2.3.8 ENERGY CROPS

Technology Description

Energy crops are fast-growing, genetically improved trees and grasses grown under sustainable conditions for harvest at 1 to 10 years of age. End uses of energy crops include biomass power (combustion and gasification), biofuels (ethanol), and new bioproducts such as plastics and many types of chemicals.

System Concepts

- Biomass feedstock supply systems are widely available throughout the United States but locally optimized for climate and soil conditions and end-use requirements.
- Quantities must be sufficient to support large-scale processing facilities.
- In the future, some crops will likely be genetically tailored in a way that facilitates separations and conversion processes for selected end uses.

Representative Technologies

- Short rotation woody crops – selected tree varieties grown as single-stem trees under sustainable conditions for year-round harvest within 4-10 years with replanting assumed.
- Woody coppice crops – selected tree varieties grown as multistemmed "bushes" under sustainable conditions for year-round harvest.
- Perennial grass crops – selected high-yield varieties of grasses grown under agronomic conditions for fall and winter harvest with stand regrowth assumed for up to 10 years, involving some modification to standard forage harvest systems.
- Genetic improvement, pest and disease management, sustainability optimization, and harvest equipment development R&D ongoing for all of the above.

Technology Status/Applications

- Short-rotation woody crops are produced commercially in the Pacific Northwest and North Central regions of the United States and many parts of the world (Brazil, Australia, Spain, etc.) for combined fiber and energy use.
- Woody coppice crops are produced commercially in Northern Europe and are being adapted to and tested at an operational scale in New York.
- Perennial grass crops have high yield potential and have been demonstrated in south, southeastern, mid-west, and north-central parts of the United States. Technology is being tested as a biomass feedstock supply system for biomass power in Iowa.

Current Research, Development, and Demonstration

RD&D Goals

- By 2005, develop feedstock crops with experimentally demonstrated yield potential of 6-8 dry ton/acre/year.
- By 2005, develop cost-effective, energy-efficient, environmentally sound harvest methods.
- By 2010, identify genes that control growth and characteristics important to conversion processes in few model energy crops.
- By 2010, improve understanding of biotechnology impacts on environment and ecology.
- By 2010, achieve low-cost, "no-touch" harvest/processing/transport of biomass to process facility.
- By 2020, increase yield of useful biomass per acre by a factor of 2 or more compared with year 2000 yields.
- By 2020, energy crops will be contributing strongly to meeting biomass power and biofuels production goals.

RD&D Challenges

- Transfer genomics information gained from arabidopsis, rice, and corn to acceleration of domestication of poplars and switchgrass.
- Develop gene maps and increased functional genomics understanding for model crops.
- Develop an efficient infrastructure for energy crop supply and utilization systems.
- Scale up seed to large-scale commercial deployment.

- Demonstrate that energy crop production is sustainable and environmentally beneficial.
- Gain acceptance by the public for the use of genetic engineering of energy crops.
- Develop expertise on machinery and logistics aspects of agricultural and forest engineering.

RD&D Activities

- Crop yield improvement research on two model woody crops (poplars and willow) and one herbaceous species (switchgrass) is being conducted by researchers in academic and USDA research organizations in many locations throughout the country.
- Genetic maps have been developed for poplars and are in process for switchgrass; work has been initiated to identify genes important to accelerated domestication of poplars and switchgrass.
- Cost-supply relationships are being generated for energy crop supplies in different regions of the country.
- Environmental research to optimize energy crop sustainable production techniques is being conducted in a few locations.
- Research on control of diseases and pests through genetics and/or cultural management.

Recent Progress

- Yields of up to 10 dry tons/acre/year have been observed in small experimental plantings of poplars, willows, and switchgrass in selected locations with genetically superior material.
- Yields of 5-7 dry tons/acre/year have been measured in small pilot-scale regional field trials of energy crops in some locations.
- Two major industrial enzyme companies are developing a new generation of cellulase enzymes to support an enzyme sugar platform.
- Farmers are engaged in energy crop R&D in several regions of the country through Federally supported demonstrations.
- An economic model for energy crop production costs has been released for public use.
- Joint USDA/DOE analysis on the economic impacts of bioenergy crop production on U.S. agriculture has shown the potential for net farm income to increase from $2.8 billion to $6 billion depending on production scenarios and feedstock prices.
- A nutrient cycling spreadsheet model applicable to forestry and short rotation woody crop applications has recently been completed and made available to industry and the public on the Web.

Commercialization and Deployment Activities

- Between 1983 and 1998, 70,000 acres of poplars were established commercially in the Pacific Northwest with significant utilization of new hybrid materials generated by the DOE-funded research programs. Opportunistic market conditions, together with short-rotation crop technology readiness and technology transfer activities, were all critical to the commercialization success in the Pacific Northwest.
- Other types of short-rotation crops – including eucalyptus, sweetgum, sycamore, and willow, and established in other parts of the country – contribute to an approximate total level of commercialization of short-rotation woody crops of about 120,000 acres. Willow contributes a partial wood supply to a cofiring biomass power demonstration project. Switchgrass is already a crop planted on many Conservation Reserve Program acres, and it is the feedstock supply for two biomass power cofiring demonstrations.