisis in 1973 oil prices doubled, and they doubled again after the crisis of 1979. Prices gradually decreased from 1979 to 1985 end abruptly decreased to 1986 levels. The situation since has been unsettled. Energy security is threatened by our dependence on foreign oil sources. Oil imports are again increasing (Figure 5).

The U.S. Department of Energy predicts petroleum use in the United States in 1988 will average 16.66 million barrels (2.65 million cubic meters) per day. Imports of crude oil and refined products are expected to rise to 6.04 million barrels (0.96 million cubic meters) per day in 1988, up from 5.8 million barrels (0.92 million cubic meters) in 1987, a 4.1% increase. Indications are that imports will provide 36% of U.S. petroleum consumption in 1988 (USDOE 1988).

Deterrents to Expanded Use

Whether increase in use of wood for energy is rapid or sluggish depends on some artificial and institutional deterrents as well as economics and environmental concerns. Some important deterrents to growth in use of wood for energy are (1) difficulties in harvesting end collecting forest wood,

(2) lack of infrastructure for marketing wood fuel products, (3) obsolete conversion technology, and (4) higher subsidy for nuclear energy per unit output then for wood.

Wood harvested for energy is usually of smaller diameter than sawlogs, veneer logs, or even Pulpwood. The harvesting of smaller material is usually more expensive, and the delivered value is often less because it is not suited for manufacture of wood products such as lumber and plywood.

The energy industry is reluctant to build plants fired by a nontraditional fuel with a supply system that may not be reliable, and the forest products industry is reluctant to develop a supply infrastructure without long-term contracts from those who would use the wood as an energy source (UT 1986). Koning and Skog (1987) propose farm or farmlike cooperatives as an alternative marketing infrastructure.

Residential wood heating has been inefficient and the source of much air pollution. But steps are being taken to assure better controls for home heating applications. New controls include catalytic converters, airtight combustion chambers, and regulated supply of combustion air. It is also necessary to develop improved technology for industrial, institutional, and commercial installations where larger quantities of wood fuel are used.

In a study by the Rocky Mountain Institute (Heede and Lovins 1985), it was estimated that more than $50 billion was spent in energy subsidies by the Federal government in fiscal year 1984. But these subsidies are unevenly allocated. Renewable energy other than hydropower produced 1.7 million Btu (1.8 million kilojoule) per dollar of subsidy. Nuclear energy received 80 times as much subsidy per unit of energy and produced about 20,000 Btu (21,100 kJ) per dollar of subsidy.

Factors Favoring Expanded Use

Important conditions favoring expansion of wood use include (1) cost savings, (2) cleanup of harvest sites. (3) reduced emissions of sulfur and nitrous oxides from boilers, (4) control of the greenhouse effect, and **(5)** national energy security.

Much recent press commentary has focused on the difficulty in finding landfill space for municipal solid waste. Much of this solid waste consists of paper, demolition waste, tree trimmings, and other forms of wood. If more of this material were used for fuel, need for landfills could be significantly reduced. Managing public and private forest harvesting operations poses a similar problem. Often brush from logging operations is concentrated and broadcast burned to prepare land for new tree growth. This consumes management funds and subjects the atmosphere to more particulate loading as well. However, in California the Forest Service now avoids broadcast burning by offering **cleanup** credits for harvesting excess wood for energy, This means that wood is burned in boilers instead of being burned in the open, and emissions are reduced.

Another increasing concern in the United States and Canada is acid rain. One suspected reason for increased acidity in precipitation, although by no means proven, is increased emission of various oxides of sulfur and nitrogen to the atmosphere. Burning wood usually produces less of these emissions than burning high-sulfur coal and sulfur-containing petroleum.

Burning fossil fuels seems to be increasing atmospheric carbon dioxide and contributing to the "greenhouse effect." This is not the case with wood burning as long as new timber grows to consume carbon dioxide given off by previous generations of wood burning. Only if forests are cleared for other types of land use, such as highways, dwellings, and cattle ranches and the removed wood is burned will there be an addition to atmospheric carbon dioxide content. Thus, normal woodburning will not add carbon dioxide to the atmosphere, but burning of fossil fuels will.

Energy security is another factor favoring wood use. The Energy Security Act of 1980 contained several specific provisions to support making ethanol from wood (Gavett 1986). It also contained general recommendations to (1) allow market forces to determine the types and quantities of wood produced and consumed for fuel and (2) support selected longer term wood development activities. A goal for liquid fuel production was determined to be 8.4 billion gallons (31.8 billion liters) of fuel alcohol (ethanol and methanol) from wood. A goal for nonalcohol wood was not set, but as directed by the Congressional Conference Report (Senate Rept. 96-824, House Rept. 96-1104) that accompanied the Energy Security Act, the U.S. Department of Agriculture and U.S. Department of Energy have forecast that 4 quad (4.2 EJ) of nonalcohol wood could be in use annually by 1990 (USDA and USDOE 1983). Most of this energy would be provided by the direct combustion of wood.

FUTURE USE OF WOOD FOR ENERGY

The Energy Security Act calls for periodic progress reports, end two have been submitted to the President. The first report contains a comprehensive wood production and use plan from 1983 to 1990, but the most recent report (USDOE 1987) neglects wood. Referring to world wood use, it states that burning wood in lumber and paper industries and "simple burning of wood and other biomass" in scattered locations are mature technologies that are not expected to contribute more than 7.5 million barrels per day of oil equivalent after 1990." This is equivalent to about 16 quad (16.9 EJ) per year and greatly underestimates the potential.

In the United States, given a slow rate of growth, it would be difficult to increase current production of 2.7 quad (2.8 EJ) to 4.0 quad (4.2 EJ) by 1990 (USDA and USDOE 1983). However, with a modest research and development effort together with extension programs, 4.0 quad (4.2 EJ) should be attainable by 1995. A strong commitment could lead to 6.o quad (6.3 EJ) by 2000, and by 2010 we could reach a sustained level of 10 quad (10.6 EJ). With all-out dedication to production of wood for energy, levels significantly higher than this would be possible. In the 12 years from 1973 to 1985 the use of wood fuel increased approximately 100%. Growth to 6.o quad (6.3 EJ) in the 12 years to 2000 would require another 122% increase.

Other projections for energy from wood are both higher and lower. The USDOE (1985) National Energy Policy Plan Projections state that by the year 2010 wood consumed by the residential and industrial sectors is projected to increase by about 60% and 25% respectively. This would mean 1.6 quad (1.7 EJ) for residential use and 2.1 quad (2.2 EJ) for industrial use. The Plan also projects 0.3 quad (0.32 EJ) in the commercial sector, for a total of about 4.0 quad (4.2 EJ).

In 1980, the Office of Technology Assessment (OTA 1980) predicted about 4 quad (4.2 EJ) from wood for the year 2000 with a hands off approach and 10 quad (10.6 EJ) with a high level of policy support for bioenergy. Pimentel et al. (1981) estimated residues from crops end forest harvests to have ***a*** gross heat energy equivalent of about 12% of the fuel consumed annually in the United States.

CONCLUSION

We have large supplies of unused wood material that would allow an increased commitment to developing wood energy. Such a commitment would (1) reduce the potential damage of a cutoff of oil imports, (2) reduce emissions of sulfur from boilers, (3) potentially help control the greenhouse effect, and (4) reduce hazards to forests by cleaning up harvest sites. An increased commitment should address (1) the need for improved conversion technology, (2) the lack of an infrastructure for marketing wood fuel products, (3) difficulties in harvesting forest wood, and (4) the much higher subsidy paid for production of nuclear energy.

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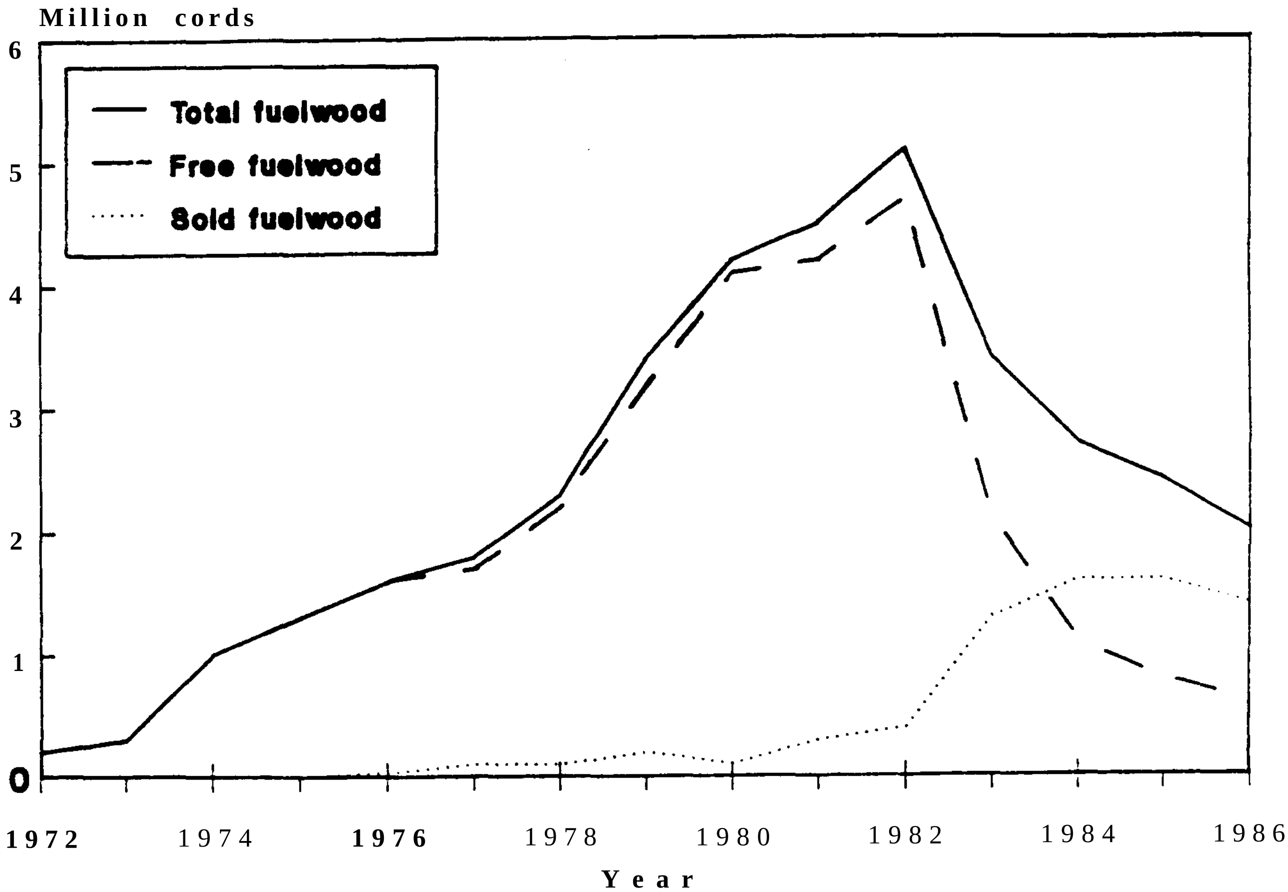
TABLE 1
Potential Wood for Use as Energy[a]

Source	Residue quantity (million ovendry tons per year)[b]
Forest	
Residues from growing stock and nongrowing stock	160
Standing live and dead trees	20
Excess growing stock	215
Mortality	95
Subtotal	490
Urban tree removals and wood wastes	70
Forest products industrial wastes	7
Waste wood from land clearing	20
Total	587

[a]Sources: USDA (1980, 1988).

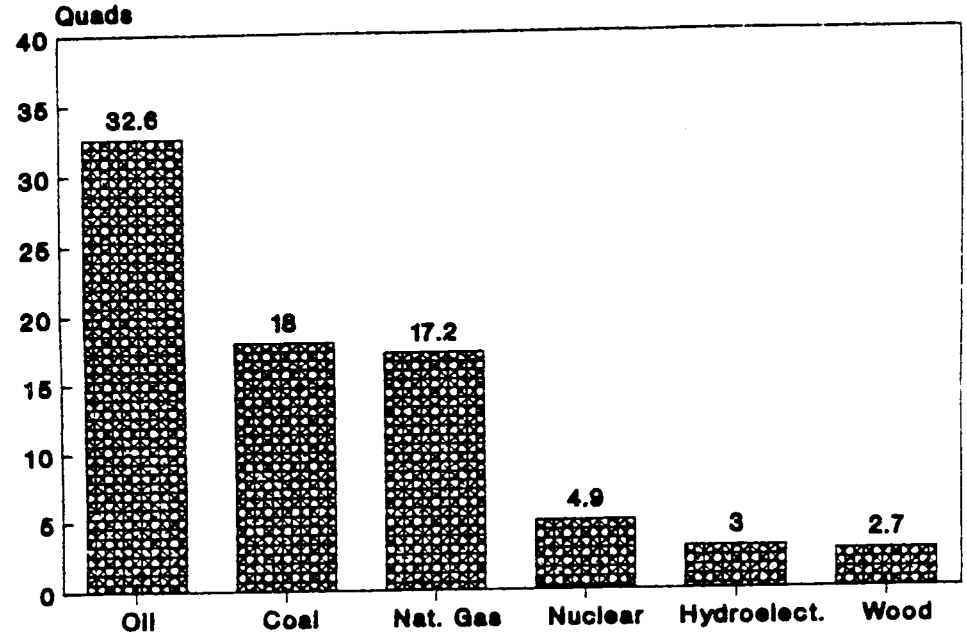
[b]Multiply ovendry tons by 0.9 to obtain ovendry tonnes.

Figure 1. National forest fuelwood harvest, 1972 to 1986.



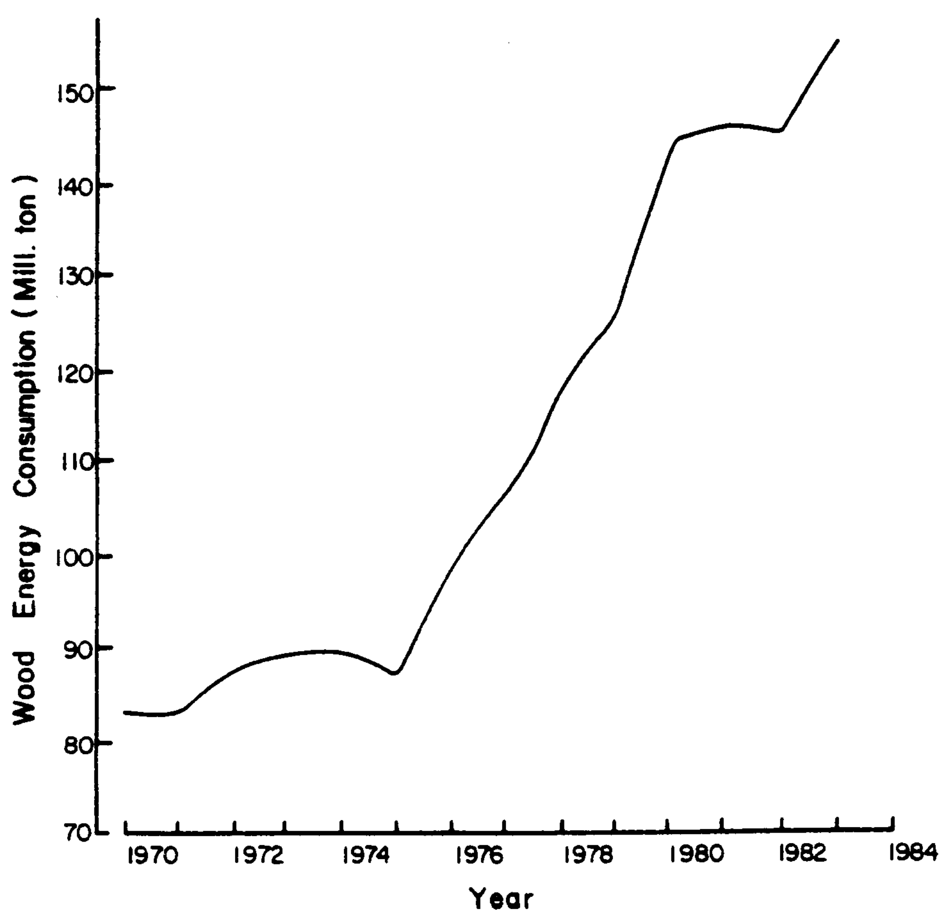
Source:USDA,Forest8ervice,1988

Figure 2. U.S. energy consumption, 1987.



Source: US DOE, EIA, Monthly Energy Review, Jan. 1988; and US Forest Service

Figure 3. Consumption of wood for energy, 1970 to 1984.



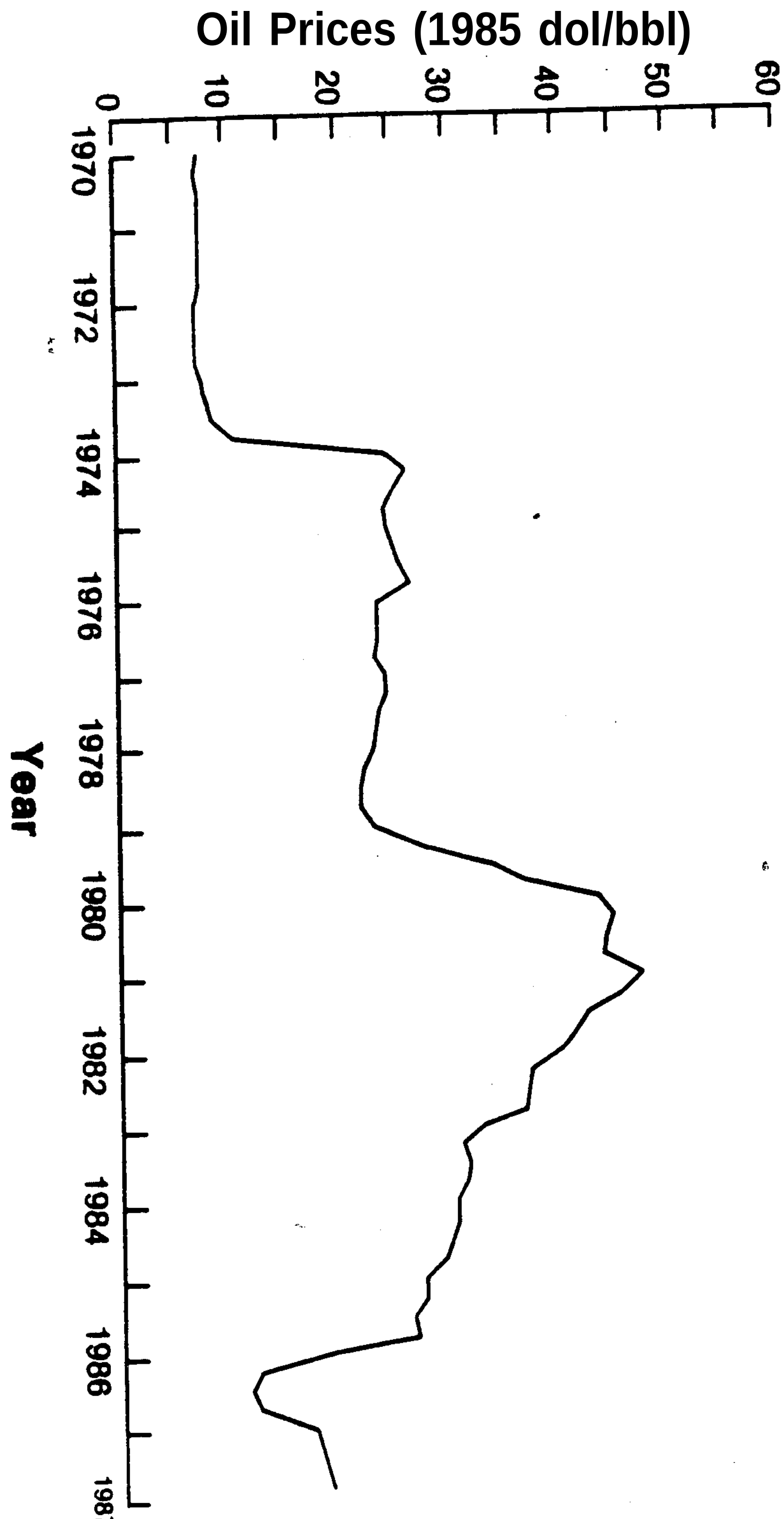

Oil Prices (1985 dol/bbl)
0
10
20
30
40
50
60
1970
1972
1974
1976
1978
1980
1982
1984
1986
1987
Year

Figure 5. Daily oil imports, 1977 to 1988.