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FORESTRY LANDS ALLOCATED FOR MANAGING ENERGY

FEASIBILITY STUDY

JAMES D. LOWTHER PHD
ENERGY RESEARCH BRANCH
DIRECTORATE OF ENVIRONICS

SEPTEMBER 1978

FINAL REPORT FOR PERIOD JUN 1978-AUG 1978

Approved for public release; distribution unlimited

CEEDO

CIVIL AND ENVIRONMENTAL ENGINEERING DEVELOPMENT OFFICE
(AIR FORCE SYSTEMS COMMAND)
TYNDALL AIR FORCE BASE
FLORIDA 32403

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: CEEDO-TR-78-41

2. GOVT ACCESSION NO.

3. RECIPIENT'S CATALOG NUMBER: Final rept.

4. TITLE (and Subtitle): FLAME - FORESTRY LANDS ALLOCATED FOR MANAGING ENERGY. Feasibility Study.

5. TYPE OF REPORT & PERIOD COVERED: June 1978 - August 1978

6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s): James D. Lowther, PhD

8. CONTRACT OR GRANT NUMBER(s): In-House

9. PERFORMING ORGANIZATION NAME AND ADDRESS: Det 1 ADTC/ECW, Tyndall AFB FL 32403

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: 63723F, JON 21038003

11. CONTROLLING OFFICE NAME AND ADDRESS: Det 1 ADTC/ECW, Tyndall AFB FL 32403

12. REPORT DATE: September 1978

13. NUMBER OF PAGES: 27

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)

15. SECURITY CLASS. (of this report): UNCLASSIFIED

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Wood	Timber	Natural Resources
Fuels	Wood Waste	
Waste Energy	Boilers	
Forest	Heating Systems	

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This study evaluated the feasibility of using wood grown on USAF installations as fuel to supply the heating energy requirements of the installations, replacing conventional fossil fuels currently being used. Arnold Engineering Development Center, Tennessee; Barksdale AFB, Lousiana; Eglin AFB, Florida; and Tyndall AFB, Florida have the potential for supplying significant portions of their heating energy requirements with non-merchantable timber grown on the installations. Avon Park Air Force Range, Florida has the potential to supply its own small heating energy requirements plus those of MacDill AFB, which is

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75 miles away.

Arnold Engineering Development Center presently has a central plant heating system. The system can be converted to a wood-burning system by altering existing boilers or replacing them with boilers having wood-firing capability. The remaining installations do not have central plant heating systems, but use small natural gas and oil-fired heating units in individual buildings. Conversion of these installations to burn wood would require construction of a wood-fired central system or systems. An alternate method of converting these installations is through the use of a pyrolysis unit to convert wood to fuel gas and fuel oil which can be burned in existing heating units. The latter alternative cannot be implemented until a large scale, continuously operated pyrolysis unit is developed.

PREFACE

This report was prepared by James D. Lowther, PhD. The study was conducted at the Civil and Environmental Engineering Development Office (CEEDO) by Dr Lowther as part of the 1978 USAF-ASEE Summer Faculty Research Program which was sponsored by the Air Force Office of Scientific Research. The CEEDO research colleague for the study was Capt William A. Tolbert.

This report has been reviewed by the Information Office (OI) and is releasable to the National Technical Information Service (NTIS). At NTIS it will be available to the general public, including foreign nations.

This report has been reviewed and is approved for publication.

WILLIAM A. TOLBERT, Capt., USAF
Chief, Energy Research Branch

EMIL C. FREIN, Maj, USAF
Chief, Envmtl Engrg & Energy Research Division

PETER A. CROWLEY, Maj, USAF, BSC
Director of Environics

JOSEPH S. PIZZUTO, Col, USAF, BSC
Commander

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TABLE OF CONTENTS

Section	Title	Page
I	INTRODUCTION	1
II	OBJECTIVE	2
III	WOOD RESOURCES	3
IV	ENERGY REQUIREMENTS	7
V	EXISTING HEATING SYSTEMS	10
VI	UTILIZATION OF WOOD FUEL	13
VII	COMPARATIVE FUEL COSTS	15
VIII	CONCLUSIONS	17
APPENDIX A	USAF Installations	18
APPENDIX B	Fossil Fuel Consumption	19
References		21

LIST OF TABLES

Table	Title	Page
1	Six Largest USAF Forest Areas	3
2	Anticipated Annual Timber Sales	7
3	Heating Energy Available from Wood	8
4	Comparison of Annual Heating Energy Available from Wood with FY77 Heating Energy Requirements (Efficiency Corrected)	9
5	FY77 Fuel Prices and Equivalent Cost of Wood and Coal	15

SECTION I

INTRODUCTION

Shortages, curtailments, and increasing costs of natural gas and fuel oil used to supply energy for comfort heating and heating of industrial and test facilities at USAF installations are well known. Predictions indicate that these conditions will become even more critical in the future as national energy requirements increase and fossil fuel supplies are depleted. In addition, the risks associated with dependence on foreign oil supplies are apparent. In order to prevent jeopardizing the missions at these USAF installations, alternate fuels to replace natural gas and fuel oil must be developed.

Some USAF installations have large forested areas. For these installations, wood can be considered as an alternate to natural gas and fuel oil presently being used as heating fuel. In addition to the obvious advantage of availability in close proximity to the point of use, the wood represents a dependable supply that is not subject to the curtailments and shortages associated with oil and gas. Equally as important, wood represents a renewable energy resource rather than a depletable energy resource. Wood is clean burning with low sulfur content and low ash content compared to coal. In fact, wood can be burned in combination with high sulfur coal in order to reduce emissions to an acceptable level. In some cases the cost of wood fuel is lower than that of other fuels.

Wood fuel is not without its disadvantages, however. Wood is bulky and requires complex handling and storage facilities compared to oil and gas. The handling and storage facilities required for wood are very similar to those required for coal. Wood has a low heating value compared to fossil fuels. The burning efficiency of wood is lower than that of conventional fossil fuels, primarily due to the high moisture content of most wood fuel. The cost of wood as a fuel is influenced by the fact that there are competing uses for wood. Poles, posts, sawtimber, pulpwood and stumpwood represent high value wood products presently harvested from USAF forest lands. Finally, conversion of existing heating systems from natural gas and fuel oil to wood can require large capital investments.

SECTION II

OBJECTIVE

The objective of this study is to evaluate the feasibility of using trees grown on USAF installations as fuel to supply heating energy for the installations in the event of a severe shortage or cutback of oil and gas fuels. The study will include an evaluation of the modifications to installation heating plants that are necessary to allow for a change to wood fuel.

SECTION III

WOOD RESOURCES

A survey of USAF installations indicates that 31 installations have a total of approximately 581,980 acres of timber lands managed under forestry management programs as shown in Appendix A (1)*. Of these 581,980 acres, 94 percent of the forest lands is on six installations as shown in Table 1. The remaining 25 installations have forested areas ranging from 60 to 6000 acres. Since these installations contain almost all the USAF forest resources, the remainder of this report will be confined to an examination of these six installations. Note that five of the six bases are located in the southeastern United States.

TABLE 1. SIX LARGEST USAF FOREST AREAS

Base and State	Approximate Forest Acreage
Eglin AFB, Florida (EAFB)	400,000
Avon Park Range, Florida (APAFR)	60,000
Arnold Engineering Dev Center, Tennessee (AEDC)	31,000
Tyndall AFB, Florida (TAFB)	26,000
Barksdale AFB, Louisiana (BAFB)	17,000
U.S. Air Force Academy, Colorado (USAFA)	14,000
	548,000
All Other	33,980
Total	581,980

AVAILABLE FORMS

For the purpose of this study, the available forms of wood fuel can be classified as merchantable, non-merchantable, and fuel trees.

Merchantable

Forest products currently being harvested and sold from the six bases are poles, posts, sawtimber (for manufacture of lumber), pulpwood, stumpwood (for distillate wood) and firewood.

* Numbers in parentheses refer to entries in the List of Reference

The Air Force Forestry Management Program operates under the Reimbursable Forestry Program as set forth in Public Law 86-601, Section 511 of 1960 (see AFM 126-1). This law provides that annual operating costs for forestry management operations such as reforestation, fire protection, and timber stand improvement for the entire USAF program cannot exceed the total annual receipts from forest sales from USAF lands.

Non-Merchantable

One form of non-merchantable timber is the residue from the harvesting of merchantable timber. This residue consists of tops, branches, foliage, stumps, and roots. Tops and branches are sometimes chipped up and sold. Some residue must be left in the woods to maintain soil quality and wildlife habitat. However, excess residue left on USAF forest lands is currently being burned as a forestry management practice to reduce the danger of forest fires. Another form of non-merchantable timber consists of trees killed by natural causes and trees of poor form or of a specie that is undesirable commercially (culls). An example of a cull specie is a hardwood in a southern pine forest. Barksdale AFB is currently paying $30.00 per acre to have cull species in their pine forests killed as a part of their timber stand improvement program. A third category of non-merchantable timber consists of saplings, seedlings and understory vegetation which must be cleared out periodically for timber stand improvement, fire protection and wildlife management purposes. Prescribed burning is frequently employed to clear out this type of vegetation.

Manufacturing wastes such as bark, sawdust, shavings, end trims, slabs and edgings represent another non-merchantable source of wood fuel. The wood manufacturing industry has used their wood wastes as fuel for decades and is moving toward energy self-sufficiency through the use of their wood wastes (2,3). For this reason, manufacturing wastes will not be available as a fuel source outside the industry in future years. Urban wood wastes are best considered as a component of potential fuel derived from solid wastes.

Fuel Trees

Fuel trees are fast growing species grown on "biomass farms" or "energy plantations" specifically for the purpose of providing fuel. Research indicates that fuel tree farms may be feasible (4,5), but not as economical as using non-merchantable wood that results from the managed production of merchantable forest products (2,3).

HEATING ENERGY AVAILABLE

Anticipated average annual sales of merchantable timber from the six installations are shown in Table 2. Under present economic conditions these products are much more valuable as materials than they would be as fuel. The production and manufacture of products from wood is much less energy-intensive than the production and manufacture of alternate products from other materials (3). This means that this merchantable wood sold from USAF bases contributes much more to the national economy and energy supply in the form of raw material for wood products than as fuel. Decreasing supplies and increasing costs of fossil fuels in the future will cause the growing of merchantable timber to continue to be a high-priority objective of USAF forest management plans. This fact, coupled with the dwindling supply of manufacturing wood wastes available outside the industry and the lower economic incentive for growing fuel trees, leads to the conclusion that the best source of wood fuel on the six installations is harvesting residues, culls, saplings and seedlings from forest lands managed to optimize the production of merchantable timber. The use of the harvesting residues, culls, saplings and seedlings for fuel is compatible with good forest management practices for timber stand improvement, fire prevention, wildlife protection and environmental protection.

Table 3 shows the heating energy estimated to be available on a continuous basis from wood grown on each of the six installations. The timber sold by the Air Force Academy is pine firewood cut primarily for insect, disease and parasitic plant control. The base forester recommends leaving the residue on the ground to aid in regeneration of the forest. Thus, the only fuel wood assumed to be available at the Air Force Academy is that presently sold for firewood.

For the five installations other than the Air Force Academy the heating energy available from harvesting residue was calculated based on the anticipated annual timber sales shown in Table 2. The harvesting residue includes tops, branches, foliage, stumps, roots and all bark except the main stem bark. The mass of residue resulting from the harvest of a certain mass of merchantable timber (main stem) was estimated using information contained in Reference 6.

Heating energy available annually from culls, saplings, and seedings was more difficult to estimate because information on the growth rates of this type of wood is not available. Historically, forest inventories have included only merchantable timber. However, inventories of cull hardwoods in representative southern pine forests were made in 1968 and 1977 (8,14). The inventories show an increase of 25 billion cubic feet of cull hardwoods on 80 million acres of southern pine forests over the nine-year period or an average growth rate of 35 cubic feet per acre per year. This volume represents main stem wood only and excludes branches, tops, foliage, stumps and roots. This estimate of the growth rate of cull hardwoods will, therefore, be very conservative. Use of such a conservative estimate will compensate for such factors as unfavorable climate, poor soil fertility and terrain poorly suited for harvesting at some locations. If the dry weight of the wood is taken to be 32.8 pounds per cubic foot (6), then the average southern pine forest produces approximately 1140 pounds of dry wood per acre per year. It is interesting to note that an independent estimate of cull hardwood growth in the pine forest at Barksdale AFB, made by the base forester, is 0.5 cords per acre per year. This quantity is equivalent to 1250 pounds per acre per year if the green wood weighs 5000 pounds per cord and has a 50 percent moisture content.

Based on a higher heating value of 8600 BTU per pound of dry wood and a boiler efficiency of 67 percent, cull hardwoods in southern pine forests are conservatively estimated to produce 6.6 million BTU of heating energy per acre per year. The values shown in Table 3 are based on 6.6 million BTU per acre per year.

SECTION IV

ENERGY REQUIREMENTS

Consumption of fossil fuel for heating purposes on each of the six installations was determined for FY77 and is shown in detail in Appendix B. It should be noted that all bases having fuel oil standby capability burned fuel oil rather than natural gas during January, February and March of 1977 in order to help alleviate a severe national natural gas shortage. Because Avon Park Air Force Range has limited heating energy requirements, the heating energy requirements of MacDill AFB, which is 75 miles away, were included with those of Avon Park.

TABLE 2. ANTICIPATED ANNUAL TIMBER SALES

Installation	Quantity	Products
AEDC	34,500 Tons	Pine and Hardwood Pulpwood Hardwood Sawtimber
APAFR	25,000 Tons	Pine Pulpwood
BAFB	10^6 Board Feet (International)	Pine Sawtimber
EAFB	100,600 Tons	Pine Posts, Poles, Pilings Sawtimber, Pulpwood
	10,000 Tons	Pine Stumps
TAFB	13,500 Tons	Pine Pulpwood
USAFA	245 Cords	Pine Firewood

Source: Base Foresters

TABLE 3. HEATING ENERGY AVAILABLE FROM WOOD EFFICIENCY CORRECTED[1]

Billions of BTU per Year

Installation	Merchantable Timber	Harvesting Residue[2]	Culls, Saplings, Etc[3]	Total
AEDC		123	185	308
APAFR			205	205
BAFB		30	112	142
EAFB		282	2,640	2,922
TAFB		42	172	214
USAFA	0.4			0.4

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[1] Based on:

- 50% moisture content, green-basis (3)
- 5000 lb/cord density, green (7)
- 67% boiler efficiency (7)
- 8600 BTU/lb higher heating value, oven-dry wood (6)

[2] Tops, branches, foliage and bark on tops, branches and foliage is considered to be 35.5% of main stem mass (excluding bark) for softwoods and 47.5% for hardwoods. Stumps, roots, and bark on stumps and roots are considered to be 23% of the main stem mass (excluding bark) for both hardwoods and softwoods (6).

[3] Based on average southern area growth rate of 1140 pounds of dry wood per acre per year (main stem only).

Table 4 shows a comparison of the annual heating energy available from wood with FY77 heating energy requirements. The quantities in Table 4 reflect the typical burning efficiencies of the wood, natural gas, fuel oil and propane. Table 4 shows that all of the six bases except the Air Force Academy have the potential to supply a significant portion of their heating energy requirements with wood grown on the installation. It should be noted that the quantities shown in Table 4 represent wood burning potential only. The wood energy availability must be verified by in-depth studies of cull growth rates, etc. In addition, the economic feasibility of harvesting and transporting the fuel wood and converting existing heating systems to burn wood must be considered.

TABLE 4. COMPARISON OF ANNUAL HEATING ENERGY AVAILABLE FROM WOOD WITH FY77 HEATING ENERGY REQUIREMENTS (EFFICIENCY CORRECTED)

Installation	Wood Energy Available[1] Billions of BTU	Heating Energy Requirements[2] Billions of BTU	Percentage of Requirements Available From Wood
AEDC	308	621	50
APAFR + MAFB	205	167	123
BAFB	142	332	43
EAFB	2,922	607	481
TAFB	214	178	120
USAFA	0.4	822	0.05

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[1] See Table 3.

[2] Based on consumption listed in Appendix B and the following burning efficiencies (7):

Natural Gas	77.8%
Fuel Oil	82.5%
Propane	78.7%

SECTION V

EXISTING HEATING SYSTEMS

Descriptions of the heating systems at the six bases were obtained from the TAB A-1 Environmental Narrative, Phase II for each base and through conversations with base Civil Engineering personnel. A brief description of the heating system at each base follows.

ARNOLD ENGINEERING DEVELOPMENT CENTER

Arnold Engineering Development Center has a central heating plant that supplies steam for comfort heating plus steam for some of the test facility heaters. In addition, natural gas and propane are burned directly in some of the test facility heaters. Plant A consists of three boilers with a capacity of 60,000 lb/hr each of 200 psig saturated steam and one boiler that supplies 20,000 lb/hr of 200 psig saturated steam. Input capacity of these boilers are 70 million BTUH each and 23.5 million BTUH, respectively. Plant A, installed in 1951, was coal fired until 1971 when the boilers were converted to natural gas and fuel oil. The larger boilers were pulverized coal fired and the smaller boiler was stoker fed. Much of the coal and ash handling equipment is still installed, however, the pulverizer units are not in salvageable condition.

Plant B, installed in 1965, supplies 42,000 lb/hr of 725 psig saturated steam for the test facilities and runs only when needed. This boiler is a natural gas and fuel oil-fired package boiler with a 65.6 million BTUH heat input. In addition to the steam system, direct-fired natural gas and propane heaters with a total input capacity of 800 million BTU are used as needed in the test facility. Family housing is heated by individual electric resistance heaters. A FY79 MCP proposes adding to Plant A a new boiler supplying 80,000 lb/hr of 200 psig saturated steam and fired by coal and refuse-derived fuel (9). The estimated total cost in FY79 dollars is $3.04 million. Clearly, wood should be one of the fuels burned by this new boiler.

AVON PARK AIR FORCE RANGE

No TAB A-1 is available for Avon Park Air Force Range. Discussions with the Base Civil Engineer indicate that there is no central heating plant at Avon Park. Older buildings are heated by propane-fired space heaters. Two buildings utilize oil-fired hot water-type heating systems. The newer buildings are heated electrically. The small size of the facilities coupled with the mild winter climate make heating energy requirements at Avon Park quite small.

MACDILL AFB

MacDill AFB is located 75 miles west of Avon Park and has primary responsibility for operation of the range. MacDill AFB is the closest USAF installation to Avon Park and, therefore, the installation that could best make use of wood fuel grown at Avon Park.

MacDill AFB has no central heating plant. The base hospital is heated with three oil-fired boilers having a total input capacity of 18 million BTUH. Sixty-five natural gas-fired boilers ranging in size from 195,000 to 8,375,000 BTUH supply individual buildings with steam or hot water. Thirty-three oil-fired heating systems, ranging in size from 190,000 to 980,000 BTUH supply steam or hot water for individual buildings. Family housing units are heated by 706 individual natural gas-fired furnaces of 80,000 BTUH each.

BARKSDALE AFB

Barksdale AFB has no central heating plant. One small central system provides heating for four buildings. All other buildings are heated with individual gas-fired units. The EPA Air Pollution Emissions Report contained in the Barksdale AFB TAB A-1 lists 2460 individual combustion sources on the base.

EGLIN AFB

No TAB A-1 is available for Eglin AFB. Eglin AFB has no central heating plant. Most buildings utilize individual natural gas-fired heating systems. Some buildings use fuel oil and LPG-fired units. In order to provide a short-term solution to the problem of natural gas curtailments, heating units in 17 buildings have been converted to burn fuel oil as well as natural gas. All of these units have a capacity greater than 100 boiler horsepower. Units in an additional 35 buildings are scheduled for conversion to natural gas/fuel oil firing.

As a long-term solution to natural gas shortages, plans are being made to install six central plants to supply steam and hot water for heating and absorption cooling. One plant would be fueled with refuse and wood, three with wood and two with coal. Estimated annual consumptions of wood and coal are 61,500 tons and 116,600 respectively. The 2,922 billion BTU of wood energy potentially available annually as shown in Table 3 represents approximately 254,000 dry tons of wood. Eglin AFB has the potential to supply much more of its heating and cooling energy needs from wood fuel than is currently planned.

TYNDALL AFB

Tyndall AFB has no central heating plant. Buildings are heated with individual natural gas-fired units. Three of the larger buildings have fuel oil standby firing capability.

U. S. AIR FORCE ACADEMY

The Air Force Academy has two natural gas/fuel oil-fired central heating plants that provide the bulk of the heating energy for the installation. Family housing and some outlying buildings are heated with individual gas-fired units. A FY80 MCP proposes to convert the two existing central plants to a single coal-fired central plant.

SECTION VI

UTILIZATION OF WOOD FUEL

In a typical harvesting operation, residue from merchantable timber, cull trees, etc., would be chipped in the woods with a mechanical chipper and blown into a chip van. The chip van would then be transported by road to the central heating plant where the chips would be unloaded into storage silos, bins, or a storage pad, either covered or uncovered.

The wood may be burned directly in a central plant to produce steam or hot water for heating or converted to alternate forms of fuel such as fuel gas, fuel oil and charcoal in a process such as pyrolysis. Direct burning is adaptable to an installation having an existing central heating plant by converting the boiler to wood-firing or replacing the boiler with a wood-fired boiler. Existing distribution and return lines, and heat exchangers in buildings served by the existing central plant could be used without alteration. The conversion of an installation having an existing central heating plant is, therefore, attractive from the standpoint of the low capital investment required for conversion.

Conversion of an installation not having an existing central heat plant would require either constructing a wood-fired central heating system or systems to serve the heating needs of the installation or constructing a plant such as a pyrolysis plant to convert the wood to fuel gas and/or fuel oil that could be used to fire existing heating systems. A pyrolysis unit would require minimum changes to existing heating units on an installation having small natural gas or fuel oil-fired heating units in individual buildings. Converting such an installation to a wood-fired central plant system would require not only the construction of a central wood-fired boiler but the construction of steam or hot water distribution and condensate return lines from the central plant to individual buildings, and the replacement of the existing furnaces and small boilers in individual buildings with heat exchangers that could utilize the steam or hot water from the central plant.

DIRECT FIRING

Wood-fired boilers may be of the spreader-stoker type, cyclone type or fluidized bed type. Spreader-stoker type boilers require the least fuel preparation while cyclone type boilers require elaborate fuel preparation facilities. More than 200 wood-fired boilers have been constructed in the United States during the last decade (10). Installation of wood-fired boilers would require no technology not already available. For those installations where all of the heating energy requirements cannot be supplied with wood, consideration should be given to burning wood in combination with coal, refuse-derived fuel and sewage sludge. A mixture of high sulfur coal and wood provides a fuel that can meet EPA requirements for sulfur dioxide emissions.

PYROLYSIS

A number of processes have been developed that use pyrolysis to convert wood to fuels such as gas, oil and charcoal (11). The advantage of such a conversion process is that the fuel gas and fuel oil could replace natural gas and fuel oil used to fuel existing heating systems. Since the four installations that do not have central heating plants have a large number of small natural gas-fired heating units and a number of small oil-fired heating units, a pyrolytic conversion unit is an extremely attractive possibility for utilizing wood as a fuel without the high capital costs required to construct a wood-fired central plant. The major disadvantage of the pyrolytic fuel gas is its lower heating value - typically 200 BTU/cu. ft. compared to 1000 BTU/cu. ft. for natural gas. The higher heating value of pyrolytic fuel oil is approximately 66 percent that of No. 2 Fuel Oil. Some of the pyrolytic fuel oil is highly corrosive to mild steel, a characteristic that could pose problems in using the oil in existing systems.

A commerical prototype pyrolysis plant designed to process 50 dry tons/day of lumber mill wastes was installed in a small lumber mill in Cordele, Georgia in 1973 (12,13). The Cordele plant was operated on a 24-hours-per-day basis for a period of eighteen months, producing gas, oil and charcoal. Technology for the pyrolytic process has not yet reached the state that would allow the construction of a large scale, continuously operating pyrolytic conversion unit for use at a USAF installation.

SECTION VII

COMPARATIVE FUEL COSTS

Table 5 shows average unit fuel prices paid by the five installations in FY77. Also shown in Table 5 are the equivalent costs of wood (50 percent moisture content, green basis) and bituminous coal. For example, at AEDC the average cost of fuel oil in FY77 was $.39/gal. Fuel oil at $.39/gal, wood at $19.36/ton and bituminous coal at $77.42/ton all have the same cost per BTU of heat added to heating steam, water or heated air. Wood at less than $19.36/ton or coal at less than $77.42/ton would be more economical than fuel oil at $.39/gal.

TABLE 5. FY77 FUEL PRICES AND EQUIVALENT COST OF WOOD AND COAL

Installation	Natural Gas $/MCF	No. 2 Fuel Oil $/gal	Propane $/gal
AEDC	1.75 (12.91) [51.62]	.39 (19.36) [77.42]	.33 (26.87) [107.47]
BAFB	1.15 (8.48) [33.92]	.0	
EAFB	1.55 (11.43) [45.72]	.35 (17.37) [69.48]	.32 (26.05) [104.21]
TAFB	1.55 (11.43) [45.72]	.40 (19.86) [79.41]	
APAFR & MAFB	1.62 (11.95) [47.79]	.37 (18.37) [73.45]	

( ) = Equivalent Cost of Wood, $/ton (50 percent moisture content, green basis)

[ ] = Equivalent Cost of Bituminous Coal, $/ton

A 1976 test by Weyerhauser Company on hardwoods in pine forests in North Carolina showed that the average cost of harvesting, chipping and delivering hardwood chips was $11.00 to $12.50 per ton (50 percent moisture content, green basis) for trees 5 - 8 inches DBH (diameter breast height) and $9.50 - $10.00/ton for trees 9 - 24+ inches DBH (2). Weyerhauser projected that improvements in harvesting technology would reduce these costs to $9.00/ton for trees 5 - 24+ inches DBH by 1978 and $8.00/ton for trees 5 - 24 inches DBH by 1981. These costs do not include any costs associated with converting heating plants to wood fuel or operating chip storage and handling facilities at the heating plant.

Reference to Table 5 shows that wood fuel would be competitive in cost to the fuel oil burned at the five installations. Most of the fuel oil is burned during periods of natural gas curtailment. As natural gas prices rise wood fuel harvesting and delivery prices are expected to be competitive with natural gas prices.

SECTION VIII

CONCLUSIONS

Preliminary information indicates that Arnold Engineering Development Center, Barksdale AFB, Eglin AFB, and Tyndall AFB have the potential for supplying a significant portion of their heating energy needs from non-merchantable wood grown on the installation. Avon Park Air Force Range has the potential for supplying all of its own heating energy needs plus those of MacDill AFB. The harvesting of wood for fuel would be consistent with forestry management practices designed to optimize the production of merchantable timber, improve wildlife habitats and protect the environment.

Of the above installations, only Arnold Engineering Development Center has an existing central plant heating system which could be adapted to burn wood fuel by installing a boiler with wood-firing capability. The installations not having central heating systems can be converted to burn wood by either installing a central heating plant system using wood-fired boilers or by installing a pyrolysis system to convert wood to fuel gas and fuel oil that can be burned in existing heating systems. Further research is required to establish the technical feasibility of the pyrolysis system.

Although waste wood from wood products industries near USAF installations is currently available, the supply of manufacturing wastes available for purchase will decrease as the wood products industry supplies more and more of their energy needs by burning their own waste wood. For this reason, USAF installations cannot depend on manufacturing wastes as a source of wood energy. Cull trees from non-USAF forest lands near USAF installations may be a source of wood fuel for these installations.

APPENDIX A

U. S. AIR FORCE INSTALLATIONS WITH FORESTRY MANAGEMENT PROGRAMS (1)

Base and State	Approximate Forest Acreage
Arnold Engrg Development Ctr, TN	31,000
Avon Park Air Force Range, FL	60,000
Barksdale AFB, LA	17,000
Charleston AFB, SC	300
Columbus AFB, MS	1,000
Dobbins AFB, GA	900
Eglin AFB, FL	400,000
England AFB, LA (Claiborne Range)	780
Griffiss AFB, NY	600
K. I. Sawyer AFB, MI	2,000
Langley AFB, VA	100
Little Rock AFB, AR	3,000
Loring AFB, ME	6,000
McChord AFB, WA	1,000
MacDill AFB, FL	800
McEntire ANGB, SC	1,200
Moody AFB, GA	600
Myrtle Beach AFB, SC	1,800
New Hampshire Satellite Tracking Sta., NH	2,800
Pease AFB, NH	2,400
Plattsburgh AFB, NY	780
Robins AFB, GA	2,300
Rickenbacker AFB, OH	60
Scott AFB, IL	600
Shaw AFB, SC	1,700
Tyndall AFB, FL	26,000
U.S. Air Force Academy, CO	14,000
Vandenberg AFB, CA	2,500
Wright-Patterson AFB, OH	300
Wurtsmith AFB, MI	200
Youngstown Municipal Airport, OH	260

APPENDIX B

FOSSIL FUEL CONSUMPTION FOR HEATING
FY77

Installation	Use	Fuel[1]	Quantity	Energy Content, MMBTU[2]	Cost $
AEDC	Central Heating Plants	NG	371,406 MCF[3]	382,548	649,960
	Central Heating Plants	FO	1,875,513 gal	253,194	731,450
	Test Facility Fired Heaters	NG	139,170 MCF	143,345	243,548
	Test Facility Fired Heaters	LPG	40,911 gal	3,743	13,484
				782,830	1,638,422
APAFR + MAFB		NG	119,361 MCF	122,942	193,678
		FO	617,845 gal	85,689	228,140
		LPG	3,942 gal	367	1,258
				208,998	423,076
BAFB		NG	407,929 MCF	427,102	467,629
EAFB	Family Housing	NG	221,000 MCF	221,000	
		NG	475,750 MCF	475,750	
			696,750	696,750	1,079,519
		FO	513,714 gal	71,920	187,779
		LPG	70,860 gal	6,590	22,616
				775,260	1,280,914

(continued)

APPENDIX B

FOSSIL FUEL CONSUMPTION FOR HEATING (continued)
FY77

Installation	Use	Fuel[1]	Quantity	Energy Content, MMBTU[2]	Cost $
TAFB	Family Housing	NG	55,605 MCF	57,940	90,109
		NG	159,200 MCF	165,886	242,781
		FO	35,346 gal	4,902	14,290
				228,728	347,180
USAFA	Central Heating Plants	NG	646,578 MCF	662,655	889,045
	Central Heating Plants	FO	1,028,000 gal	153,840	362,335
	Family Housing, *Misc. Bldgs.*	NG	281,033 MCF	270,635	424,641
				1,047,130	1,676,021

1 Fuel: NG = Natural Gas, FO = Fuel Oil, LPG = Propane

2 Energy content based on higher heating value of fuel:
MMBTU = millions of BTU

3 MCF = thousands of cubic feet

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