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BIOMASS ENERGY IN CANADA ITS POTENTIAL CONTRIBUTION TO FUTURE ENERGY SUPPLY

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SUMMARY

Canada has entered an age where all opportunities to reduce the reliance on imported sources of energy, most notably oil, must be actively pursued. In addition to ensuring that future energy demand is reduced as much as is practically possible through energy conservation, technologies to convert new sources of energy will be required to supplement the conventional energy sources of oil, and to a lesser extent, natural gas. These new sources include oil sands, heavy oil, solar, wind, as well as biomass. This report discusses the opportunities presented by biomass.

Although biomass accounted for virtually all the energy used in Canada a century ago, its current contribution is only 4.1% of total primary energy demand; over 95% of this current use results from the on-site conversion of waste produced by the forest products industry.

Canada is particularly fortunate when biomass is considered as a form of energy, as its biomass resource inventory is the third largest in the world.

Table 1 is a summary of the amounts of the prinicpal types of biomass that are estimated to exist (or in the case of energy plantations, could potentially exist) in Canada. Municipal solid waste, although included in this table, is not a form of primary biomass and has characteristics associated with social and industrial activity which require its continual use or disposal with very little potential for storage. Fuel grade peat covers extensive areas of Canada, as much as 25% of the land mass. The 0.1% of the land mass that has been inventoried contains an energy supply potential of 4480 PJ*. It should, however, be noted that this source is not renewable; like fossil fuels, it is only available once and therefore is not included in the table.

The amount of this resource that could be expected to be available at any one time will, of course, depend on the price that is paid for its recovery. Figure 1 is an estimate of the current availability of the major types of biomass at costs between $10 and $50/t.**

*These and other abbreviations are defined in Appendix C.

**All references to t(tonne) are in oven dry tonnes, unless otherwise specified.

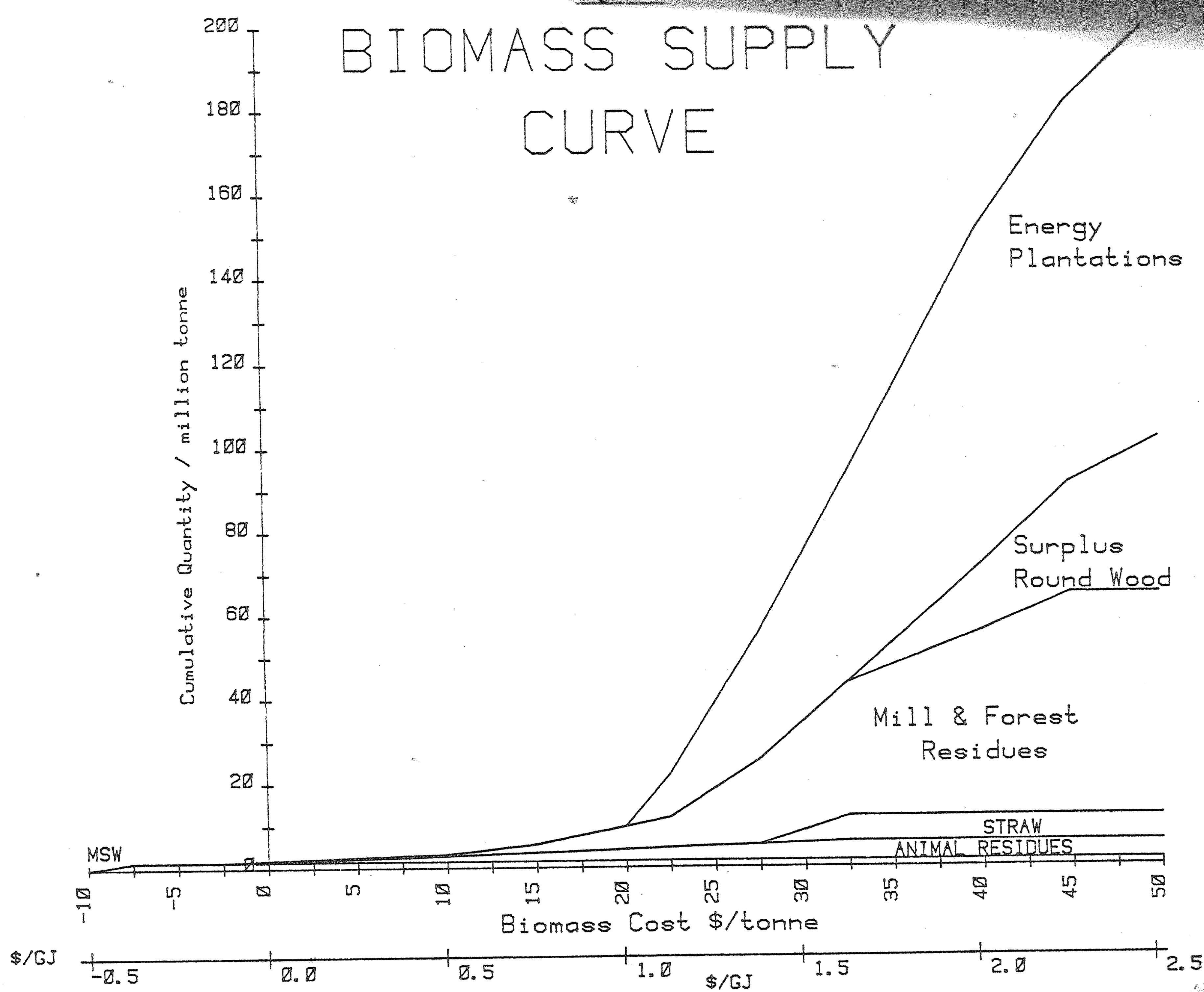
TABLE 1

SUMMARY OF ADDITIONAL ENERGY CONTRIBUTION
POTENTIALLY AVAILABLE FROM
VARIOUS BIOMASS SOURCES

Source	Amount Available (Mt/y.)	Energy Content (PJ/y.)	Percent of Total 1978 Fossil Fuel Energy Requirements
Pulp & Paper Mills	0.5	8	0.2
Lumber ** and Plywood Mills (excluding Chips & Cores)	7.2	144	3.0
Straw	15	219	4.6
Animal Manure	10	221	4.6
Municipal Solid Waste	9.3	103	2.1
Farm Woodlots	3.2	64	1.3
Logging Residues	50.4	1,008	21.0
Degraded & Deserted Forest	*	*	*
Surplus Merchantable Wood (Economical & Accessible)	19.3	386	8.0
Energy Plantations	310	6,200	129.0
	424.9	8,353	173.8

*No estimate available

**Lumber mills include both sawmills and planing mills


BIOMASS SUPPLY CURVE
Energy Plantations
Surplus Round Wood
Mill & Forest Residues
STRAW
ANIMAL RESIDUES
MSW
Cumulative Quantity / million tonne
200
180
160
140
120
100
80
60
40
20
0
-10
-5
0
5
10
15
20
25
30
35
40
45
50
Biomass Cost $/tonne
$/GJ
-0.5
0.0
0.5
1.0
1.5
2.0
2.5
$/GJ

There are a variety of technologies in various stages of development that convert biomass to energy. Figure 2 is a simplified illustration of the major technologies that can be used to convert the five major types and sources of biomass (forest, agriculture crop, animal, aquatic, and municipal solid waste) into nine different forms of fuel or energy. Four of these fuels are liquid (ethanol, methanol, liquid hydrocarbons and pyrolytic oils), three are gaseous (methane/CO_2, methane and synthetic gas), one is solid (charcoal). The remaining form of energy is heat.

Figure 3 illustrates the various conversion technologies that can be used to convert the major types and sources of biomass into a variety of forms of energy or fuel. Each is briefly described below:

- Combustion - The process represents the burning of organic material to produce heat.

- Acid Hydrolysis - This process converts cellulosic material, usually wood or straw, into sugars through the application of an acid.

- Enzymatic Hydrolysis - This process also converts any cellulosic material into sugars through the action of special enzymes.

- Fermentation - The production of alcohol from sugar or starch through fermentation dates to antiquity.

- Destructive Distillation - This process, which converts wood into charcoal, can be traced back to antiquity and still provides the principal cooking fuel in many countries. Although methanol, a byproduct of charcoal production, was originally produced entirely from this process, it is now made exclusively from synthesis gas.

- Anaerobic Digestion - Certain bacteria, in the absence of oxygen, convert slurried organic material into a combustible gas containing 70% methane.

FIGURE 2

TECHNOLOGIES FOR THE CONVERSION OF RENEWABLE BIOMASS TO ALTERNATIVE ENERGY FORMS

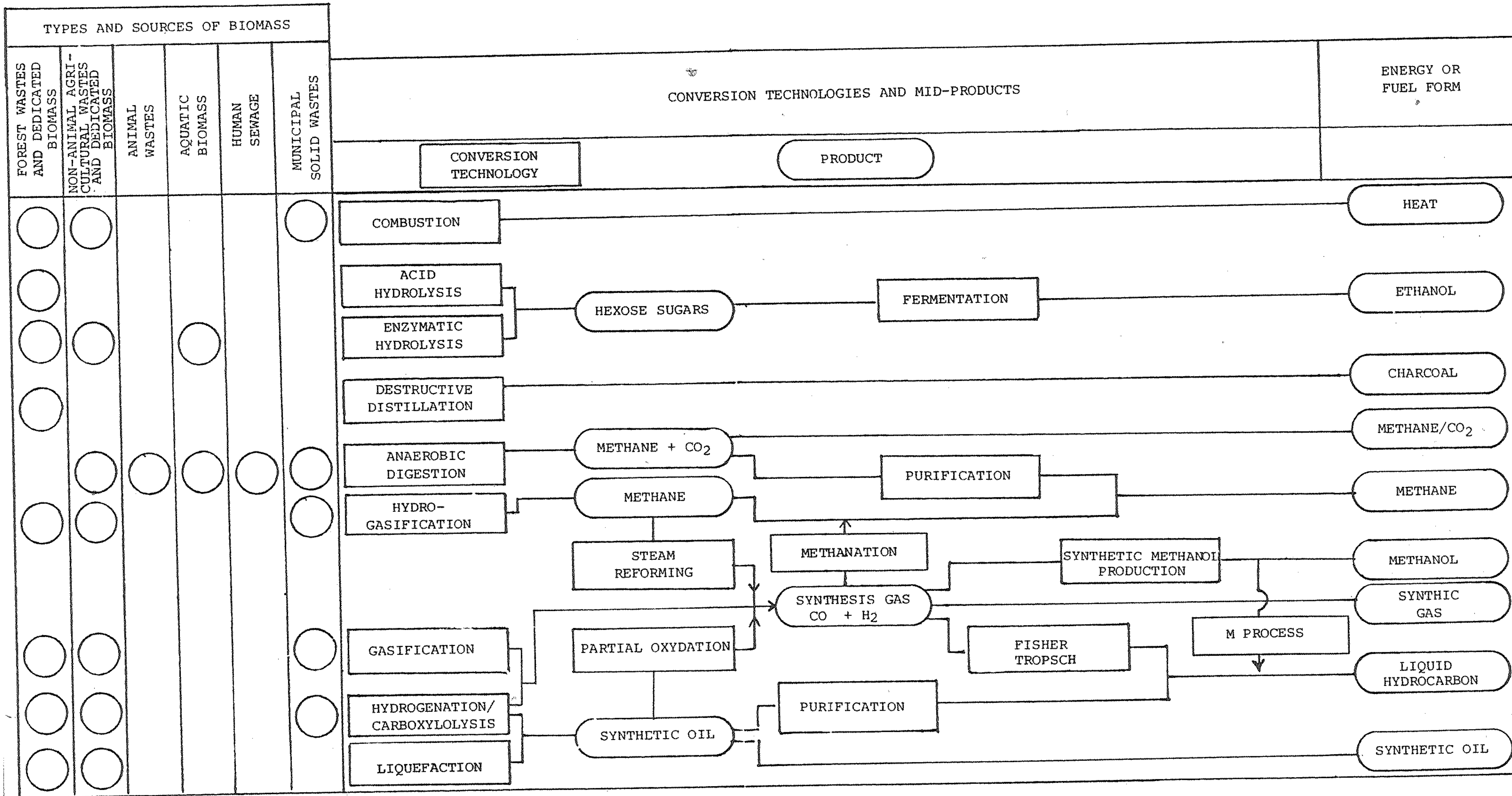
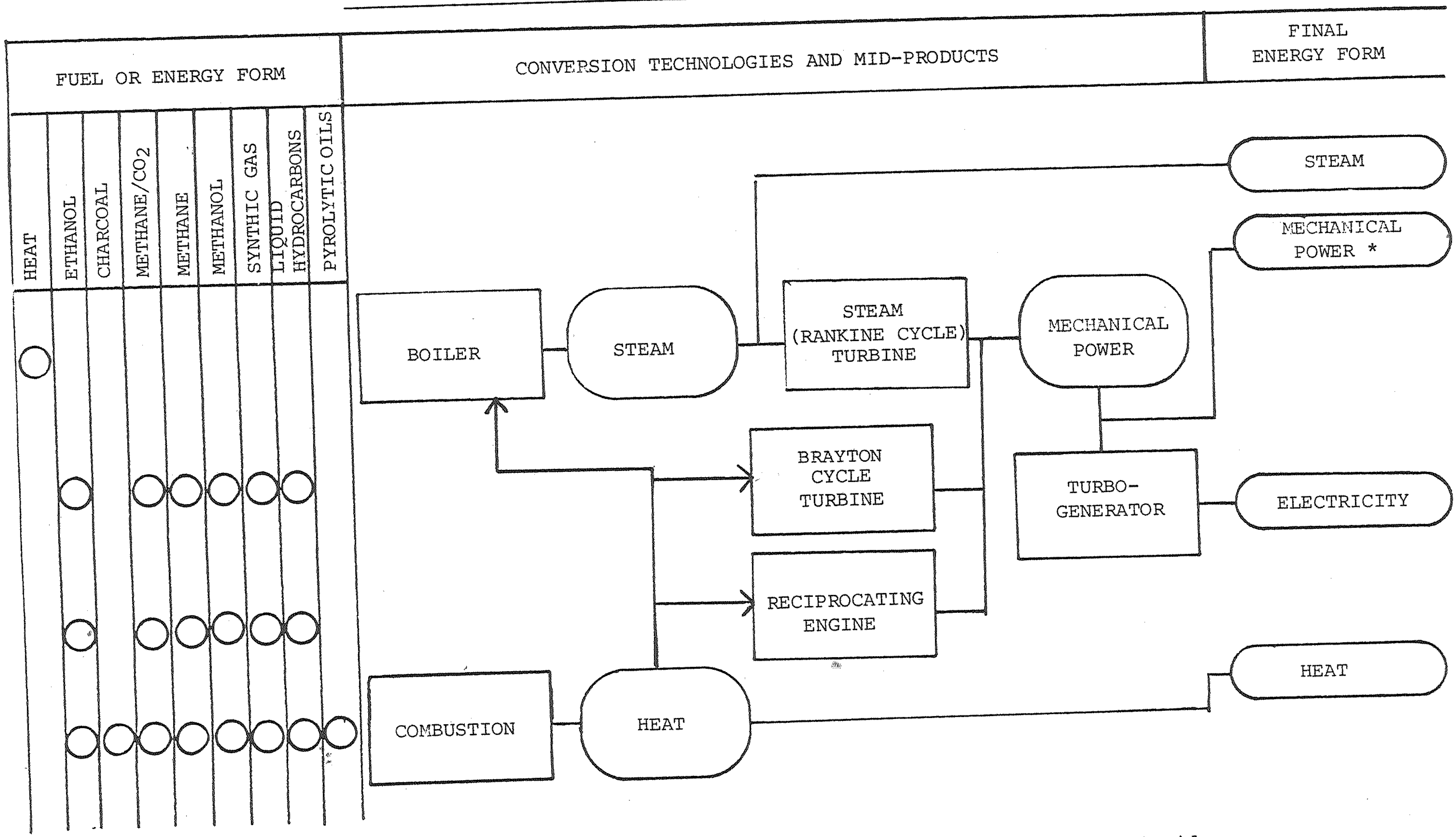


FIGURE 3

TECHNOLOGIES FOR THE CONVERSION OF BIOMASS-DERIVED FUELS/ENERGY TO FINAL ENERGY FORM



* Three of the liquid fuels derived from biomass (ethanol, methanol and liquid hydrocarbons) are particularly suitable as fuels for non-stationary engines. (i.e., to power various types of vehicles)

- Purification - The gas produced by anaerobic digestion can be purified to produce pure methane (synthetic natural gas or SNG) which could then be distributed through the existing natural gas pipelines.

- Hydrogasification - This process first converts biomass to hydrogen which is then reacted with the remaining biomass to yield gas that can be upgraded to pipeline quality SNG.

- Gasification - When heat is applied to organic matter in the absence of sufficient oxygen for full combustion, a combustible gas is produced, composed primarily of hydrogen, carbon monoxide and, in some cases, nitrogen.

- Synthetic Methanol Production - The gas produced in a gasifier can be purified to a synthesis gas containing carbon monoxide and hydrogen that can then be converted into methanol or wood alcohol using commercial processes currently used to convert natural gas or naptha into methanol.

- M Process - This new process, which has been developed by Mobil Oil, converts methanol into synthetic gasoline.

- Steam Reforming - Synthetic natural gas or methane can be converted to synthesis gas through a process commonly used in the petrochemical industry called steam reforming.

- Fisher-Tropsch - This process, which can convert biomass into a synthetic crude oil, was originally developed and used in Germany prior to World War II and is currently being used extensively in South Africa to convert coal to oil. Synthetic methanol production is a type of Fisher-Tropsch reaction.

- Hydrogenation/Carboxylolysis - These processes convert biomass to a liquid fuel or synthesis gas through the addition of carbon monoxide/hydrogen and alkaline catalysts for hydrogenation and carboxylolysis, respectively.

SOURCE: MIDDLETON ASSOCIATES

- Liquefaction - The application of heat to organic matter in the absence of sufficient oxygen for full combustion and, when certain process variables are established (temperature, pressure, residence time, etc.), results in the production of a synthetic liquid fuel oil.

- Partial Oxidation - The synthetic oil produced by either hydrogenation, carboxylolysis or liquefaction can be converted into a synthesis gas by partial oxidation.

The nine forms of energy or fuel can, in turn, be converted into four principal final energy forms: steam, mechanical power, electricity and heat. The technologies used for these conversion processes, which are illustrated in Figure 3, are briefly described below:

- Boiler - A boiler, as the name implies, produces steam through the application of heat.

- Steam (Rankine Cycle) Turbine - This process converts steam into mechanical power by passing the steam through a series of turbine blades.

- Reciprocating Engine - This process also converts heat into mechanical power through the application of heat in an Otto or Diesel cycle.

- Brayton Cycle Turbine - This process converts heat to mechanical power through the expansion of hot gases through the vanes of a rotating turbine.

- Turbogenerator - This process converts mechanical power into electricity by the rotation of magnetic fields.

The development of Canada's biomass energy potential can be seen as progressing according to the following three stages:

- near term opportunities which utilitize biomass at the point where it is generated (e.g., wood waste at forest product mills, crop and animal waste at farms, municipal solid waste in cities and wood from privately owned woodlots cut by homeowners for use in home heating).

- medium term opportunities (to the year 2000) which involve transporting the biomass, usually in a processed state, to a conversion facility where a transportable and storable form of energy may be produced.

- long term opportunities (beyond 2000) which involve more futuristic approaches such as the managing of biomass energy plantations and the direct recovery of hydrogen gas or liquid hydrocarbons from plants.

In an effort to encourage the realization of the energy potential of biomass, the federal government has established the following programs:

- FIRE (Forest Industry Renewable Energy). This program has a total budget of $103 million in its 5 year life (1979-1984), and provides up to 20% of the capital cost of facilities to utilize waste forest biomass for energy. It is managed by the Department of Energy, Mines and Resources.

- ENFOR (Energy from the Forest). This program has a total budget of $29.9 million over its 5 year life (1979-1984) and provides funding for research, development and demonstration projects to provide the technological basis for the expanded use of biomass as a fuel. It is co-ordinated by the Canadian Forestry Service of Environment Canada.

- BELG (Biomass Energy Loan Guarantee). This program, which has a total budget of $150 million for the period 1978-1984, provides loan guarantees of up to 50% of the capital cost of certain projects and up to 66 2/3% of projects that include cogeneration. It is administered by Energy, Mines and Resources.

- AERD (Agricultural Engineering Research and Development). This on-going program, co-ordinated by Agriculture Canada, provides financial support for the research, development and demonstration of methods to reduce agricultural dependance on fossil fuel.

- DRECT (Development and Demonstration of Resource and Energy Conservation Technology). This program, co-ordinated by Environment Canada, provides funds for the development of new technologies to utilize municipal and industrial waste for energy production.

- Federal/Provincial Agreements. The federal government has budgeted $114 million over 5 years which is to be matched by funds from the provinces to demonstrate both energy conservation and renewable energy technologies. This is being co-ordinated by Energy, Mines and Resources.

It is believed that a realistic goal for the next ten years would be to double the current use of wood wastes within the forest products industry, primarily from mill residues but also including some forest residues. This would bring the total contribution of wood up to 8% of total 1977 primary energy demand. In the medium term, the use of the remaining forest and farm residues as well as non-commercial species of wood could result in a contribution of as much as 0.8-1.0 EJ of energy. In the longer term, the contribution of biomass to total primary energy supply could be as much as 10-20% of total primary energy demand through the utilization of energy plantations.