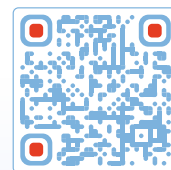


Follow the QR code for other factsheets, background information and references:



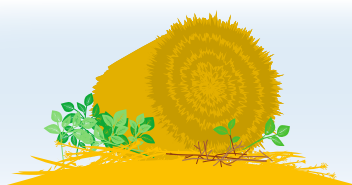
CELLULOSIC BIOFUELS

Cellulosic biofuels are liquid fuels that can replace conventional gasoline and diesel. These are made from cellulose – hardy materials that form the structure of plants. Cellulose is abundant in low value materials such as agricultural residues.

FUEL TYPES

- ◆ **Cellulosic ethanol:** Cellulose is broken down into sugars using enzymes or high temperatures; yeasts then ferment the sugars into **ethanol**.
- ◆ **Cellulosic liquid hydrocarbons:** Thermal break-down of cellulose is followed by chemical upgrading into bio-based **petrol, diesel, and jet fuel**.

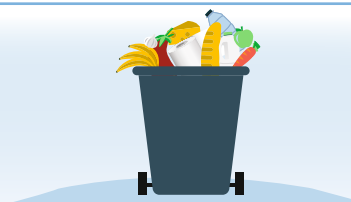
FEEDSTOCKS



Agricultural and forestry residues
Straw, husks, twigs and leaves, ...



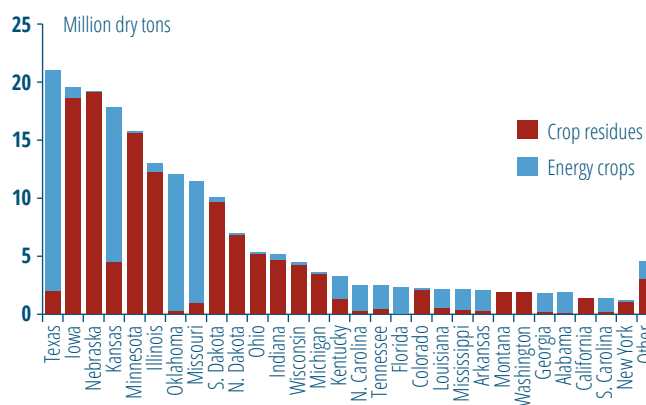
Energy crops
Purpose-grown biomass crops such as grasses and coppice



Waste
Biogenic fraction of municipal solid waste (MSW)

- ◆ Up to 1 billion tons of feedstock – sufficient for 80 billion gallons of cellulosic fuel – could be available by 2040.
- ◆ Fully delivering this in a sustainable way would require strong incentives and strong regulation.
- ◆ Cellulosic feedstocks tend to be more dispersed and more bulky than first-generation feedstocks, and therefore more costly to gather and transport.
- ◆ By-products of commercial processes (such as from saw-mills) tend to be more concentrated; but often have existing commercial uses.
- ◆ A related process can be used to produce jet fuel, diesel or gasoline from biogas.

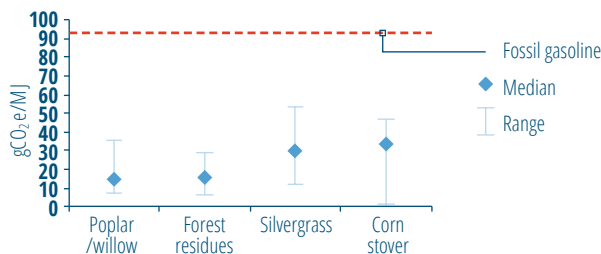
ESTIMATED POTENTIAL (CURRENT) FOR PRODUCTION OF CELLULOSIC FUEL FEEDSTOCKS, BY STATE



GREENHOUSE GAS (GHG) EMISSIONS

- ◆ Cellulosic biofuels can have lower greenhouse gas emissions than fossil fuels or first-generation biofuels because:
 - ◇ Feedstocks may be wastes and residues that would otherwise have decayed without use;
 - ◇ Bioenergy crops can be grown with less farm inputs and less soil disturbance than first-generation crops;
 - ◇ Indirect land use change emissions are expected to be lower than from first-generation biofuels.
- ◆ Unsustainable production practices could still undermine performance.

EXAMPLES OF GREENHOUSE GAS EMISSION SCORES FOR CELLULOSIC ETHANOL



FARM/FORESTRY RESIDUES VERSUS CROPS

Residual feedstocks are often treated as 'free' by-products of cultivation. It is standard practice not to attribute any of the environmental impacts of crop cultivation (GHGs, pollution, water use, land use change) to the residues. Fuels from residual feedstocks are therefore identified as having lower environmental impact.

PRODUCTION

- ◆ Only a handful of commercial-scale cellulosic biofuel plants have been built in the U.S.
- ◆ These have struggled to achieve viability, and several have been forced to close without reaching targeted production rates.
- ◆ Currently one commercial-scale cellulosic liquid plant is in early operational stages.
- ◆ Domestic cellulosic ethanol production is only about 1.3 million gallons per year.

AIR POLLUTION...

...FROM FUEL USE

- ◆ Cellulosic ethanol is chemically the same as corn ethanol and shares its combustion characteristics (see Factsheet 2).
- ◆ Cellulosic diesel/jet/gasoline are like HVO fuels (Factsheet 3) and burn cleaner than fossil fuels.

...FROM FUEL PRODUCTION

- ◆ Cellulosic biofuel facilities are expected to have higher pollutant emissions per unit of output than either first-generation biofuel plants or oil refineries.

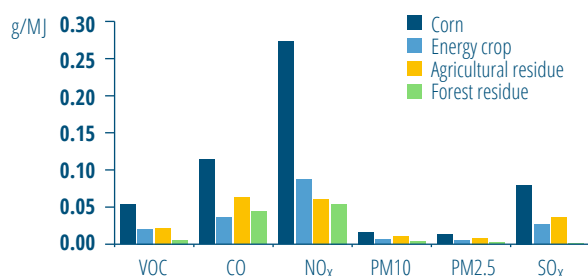
SOIL AND ECOLOGICAL IMPACTS

- ◆ Cellulosic fuels from energy crops tend to have lower ecological impacts than either fossil fuels or first-generation biofuels, but it depends on the production system.
- ◆ In principle, energy crops can be more easily integrated with conservation and regenerative agriculture practices, such as the use of deep-rooting trees and perennial grasses on marginal land.
- ◆ However, ecological risks still remain:
 - ◇ Over-harvesting of field residues can lead to soil erosion and habitat loss, as well as incursion of weeds;
 - ◇ Introduction of energy crop monocultures onto previously uncropped land could reduce habitat diversity, and may pose invasiveness risks.

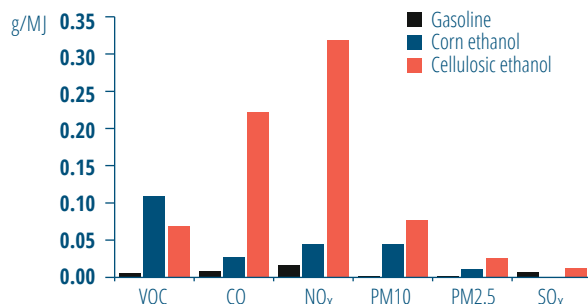
ENVIRONMENTAL IMPACTS OF ENERGY CROPS

Energy crops are associated with lower agricultural pollution levels and water consumption than corn or soybeans.

POLLUTANT EMISSIONS FOR FEEDSTOCK
production per unit of finished ethanol fuel



INDICATIVE FUEL PRODUCTION EMISSIONS
per unit of energy for gasoline and ethanol



ESTIMATED WATER DEMAND FOR ETHANOL PRODUCTION

