BIOMASS FEEDSTOCKS FOR METHANE PRODUCTION

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Summary

The Institute of Food and Agricultural Sciences (IFAS), University of Florida, and the Gas Research Institute (GRI), jointly plan, manage, and fund a comprehensive regional methane from biomass program. Fifty-three research projects, involving about 70 faculty scientists, are designed to develop local biomass resources and conversion processes to produce significant quantities of methane. Over 200 species/varieties in seven plant resource groups and wastes are being tested as potential feedstocks for methane. Preliminary yield ranges (tons/ha/crop) are available for woody (7-23); freshwater aquatic (15-57); root/tuber (2-20); and grasses/related (22-57) crops. Other yields (marine/halophyte/hydrocarbon producer and wastes) will be available later. Investigations with promising species include: tissue culture propagation, genetic selection/improvement, multiple/polyculture cropping systems, and economic/energetic analyses of pilot farm operations. All biomass feedstocks are being evaluated using standardized biological and thermochemical gasification procedures. Physicochemical data for the biomass materials are combined with methane yield results to develop predictive models. Research on gasifier designs seeks to determine efficient conversion methods for multiple feedstocks. Biomass yield/conversion data are placed in a systems context to evaluate the potential for meeting the gas needs in specific locations.

Introduction

Biomass is a promising alternative energy source for certain regions. Developing the potential for such alternatives is needed because of the eventual decline in the availability of inexpensive supplies of fossil energy sources. Estimates vary as to the overall potential for biomass as an energy source, but recent assessments for the U.S.A. by the Energy Research Advisory Board for the U. S. Department of Energy placed the potential of net energy at about five quads by the year 2000. Other analyses (e.g., Office of Technology Assessment for the Congress of the United States) arrived at higher contributions. These evaluations were based on land-based biomass crops and waste. Freshwater aquatic and marine biomass crops could add significant increments to these estimates of biomass energy potential.

Energy supplies in the future probably will come from a variety of renewable but site specific sources. The southeastern United States is in a favorable location for developing biomass energy. In this region,

Florida, appears particularly well-suited for a focused effort on biomass for energy. The State is bounded by 2200 km of marine coast with the Atlantic Ocean on the East and the less turbulent but nutrient-rich, shallow Gulf of Mexico on the West and a continental land mass on the North. The State's climate ranges from temperate to tropical and possesses considerable land and freshwater resources (8 percent of the State's total surface area of 14 million hectares is freshwater). Soil environments range from droughty to flooded sands and loams.

The Institute of Food and Agricultural Sciences (IFAS), University of Florida and the Gas Research Institute (GRI) both recognized the potential for biomass-derived methane and the advantages of a joint comprehensive program. The program initiated in 1981, is jointly planned, managed, and funded. The research and development effort addresses biomass production by seven plant resource groups, waste capture and the conversion of these biomass resources to methane.

Biomass Production

The GRI/IFAS Methane from Biomass and Waste Program is systematically evaluating potential biomass crops in woody; freshwater aquatic; grasses and related; root and tuberous; halophyte, hydrocarbon producer; and marine plant resource groups. Crops and production systems currently available were developed for food, feed and fiber purposes and not for energy. Thus, the crops developed for those purposes often are not economically and energetically suitable for energy feedstocks. Biomass crops in contrast to food crops must produce large quantities of biomass with modest production inputs. To achieve this they must tolerate low fertility environments; show rapid juvenile growth; complete with weeds, give high yields per unit time; resist pest and disease attacks; and tolerate drought and other physical stresses. Developing feedstocks for methane will employ the same approaches and scientific principles used to develop crops for other purposes including: screening species for adaptability and biomass production potentials; identifying variability and improving the desirable candidate crops through genetics; devising cropping strategies, determing cultural in-puts and developing harvesting/handling systems. Highly productive crops are selected and adapted to production areas by including them in energy cropping systems so that year-round supplies of biomass feedstocks can be sustained. A "production area" is determined by the environment, the land and water resources available and the gas requirements in an area.

Several projects (Table 1) contribute to the screening of biomass species. Species showing promise are being researched to improve their growth and yield by determining the appropriate planting density, fertilizer treatments, planting dates and propagation methods and harvesting frequency to maximize net energy yield per unit of invested energy, area, and time. In some cases energy crops may be included in a food crop rotation. Over 200 species/varieties are presently included in the screening process (Table 2).

Biomass Conversion

Convertibility to methane is an important characteristic of a potential biomass crop. Thus, each species is subjected to biomass gasification screening through a standardized process (Figure 1). Biomass

material is received fresh from field plots, subjected to size reduction, inoculated with methanogenetic organisms and incubated for 60 days. Gas production and quality is measured periodically to assess rates. In parallel, sample portions are subjected to rumen fluid inoculations to assess their fermentability to the organic acids important to methane production.

Table 1. Research Projects Contribution to Various Areas of Biomass Production, Conversion, and Information/ Systems Analysis in the GRI/IFAS Program

Research Area	Number of Contributing Projects
Gasification	
.. biological	9
.. thermochemical	3
Plant Resources	
.. woody	5
.. freshwater aquatic	8
.. grasses/related	7
.. root/tuber	4
.. marine/halophyte	7
.. hydrocarbon producer	1
Waste	5
Information Management/Systems Analysis	4

Table 2. Species/Varieties Among Plant Resource Groups Under Evaluation in GRI/IFAS Program

Resource Group	Species/Varieties	Yield Range 1/ (tons/ha/crop)
Woody	62	7 - 23
Freshwater Aquatic	30	15 - 57
Grasses/Related	89	22 - 57
Root/Tuber	115	3 - 22
Marine/Halophytes	35	not available
Hydrocarbon Producer	10	not available

1/ Except for perennial evergreens (e.g., Eucalyptus, Pinus etc.) few crops grow all year. Two to three crops per year are possible for some root crops (Ipomoea or Manihot in summer/ Beta or Brassica in cool season. Also other crops may be sequenced (e.g., Eichhornia followed by cool-season Hydrocotyle) to sustain year-round production.

Methane assays and fermentation incubations and the biomass sample charcterizations follow the scheme shown in Figure 1. Biomass samples (especially the lignocellulosics with higher dry matter contents) are subjected to thermochemical gasification. Gas yields of samples typical of the range of species among the groups (Table 2) have been gasified in free-fall gasifiers with various carrier gases (e.g., argon, hydrogen,

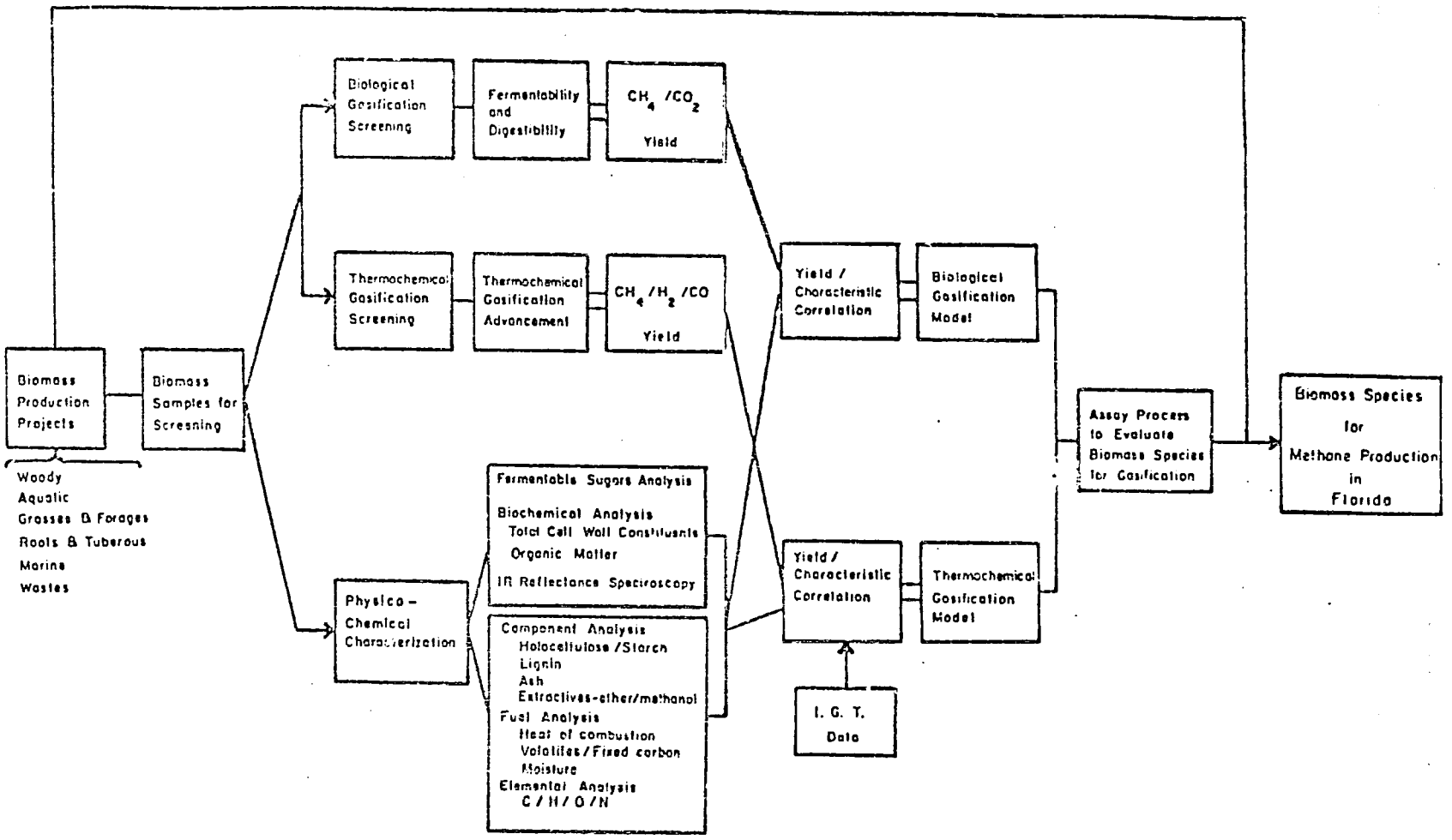


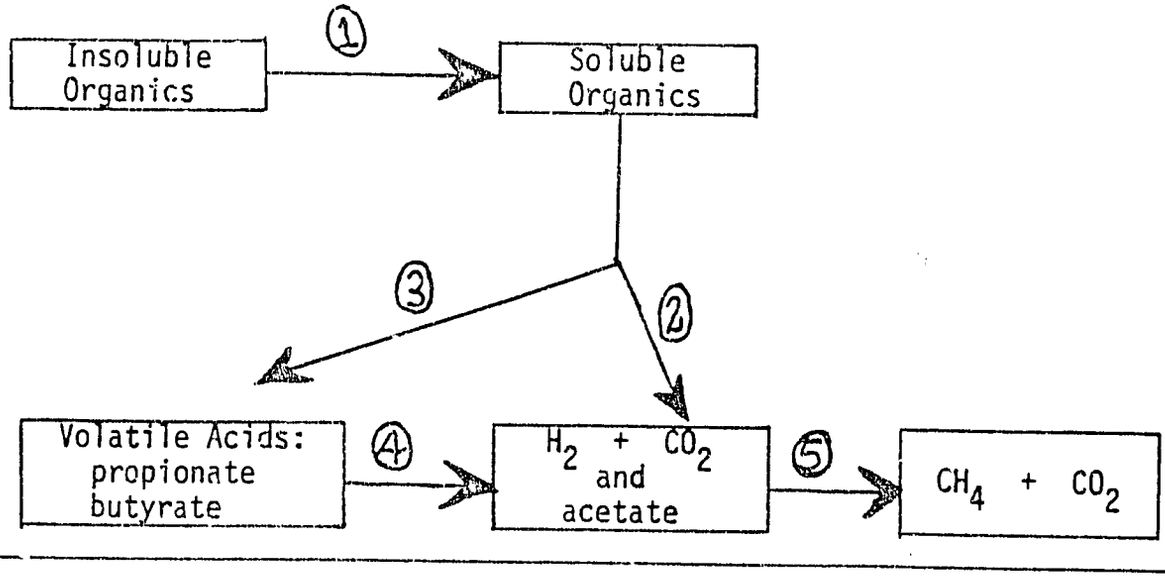
Figure 1. Flow Sheet for Biomass Screening for Gasification

etc.). In an effort to develop rapid, inexpensive screening procedures, an air-blown down-draft gasifier is being used. In all cases, methane, carbon monoxide, hydrogen, and carbon dioxide yields are quantified. Options for reforming CO and H_2 into CH_4 are being considered.

When gas yield and biomass composition data are complete, correlation analyses will be conducted to develop prediction models. The goal is to use an easily measurable chemical component(s) for predicting gasification properties. For example rapid, inexpensive evaluations could be made if infrared reflectance spectroscopy data from ground, dry biomass samples were to prove highly correlated with gas yields.

Several projects (Table 1) address ways to advance biological gasification by understanding the several process steps involved (Figure 2). These, focus on increasing cellulase enzyme levels (process 1) increased rate of priopionate to acetate (process 4) and increased rate of acetate to methane (process 5). Experimental digesters (bench to 20,000 liters) in various configurations are in place to develop biological and engineering data for designing systems to handle both high and low-solids biomass.

Figure 2. Schematic Representation of Five Process-Steps in the Conversion of Complex Biomass Organics to Methane



Conclusion

Data from all projects are stored in an information management system (Comprehensive Scientific Information Management System. CSIMS is the subject of another presentation in this conference). The data are retrieved as needed for production and conversion systems analysis in relation to gas utilization requirements in regional production areas.