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RESIDENTIAL WOOD AND COAL COMBUSTION

TASK 2

SUMMARY OF MAJOR FUEL USE PROJECTIONS

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EXECUTIVE SUMMARY

The most likely scenarios for residential wood and coal combustion in the next 20 years show a slight increase in wood and a steady coal use. Residential wood combustion is projected to increase from 0.7 to 0.8 quads in 1980 (quad = one quadrillion BTU's = 10^{15} BTU's = 56 million cords wood = 58 million tons wood) to about 1.0 quads in the year 2000. Residential coal combustion is expected to remain at about 0.1 quads until the year 2000 (1 quad = 45 million tons coal).

Projections for residential wood and coal combustion should be used with caution. They are largely dependent on the relative cost to the conventional fuels, which can only be roughly estimated at this time. A major increase in oil prices or disruption in oil supplies would have a substantial impact on both wood and coal combustion levels. Coal in particular is available in relatively large quantities if there is a demand for it by the residential sector. Wood, on the other hand, is expected to be a supply limited resource, with increasing competition for such uses as lumber, particleboard, pulp, and boiler fuel.

A major study by Norman Marshall (Dartmouth College) on residential wood use nationally and by region has been completed, but is still under review. It is expected to be available in January, 1983. This study appears to be far more sophisticated than previous residential wood use projections, and should be used as the most accurate projection for residential wood use. There are no major residential coal combustion projections known to be under development at this time, beyond the annual projection done by the U.S. Department of Energy for all major fuels and users.

INTRODUCTION

This century has seen a steady shift in residential space heating from coal and wood to oil, gas, and electricity. By the early 1970's, the use of wood and coal in individual homes had virtually disappeared. With the recent large cost increases and supply uncertainties associated with the conventional fuels, however, many people have expressed interest in switching back to coal and wood. This is of particular concern to air pollution control planners, since these two solid fuels are associated with substantial particulate, hydrocarbons (including polycyclic organic matter), carbon monoxide, sulfur dioxide (coal only) emissions, and visibility reduction.

This report gathers together the various residential fuel use projections for the next 20 years for coal and wood, both on a national and regional basis. The projections will be briefly evaluated as to the major assumptions, and the major strengths and weaknesses of each projection. These fuel use projections were located through a limited literature search and by personal contact with the agencies or groups most likely to have made such projections.

BACKGROUND

Fuel use projections are made on a regular basis for the major fuels and users by the U.S. Department of Energy. These projections are generally based largely on economic factors, including projected energy prices and estimated growth in the Gross National Product. Projecting either residential wood or coal use with such economic factors presents special problems. Both solid fuels have relatively high transportation costs, which result in localized markets only. These local markets make it much more difficult to determine national fuel use. Coal sold for residential use is not tracked separately, making it even more difficult to accurately project the use of this fuel. Wood has the additional problem that much of the wood used is cut by the user, so that it does not pass through even a local market where it could be quantified.

A number of non-economic factors also can be expected to have major impacts on projected coal or wood use. Negative factors include the additional inconvenience and time required to burn the solid fuels; the dirt and odors associated with wood and coal; the perceived pollution problems and possible restrictions by air pollution control agencies; and safety hazards from house fires and wood gathering and preparation.

Other non-economic factors can have the effect of increasing the use of wood in particular. These include the positive feelings of independence from oil and electric companies, the enjoyment of the outdoors during firewood gathering, the aesthetic pleasure from a fire, and the value of the exercise involved.

The major area of uncertainty in all energy use projections is the price and availability of oil. We are still feeling the effects of major oil price increases and embargoes of the 1970's, in the shifting of energy sources in various sectors. Further major disruptions or price increases can be expected to cause further shifts in energy use that are not anticipated in the energy use projections made to date.

For all these reasons, it should be understood that fuel use projections for residential coal and wood combustion should be used with caution. They are educated guesses of what will happen in the future and are more useful as indications of general fuel use trends and the major factors influencing them, than as actual predicted levels of fuel use at any given time.

RESIDENTIAL WOOD COMBUSTION USE PROJECTIONS

In these days of rapidly changing prices for various fuels, it is difficult to predict the future use of even the conventional fuels such as natural gas or oil. Predicting residential wood use includes additional areas of uncertain data as well. Factors that will affect the amount of residential wood combustion in each region include:

- How much wood is available "free" for the taking?
- How far away is the wood source (transportation costs become become significant over 50-100 miles)?
- Is there a "woodburning ethic" which views firewood gathering as recreational, or a positive responsible conservation measure?
- How much competition is there now and will there be in the future for existing firewood (i.e. use of wood residue by pulp or particle-board mills)?
- What value is placed on the additional time required by the resident to heat with wood?
- How serious a problem do users consider the litter and dirt which results from burning wood?
- How expensive are wood stoves, is there a tax credit for installing them, and will pollution problems require more expensive, cleaner stoves?
- How expensive is wood for those not getting it "free", and how does this cost compare to that of gas, oil, and electricity including rate of price changes for the various fuels?
- What are the heating needs for a particular area, including weather, housing age, house size, number of houses?
- What changes in wood stove efficiencies, improvements in burning practices, lowering of heating level expectations, and increase in insulation levels can be expected over time?
- What increases and geographical shifts in population are expected?
- How much wood is actually being burned, and how much wood is potentially available now and in the future for firewood?

- What effect will rising costs and increased education about combustion efficiencies have on fireplace use (common now, but generally not an efficient heat source)?

- How secure are wood supplies perceived to be relative to conventional fuel supplies?

- Will changes in national priorities for our forests (building materials versus firewood versus wood fuel for power plants versus wildlife) result in increases or decreases in fuel wood availability?

An illustration of the limitations in accuracy of wood use trends is the wide divergence of estimates of current wood usage. The U.S. Forest Service estimated 1978 residential wood use at 0.12 "quads" (quadrillion BTU's), with an unknown basis for this estimate[1]. The U.S. Department of Energy estimated 1978 residential wood use at 0.6 quads, using wood stove sales and an average amount of wood burned per unit[2]. A Gallup survey of 3108 households resulted in an estimate of 0.9 quads wood burned in 1978[3]. This wide range and lack of agreement on current wood use, which should be much better known than wood use ten or twenty years from now, is an indication that any projection should be used with care.

NATIONAL WOOD USE PROJECTIONS

The two major groups showing a continuing interest in residential wood use trends are the U.S. Forest Service (USFS) and the U.S. Department of Energy (DOE). The DOE makes regular reports on projected energy uses for all significant fuels and users, as well as special reports for specific uses. The USFS is interested in the significant demands placed on American forests. Other groups sponsoring or making national wood use projections are the Office of Technology Assessment (U.S. Congress) and the Solar Energy Research Institute. The studies are summarized in Table 1.

Four different studies sponsored by four different offices within DOE over the last three years were found. These four studies showed very different results, even for the 1980 figures (0.2 to 0.7 quads wood burned - see Table 1). Assuming that the Gallup survey results showing 0.9 quads burned in 1978 is the most accurate estimate, and assuming that residential wood combustion has not substantially decreased since 1978, the highest DOE projections are probably the most accurate of these four DOE studies. Unfortunately, the group within DOE dealing with biomass has seen considerable cuts in funding and high turnover, and the person responsible for the higher projections is no longer at DOE, and left no documentation behind as to the methodology he used in making his estimate. This projection shows wood use gradually increasing from 0.7 to 1.0 quads by 2000, and then remaining constant for the following 20 years[7]. This leveling off is ascribed to wood supply limitations and the inability to move wood long distances economically.

Another study, done by Brookhaven National Laboratory under contract to DOE, is due in draft form in November, 1982. This study is reported to be an econometric model which deals only with wood that is purchased (it is assumed that the use of "free" wood will remain constant). According to the Task Manager, Frederick Lipfert of Brookhaven, his model is driven strictly by the relative price difference between wood and other fuels and does not consider non-economic factors such as inconvenience. David Moses is the DOE Project Manager for this wood use study. The U.S. Forest Service published wood use trend data in late 1981 which appear quite low, showing an increase in wood use from 0.1 quads in 1980 to 0.3 quads in the year 2000. The basis for these figures are past wood use trends, population and fuel price trends, and fireplace and wood stove sales trends.

A much more sophisticated and detailed computer simulation model has been developed by Norman Marshall (Dartmouth College) under contract to the USFS. Marshall used a version of this model to project New England residential wood use last year (see the following section for

TABLE 1

National Residential Wood Use Projections

Study Title	Sponsoring Agent	Date of Study Publication	Basis for Projection	Fuel Use-Quadrillion BTU/[1]yr					Comments
				1980	1985	1990	1995	2000	
? Norman Marshall	US Forest Service	1/83 (expected)							Expected to be the most reliable projection currently available.
"An Assessment of the Forest and Rangeland Situation in the U.S."	US Forest Service	10/81	Past use trends, population, fuel price trends, and sales trends	0.1	0.2	0.2	0.2	0.3	-----
Energy From Biological Processes	Office of Technology Assessment (US Congress)	7/80	Booz, Allen study plus population trends	-	-	-	-	1.0 2.0	Higher figure if vigorous support for RWC and high conventional energy prices; lower figure if no interference
Report on Building a Sustainable Energy Future	Solar Energy Research Institute	4/81	Current trends, expected fall from increased competition for wood and increased stove efficiencies	-	-	1.5 to 2.0	-	1.0	-----
Energy Projections to the Year 2000 - July 1982 Update	DOE - Office of Policy, Planning & Analysis	8/82	"Other existing demand models"	0.2	0.2	0.2	0.3	0.3	-----
1981 Annual Report to Congress	DOE - Energy Information Administration	2/82	Unknown	0.7	0.7	0.8	0.9	1.0	-----
Assessment of Proposed Federal Tax Credits for Residential Wood Burning Equipment, Booz, Allen & Hamilton	DOE - Office of Building & Community Systems	11/79	Woodstove sales, installation cost, tax credit policy (if any)	-	0.8 1.0	-	-	-	Higher figure if 30% tax credit in 1981
The Use of Wood For Fuel; Historical Series and Projections to the Year 2000, Bradburd et.al.	DOE - Office of Energy Use Analysis	1979	Current conventional & wood fuel prices, borrowing rates, heating requirements, installation costs, current distribution on woodburning households, population	0.3	0.3	0.3	-	0.3	Assumes that relative prices of wood/conventional fuels remains unchanged over time; all woodburning occurs in rural areas, rural/urban ratio will remain constant

[1] One quad = 56 million cords wood = 58 million oven dried tons wood

discussion of this model). He has since revised the model and put in data from different regions to come up with national fuel use trends, as well as regional trends. This study has been completed, but is undergoing review at this time and will not be available until January, 1983. It is expected that these results will be far superior to the other estimates done to date.

The Office of Technology Assessment projects residential wood use in 2000 to be between 1.0 and 2.0 quads, depending on governmental support for RWC and conventional energy prices[4]. These projections are reported to be based on wood stove sales, installation costs, tax credit policies, and population trends.

The Solar Energy Research Institute presented testimony before a Congressional Committee showing a rise in wood use to 1.5 to 2.0 quads in 1990, dropping to 1.0 quads in the year 2000[5]. The 1990 figure was developed using extrapolation of current trends, with the subsequent drop attributed to increasing competition for wood and increased stove efficiencies.

REGIONAL WOOD USE PROJECTIONS

Only two major regional studies were found - Marshall's study on New England[8] and Battelle Northwest study on the Pacific Northwest done for DOE. In addition, EPA Region X conducted a study on three Pacific Northwest cities and the Bonneville Power Administration did a study on electrically heated homes for the Pacific Northwest.

As previously discussed, the Marshall computer simulation model was the most complex encountered. The major assumptions of this model are listed in Table 2. A disadvantage to this model is that factors affecting wood supply are not included.

Marshall's wood use projections for New England show a slight decrease in wood use by 1990, with an increase after that. The projected decrease by 1990 is the result of increased wood stove efficiency and improved insulation. Marshall notes that under the most likely scenario, wood fuel prices will increase in real terms 50% by the year 2000, whereas conventional fuel prices will increase by 90%. The growth in wood stove use is slowed by several factors: later installations are presumed to be more expensive (i.e., the cheaper installations occur first); the availability of "free" wood will decrease; and people not wanting the inconvenience of wood heating will resist switching to wood (i.e., those not minding the inconvenience will switch earlier).

One of the significant advantages of Marshall's model is the good data available for actual wood use in New England in the 1970's, gathered by the U.S. Department of Agriculture. This data allows the model to be calibrated (or tested), by starting with 1970 data and comparing the models' projections for 1970-1980 with the actual levels of woodburning that occurred.

It is interesting to compare Marshall's projections in the year 2000 with the national projections. According to the DOE's Estimates of U.S. Wood Energy Consumption from 1949 to 1981[2], New England burned about 7.7% of the residential wood used in the U.S. as of 1980. Assuming that New England maintains that share until 2000, then Marshall's projections for New England correspond to a national total of 1.0 quads in the year 2000. This is the same figure as several of the more likely national projections previously discussed.

Marshall did run his computer model with several variations or possible scenarios to determine the model sensitivity in final wood use figures. For example, high and low conventional energy price scenarios were used (DOE figures). These variations showed the year 2000 wood use figures to be 64% higher (high energy prices) and 19% lower (low

TABLE 2: BASIC ASSUMPTIONS OF WOODSTOV-2 MODEL BY NORMAN MARSHALL

Residential Sector

- Wood-heating equipment may be installed in new housing units or retrofitted into existing housing.
- Decisions to invest in wood-burning equipment are made on the basis of marginal costs and benefits.
- The decision to install wood heating equipment in new housing is a function of fuel savings and non-economic factors.
- The decision to retrofit wood-heating equipment in new housing is a function of economic payback period and non-economic factors.
- The economic payback period is equal to installation cost divided by annual fuel savings.
- Installation cost reflects the amount of the housing with installed capacity, the fraction of the household's heating needs met by the wood-heating capacity, and by the level of pollution abatement.
- The least expensive installations will in general be performed first. Therefore, as the market is penetrated, installation cost increases.
- Early adopters with their own wood supply will have a lower perceived wood-heating cost than later adopters who must purchase all of their wood.
- Non-economic factors incorporated into the model are convenience and pollution.
- Consumers for whom convenience is not a major issue will in general install wood-burning equipment first. Therefore, as the market is penetrated, inconvenience cost increases.
- Fuel prices, the size of the housing stock, heating efficiencies, and household heating requirements are all exogenous inputs into WOODSTOV-2.
- Stove usage may displace a greater quantity of fuel than if the same quantity of heat were provided by a central furnace.

(continued)

TABLE 2 (Continued)

Coal Module

- Coal and wood are interchangeable fuels in many instances.
- If wood-heating cost grows substantially above coal-heating cost, many wood users may switch to coal.

Pollution Sector

- Particulates from air-tight stoves are significant potential sources of emissions.
- Pollution regulation could take the form of either area bans or performance standards for new stoves.
- Performance standards could increase the cost of installing wood-burning equipment.

energy prices) compared to the base or most likely prices. The results from the alternate scenarios are presented in Table 3. When the number of variables and assuptions that were used are considered with their possible errors, it is clear that care should be used with wood use projections.

Projections for three Pacific Northwest cities were made in 1981 under a contract from EPA Region X. These projections were for Portland, Oregon, Seattle and Spokane, Washington. Norman Marshall's model was used. These projections show a substantial increase in the early 1980's, followed by a slight decline by 1990, and then further increases until the year 2000 for Portland. The Seattle figures predict a sharp increase by 1985, followed by fairly constant annual usage through the year 2000. The Spokane projections are for a slight increase by 2000.

The three regional studies discussed are summarized in Table 4.

TABLE 3

Marshall's Projections for New England Residential Wood Use
With Different Assumptions

	1985		1990		1995		2000	
	10^6cds/yr	Quads/yr	10^6cds/yr	Quads/yr	10^6cds/yr	Quads/yr	10^6cds/yr	Quads/yr
Base	3.40	.061	3.24	.058	3.63	.065	4.22	.076
Low Energy Prices	3.08	.055	2.68	.048	2.52	.045	2.36	.042
High Energy Prices	3.74	.067	3.85	.069	4.95	.089	6.90	.124
30% Tax Credit in 1981	3.65	.066	3.32	.060	3.62	.065	4.09	.074
High Conservation	2.75	.050	2.04	.037	1.98	.036	2.08	.037
Low Wood Price	3.48	.063	3.48	.063	4.12	.074	5.15	.093
High Wood Price	3.12	.056	2.70	.049	2.77	.050	2.93	.053
Coal Penetration	3.09	.056	2.88	.052	3.05	.055	3.20	.058
Pollution Problem	3.19	.057	3.10	.056	3.55	.064	4.15	.075

TABLE 4

Major Regional Residential Wood Use Projections

Study Title	Area Covered	Residential Wood Use - 10^3 Cords/Year				
		1980	1985	1990	1995	2000
The Dynamics of Residential Wood-Energy Use in New England 1970 - 2000, by Norman Marshall	Maine, Vermont, New Hampshire, Rhode Island, Connecticut, & Massachusetts	--	3400	3240	3630	4220
Residential Wood Combustion Study - Wood Fuel Use Projection, by Greene and Gay under contract to Del Green Assoc.	Portland, Oregon, Seattle & Spokane, Washington	Port 340 Sea 155 Spo 121	Port 430 Sea 195 Spo 126	Port 410 Sea 195 Spo 126	Port 450 Sea 200 Spo 129	Port 480 Sea 195 Spo 129

RESIDENTIAL COAL USE TRENDS

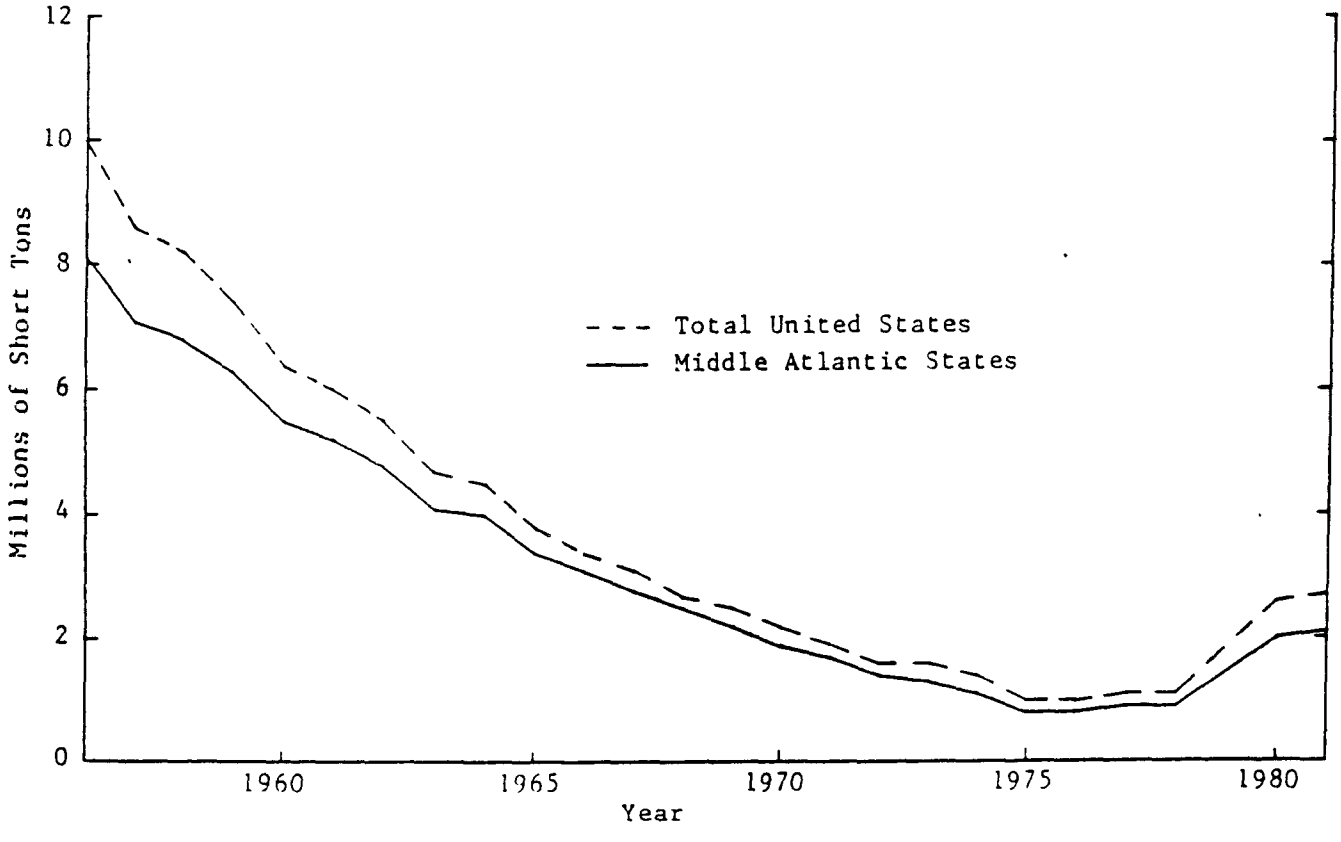
By 1974, the use of coal in the residential sector had virtually disappeared except near coal fields[14]. Residential coal combustion continued at a low level until the late 1970's, when oil and electricity prices had risen to the point where coal again was cost competitive, at least in New England. During the winter of 1980-81, a serious shortage occurred of anthracite in the sizes most often used in residential units in the Northeastern United States. The 1981-82 heating season showed a continued demand for residential coal, but no shortages as appeared the previous winter. The March 22, 1982 issue of Coal Week attributes the decrease in home heating oil prices as a partial reason for the lack of the expected residential coal shortage. Figures 1, 2, and 3 show Pennsylvania anthracite use during the last 25 years in the sizes most often used in residential coal stoves. Bituminous coal is used in many regions of the country. However, similar data to that shown in Figures 1, 2, and 3 was not available.

Despite some renewed interest in residential coal combustion, from an overall energy standpoint this coal use is still insignificant both in terms of percentage of energy use in the residential sector (less than 1%) and of total coal use (less than 0.3%). For this reason, no special studies aimed directly at residential coal use projections have been completed either by the U.S. DOE or by major coal industry groups. DOE is currently completing a study on expected residential coal use in the 1981-84 period, and a projection of market potential (not actual projected use) until 1995 or 2000. The draft report was due in November, 1982.

Two projections have been completed by DOE, showing fairly different results. The first study, Energy Projections to the Year 2000[6], shows residential coal use at a constant level of 0.1 quads from 1980 to 2000. The basis of the first study is to project the total coal use for all sectors based on the GNP and projected relative energy prices, and then to break it down to residential use based on other demand studies and judgment. Twenty years actual data were used to calibrate this model. The 1981 Annual Report to Congress also includes such factors as improvements in technology, the effect of governmental programs, and equipment price, but starts with 1975 data. Since actual coal use in 1980 was 0.065 quads and this study projects 0.26 quads for 1980, the accuracy of the other years' figures are open to question. The third study, by the Office of Technology Assessment (U.S. Congress) is based on the 1977 Annual Report to Congress by DOE, and is expected to be less accurate than the 1981 Annual Report to Congress simply because the data inputs are older. The three studies are summarized in Table 5.

FIGURE 1

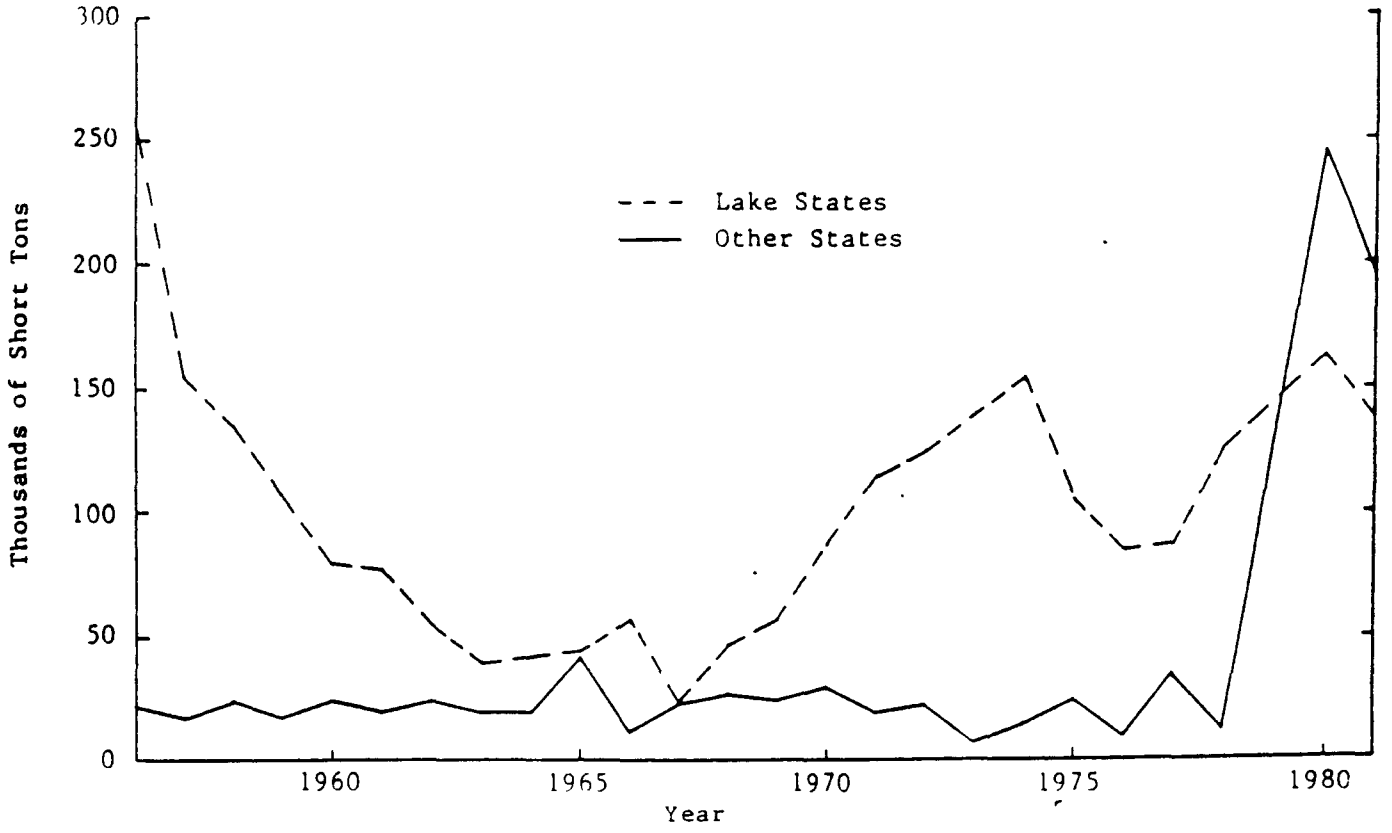
Distribution of Pennsylvania Anthracite, Sizes Pea and Larger,
to the Middle Atlantic States (NJ, NY, PA) and Total United States



From Residential Coal Use, presented by Dr. Jerry Pell, U.S. DOE, at the 1982 International Solid Fuel Trade Show & Conference, Atlantic City, New Jersey, April 6, 1982.

FIGURE 2

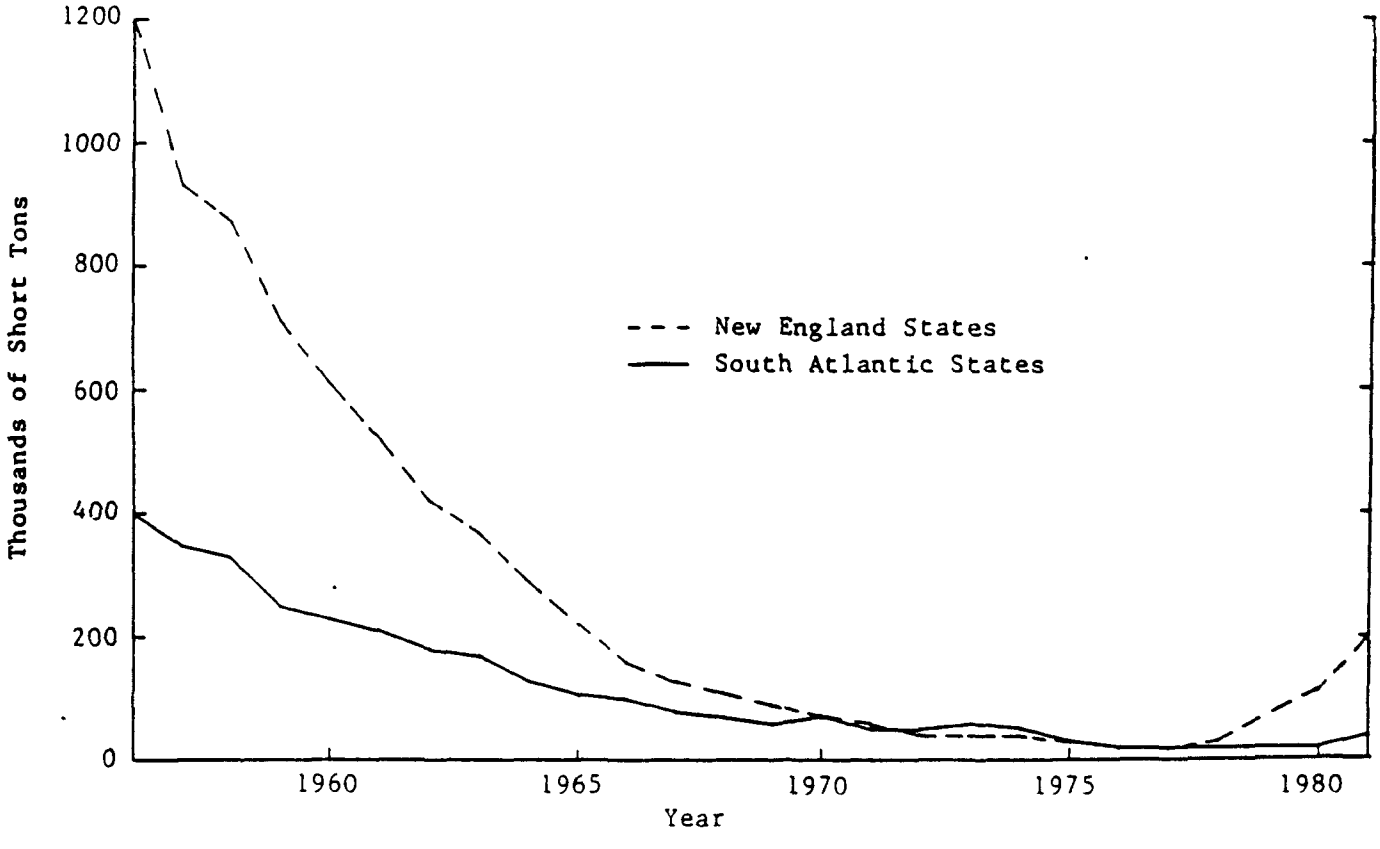
Distribution of Pennsylvania Anthractite, Sizes Pea and Larger, to the Lake States (IL, IN, MI, NM, OH, WI) and to States Other than New England, South Atlantic, Lake , or Middle Atlantic



From Residential Coal Use, presented by Dr. Jerry Pell, U.S. DOE at the 1982 International Solid Fuel Trade Show & Conference, Atlantic City, New Jersey, April 6, 1982.

FIGURE 3

Distribution of Pennsylvania Anthracite, Sizes Pea and Larger,
to the New England States (CT, ME, MA, NH, RI, VT)
and to the South Atlantic States (DE, MD, VA, WV)



From Residential Coal Use, presented by Dr. Jerry Pell, U.S. DOE, at the 1982 International Solid Fuel Trade Show & Conference, Atlantic City, New Jersey, April 6, 1982.

TABLE 5

National Residential Coal Use Projections

Study Title	Sponsoring Agency	Date of Study Publication	Basis for Projection	Fuel Use-Quadrillion BTU/[1]yr					Comments
				1980	1985	1990	1995	2000	
Energy Projections to the Year 2000	DOE - Office of Policy, Planning & Analysis	8/82	Coal use for all users based on GNP and relative energy prices. Breakdown to residential based on other demand studies and judgement	0.1	0.1	0.1	0.1	0.1	Probably most accurate. Model calibrated using 20 years actual fuel use. 1980 fuel use from DOE survey of actual fuel use.
1981 Annual Report to Congress	DOE - Energy Information Administration	2/82	Assumptions on GNP, relative energy prices; improvements in technology, governmental programs, equipment price	0.3	0.3	0.2	0.2	0.2	Uses 1975 as base year; 1980 figure is projected, and is much higher than the 0.065 quads actually burned in 1980.
The Direct Use of Coal: Prospects and Problems of Production and Combustion	Office of Technology Assessment - US Congress	4/79	1977 Annual Report to Congress, DOE	-	0.3[2]	-	-	0.6[2]	Expected to be less reliable than the above studies since it is based on similar but older data.

[1] One quad = 45 million tons coal

[2] Includes commercial use. Energy Projections to the Year 2000 lists commercial use as about equal to residential use.

All three studies are "driven" by expected relative fuel costs. Obviously, a major increase in oil prices or uncertainty about oil supplies could result in a substantial switch to other fuel uses. If demand for coal in the residential sector increased, the delivered price for coal might actually decrease because of reduced transportation costs [11]. Because of the low demand, most residential coal is now bought in small quantities from the smaller mines. It is expected that transportation and handling costs could be reduced if the demand for residential coal increased.

Some factors that could substantially affect the shift to coal from residential space heating are not included in these projections. These include public reluctance to switch to coal, even with a cost advantage, because of perceived safety problems, image problems (dirty and old-fashioned fuel), inconvenience/time required with coal and possible air pollution agency restrictions such as the sulfur content of coal.

No major regional projections were found for residential coal use.

REFERENCES

1. An Assessment of the Forest and Range Land Situation in the United States, U.S. Department of Agriculture - Forest Service, October, 1981.

2. Estimates of U.S. Wood Energy Consumption from 1949 to 1981, U.S. Department of Energy, August, 1982.

3. Wood As A Viable Home Heating Alternative: A National Survey Conducted By the Gallup Organization, Inc., June - July, 1979, Analysis by John Davies and Paul Cohen, Garden Way, Inc.

4. Energy From Biological Processes, Office of Technical Assessment (Congress of the United States), July, 1980.

5. Report on Building a Sustainable Energy Future, Solar Energy Research Institute, 1981.

6. Energy Projections to the Year 2000 - July, 1982 Update, U.S. Department of Energy, Office of Policy, Planning and Analysis, August, 1982.

7. 1981 Annual Report to Congress, U.S. Department of Energy, Energy Information Administration, Volume 3, Supplement 2, Supplement 3, February, 1982.

8. The Dynamics of Residential Wood-Energy Use in New England 1970 - 2000, Norman Marshall, Dartmouth College, October, 1981.

9. The Use of Wood as Fuel: Historical Series and Projections to the Year 2000, Bradburd, Over, Schneider, and Art; Williams College. Contract to U.S. Department of Energy, Office of Energy Use Analysis.

10. Assessment of Proposed Federal Tax Credits for Residential Wood Burning Equipment, Booz, Allen & Hamilton, Inc., contract to U.S. Department of Energy, Office of Building & Community Systems, November, 1979.

11. The Direct Use of Coal: Prospects and Problems of Production and Combustion, Office of Technology Assessment, Congress of the United States, April, 1979.

12. Residential Coal Use, Jerry Pell, U.S. Department of Energy, Division of Coal Utilization Resources Development, at the 1982 International Solid Fuel Trade Show & Conference, Atlantic City, New Jersey, April 6, 1982.

13. Residential Combustion of Coal and Wood: Equipment and Fuel Supply, TRC under contract to U.S. Environmental Protection Agency, August, 1979.

14. Source Assessment: Residential Combustion of Coal, DeAngelis and Rezink, Monsanto Research Corporation for U.S. Environmental Protection Agency, 1979.

PERSONAL CONTACTS

1. Terry Esvelt, Bonneville Power Administration, 10/05/82
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15. -----, Pennsylvania Coal Mining Association, 9/16/82
16. Dane Bickley, *Governor's Energy Council* (Pennsylvania), 9/16/82
17. Dr. Jerry Pell, formerly of U.S. Department of Energy, 9/16/82
18. Howard Feibus, U.S. Department of Energy, 9/20/82
19. -----, Wood Heating Alliance, 9/22/82
20. Mark Bailey, U.S. Department of Agriculture, Economics, Statistics, and Cooperative Service, 9/22/82