Pathway Creation Data

Foreword:

The purpose of this document is to assist new users in the creation of a fuel pathway in the GREET.net model. This tutorial follows the workshop pathway creation presentation, and acts as an aid for audience members learning the ins and outs of this new software. It outlines the steps taken and the parameters inputted in case one were to miss a step or fall behind. Thank you for coming to the workshop and for being some of the first GREET.net users.

Resources

These resources needs to be added or updated in the current database

Resource 1:

Set as primary and renewable

Name	Miscanthus
State	Solid
Density	
Low Heating Value	15.349 mmBtu/ton
High heating Value	16.442 mmBtu/ton
Sulfur Ratio	0.09%
Carbon Ratio	47.8%

Resource 2:

Name	Cellulase
State	Solid
Density	
Low Heating Value	
High heating Value	
Sulfur Ratio	
Carbon Ratio	

Resource 3:

Name	Yeast
State	Solid
Density	
Low Heating Value	
High heating Value	
Sulfur Ratio	
Carbon Ratio	

Resource 4:

Name	Ethanol
State	Liquid
Density	2998 grams/gal
Low Heating Value	76330 btu/gal
High heating Value	84530 btu/gal
Sulfur Ratio	$5.7 \cdot 10^{-5}$ %
Carbon Ratio	52.2%

Create Stationary Process 1: Miscanthus Farming

Process Resources:

Main Output: Miscanthus 1 ton

Resource	Amount	Source	Source Selection	Set As
Miscanthus	1 ton (for renewable energy content)	Primary Resource		Input
Diesel For Non Road	122010 btu	Single Pathway	Conventional Diesel Production	Input
Electricity	9466 btu	Single Pathway	Transported Electricity for U.S.	Input
Nitrogen	3.517 kg	Pathway Mix	Nitrogen Average	Input
Phosphoric acid P2O5	1.228 kg	Single Pathway	Phosphoric acid Production	Input
Potassium Oxide K2O	5.008 kg	Single Pathway	Potassium Oxide Production	Input
Herbicide	28 g	Pathways Mix	Combined Upstream: For herbaceous Biomass	Input

Emissions due to fertilizer use:

Emissions due to Nitrogen Use	Mass Ratio per mass of N in fertilizer
CO2 from Urea	33.157 %
NOx from Nitrogen	1.393 %
N2O from Nitrogen	2.082 % (= $1.325 \cdot \frac{44}{28}$ %)

Technologies:

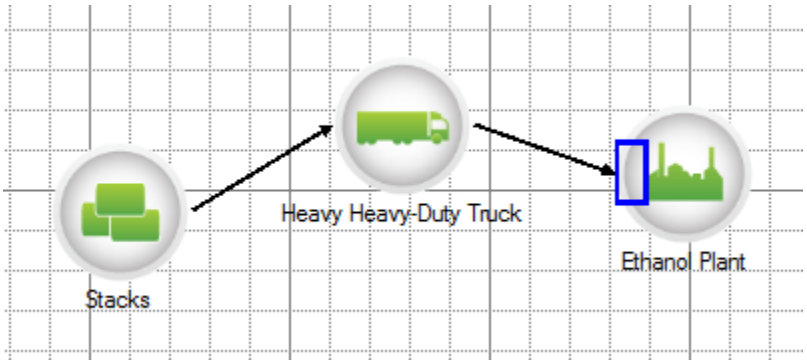
Technologies for Diesel for Non Road:	
Farming Tractor	80 %
Stationary Reciprocating Engine	20 %

Create Transportation Process 1: Miscanthus to Biofuel Refinery

Step Parameters:

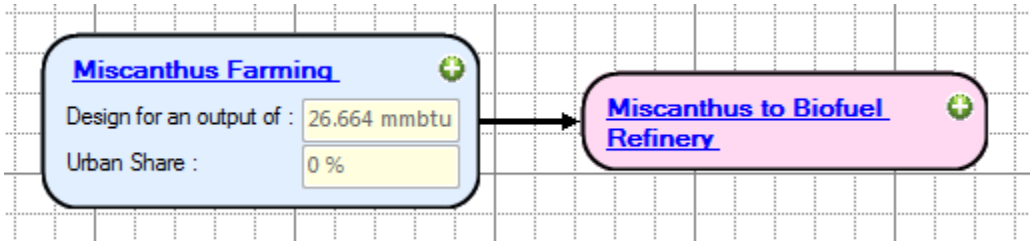
Name	HHDT
Distance	30 miles
Urban Share	5%

Payload	25 ton
Fuels	100% Diesel



Create Pathway 1: Miscanthus Farming and transportation

Assemble the pathway made of the two previous processes:



Life Cycle Results:

Per ton of Miscanthus		
Total energy	15,820,168	In btus
Fossil fuels	461,324	
Coal	42,734	
Natural gas	196,693	
Petroleum	221,897	
VOC	33.5	In grams
CO	75.9	
NOx	177.7	
PM10	20.6	
PM2.5	13.1	
SOx	99.6	
CH4	122.2	
N2O	79.4	
CO2	33,601	

Stationary Process 2: Miscanthus Fermentation to Ethanol

Process Resources:

Main Output: Ethanol 1 gal

Resource	Amount	Source	Source Selection	Set As
Miscanthus	1/90 ton	Main Output of Previous Process	N/A	Input
Diesel for Non Road	180 btu	Single Pathway	Conventional Diesel Production	Input
Cellulase	100.80 g	Pathway Mix	Fixed Pathway Mix	Input
Yeast	241.92 g	Pathway Mix	Fixed Pathway Mix	Input
Electricity	2.280 kWh	N/A	N/A	Co Product 1

Note: It is normal to see errors in the process now as we need upstream values for Cellulase and Yeast

Technologies:

Technologies for Miscanthus conversion:	
Small Industrial Boiler	40%
CO2 Credit for Burned Biomass	(40%)

Technologies fueled by Diesel for Non Road:	
Commercial Boiler	33.3 %
Stationary Reciprocating Engine	33.3 %
Turbine	33.3 %

Species	Emission Factors for Small Industrial Boiler burning Miscanthus
VOC	5.341 g/mmBtu
CO	76.800 g/mmBtu
NOx	110.000 g/mmBtu
PM10	12.661 g/mmBtu
PM2.5	6.331 g/mmBtu
SOx	Auto. Balanced: 106.3 g/mmBtu
CH4	3.834 g/mmBtu
N2O	11.00 g/mmBtu
CO2	Auto. balanced: 103.44kg/mmBtu

Co Product 1:

Displaced resource	Electricity
Displaced resource upstream	US Mix
Displacement ratio	100%

Non Combustion Emissions:

Species	Amount
VOC	1.120 g
PM10	0.856 g
PM2.5	0.146 g
CO2 LUC	-987 g

Add Cellulase Pathway Mix

Life Cycle Resources needed per ton of product:

Resource	Amount	Species	Amount
Natural Gas	28.270 mmBtu	VOC	1.355 kg
Corn	20.949 mmBtu	CO	2.550 kg
Coal	7.162 mmBtu	NOx	3.485 kg
Crude Oil	2.224 mmBtu	PM10	1.453 kg
Nuclear Energy	1.077 mmBtu	PM2.5	0.474 kg
Hydroelectric Power	344,268 btu	SOx	2.634 kg
Bituminous Oil	193,310 btu	CH4	15.197 kg
Wind Power	122,113 btu	N2O	0.691 kg
Forest Residue	59,329 btu	CO2	2598 kg

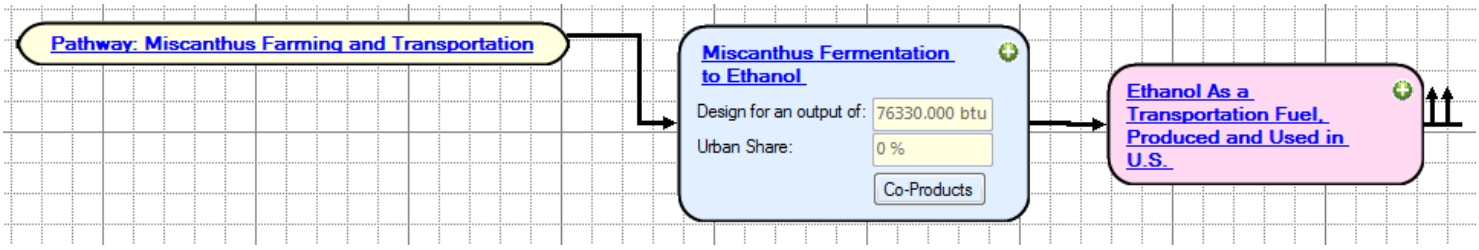
Add Yeast Pathway Mix

Life cycle Resources needed per ton of product:

Resource	Amount	Species	Amount
Natural Gas	29.970 mmBtu	VOC	0.739 kg
Coal	4.531 mmBtu	CO	3.267 kg
Sugar Cane Bagasse	2.828 mmBtu	NOx	2.606 kg
Crude Oil	842,941 btu	PM10	1.108 kg
Nuclear Energy	681,326 btu	PM2.5	0.416 kg
Hydroelectric Power	219,421 btu	SOx	3.149 kg
Wind Power	77,259 btu	CH4	15.466 kg
Bituminous Oil	73,284 btu	N2O	0.043 kg
Forest Residue	37,874 btu	CO2	2268 kg

Pathway 2: Miscanthus to Ethanol

Use the product of Pathway 1 to feed the fermentation process, and save this as a new Miscanthus to Ethanol pathway.



Feed: Miscanthus Farming and Transportation (pathway 1)

First Process: Miscanthus Fermentation to Ethanol (stationary process 2)

Second Process: Ethanol as Transportation Fuel Produced and Used in U.S. (existing in current database)

Life Cycle Results:

Per mmBtu of Ethanol		
Total energy	2,317,604	In btus
Fossil fuels	65,936	
Coal	-105,674	
Natural gas	119,116	
Petroleum	52,495	
VOC	47.7	In grams
CO	82.0	
NOx	134.0	
PM10	6.6	
PM2.5	5.4	
SOx	92.8	
CH4	53.7	
N2O	22.3	
CO2	-12,460	

Troubleshooting ideas:

Everything looks right except CO2 which is way:

Check your land use change value in the fermentation process. Check the credit for burned biomass in the fermentation plant. Check the technology emission factors for the Miscanthus boiler.

My energy results are off by 5-10%:

Probably a wrong amount on an input or a missing input. If the results are off by much it might be the distance on the transportation process between farming and transportation. Typically all your emissions should be off too as usually they depend on the input amounts.

All my results look good except one emission:

There is probably an emission factor in the boiler for Miscanthus which is off, or one of the values in the fixed upstream for yeast and cellulase.