Biofuel Development and In-State Production Incentive

Summary: The Biofuel Development and In-State Production Incentive Act (Act 78 of 2008) requires minimum volumes of cellulosic ethanol and biodiesel to be blended into gasoline and diesel fuel, commensurate with specified in-state production levels of these biofuels.

Background: This analysis quantifies the costs and GHG savings of expanded biofuel production and use associated with Act 78 and the federal Renewable Fuels Standard program (RFS/RFS2). The biofuel pathway used in this quantification represents the amount of fuel that Pennsylvania would require in order to meet its share of the RFS. The quantities of biofuel being considered in this analysis are shown in Table 1. The State biofuel mandate (Act 78) will be valuable to ensure that biofuel produced will be blended and sold in the state, thus ensuring a market for biofuel producers. However, because Act 78 does not specifically outline years in which certain levels of biofuel production must occur, the federal RFS was used as a stand-in.

The GHG impact of Act 78 was modeled separately and in combination with the national RFS. It was determined that the national RFS would result in the blending of 10 percent ethanol into all PA gasoline sooner and regardless of implementation of Act 78. The national RFS has minimum GHG life-cycle assessment standards for all biofuels. These standards were incorporated into the modeling. Because of the national RFS life-cycle standards for ethanol, no additional GHG reductions are expected for PA as a result of the cellulosic ethanol requirement in Act 78. However, there are additional reductions in GHG emissions beyond what is provided in the national RFS, because Act 78 ensures a greater volume usage of biodiesel, provided that in-state production and infrastructure requirements of Act 78 are met. The details of Act 78 that specify minimum production levels that will trigger the required blending of biofuels are as follows:

- E-10 required one year after in-state production of cellulosic ethanol reaches 350,000,000 gallons
- B2 required one year after in-state production of biodiesel reaches 40,000,000 gallons, implemented January 1, 2010
- B5 required one year after in-state production of biodiesel reaches 100,000,000 gallons
- B10 required one year after in-state production of biodiesel reaches 200,000,000 gallons
- B20 required one year after in-state production of biodiesel reaches 350,000,000 gallons

In-state production must continue to increase, and the required infrastructure (blending, transportation, and storage) must continue to be installed and maintained. This analysis looks specifically at how biofuels could reduce the carbon content of fuel and, therefore, reduce overall transportation emissions. The gallons of diesel fuel and gasoline forecast to be used in Pennsylvania vehicles come from communication with PennDOT and Michael Baker, Inc., who provides technical assistance in this area to PennDOT. The goal is to reduce the life-cycle emissions from biofuels based on the quantities needed to fulfill Pennsylvania's portion of the federal RFS. Pennsylvania accounts for 3.63 percent of total U.S. fuel consumption. Using this breakdown, the amount of biodiesel required is shown in Table 1. Cellulosic ethanol is specifically required in the RFS, whereas other advanced biofuels were assumed to come from biodiesel, and later from algae biodiesel. Biodiesel is currently the most significant source of renewable fuel in Pennsylvania, and this is why advanced biofuels are assumed to come as biodiesel.

Table 1. Quantities of Biofuels Required in PA based on RFS, and Produced in the Agriculture, Forestry, and Waste Management Analysis

Year	Cellulosic Ethanol (Million Gals)	Gen-1 Biodiesel (Million Gals)	Algae Biodiesel (Million Gals)
2013	36	64	0
2014	64	64	9
2015	109	64	27
2016	154	64	45
2017	200	64	64
2018	254	64	82
2019	309	64	100
2020	381	64	100

The life-cycle emission factors used for gasoline (11.32 kilograms of carbon dioxide equivalent per gallon [kg CO_2e/gal]) and for diesel (11.35kg CO_2e/gal) are from the Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) model (Argonne National Laboratory [ANL]). The figure for gasoline/diesel gallons replaced is determined based on the different heat contents of the biofuels (e.g., the heat content for gasoline is higher than that of ethanol but lower than that of diesel fuel) (Energy Information Administration [EIA], 2007). This means that in order to replace 1 gallon of gasoline, significantly more than 1 gallon of ethanol is needed to provide the same energy. The life-cycle emissions per British thermal unit (Btu) are shown in Table 2.

Table 2. Life Cycle CO_2e Emissions per Million Btu

Type of Fuel	Btu/Gal	kg CO_2e/Million Btu	kg CO_2e/Gal
Gasoline	114,000	99.29	11.32
Diesel	129.500	87.64	11.35
Soy/Grease Biodiesel (B100)	128,500	38.61	5.36
Algae Biodiesel	128,500	19.06	2.64

kg CO_2e = kilograms of carbon dioxide equivalent; Btu = British thermal unit; E100 = 100 percent ethanol; B100 = 100 percent biodiesel; gal = gallon.

The biofuels being considered in this analysis are biodiesel from soy/waste grease and algae biodiesel. The GHG savings of each individual fuel compared with conventional fossil fuels are shown in Table 3. Soy/waste grease biodiesel is considered Generation-1 (Gen-1) biodiesel and is currently being produced in Pennsylvania. This is assumed to increase until 2014, and then remain at that constant level for the rest of the period. Algae biodiesel production does not begin until 2014, and increases steadily from then on. The amount of each biofuel required in the policy is shown in Table 2. The emission reductions of these biofuels are calculated by multiplying the gallons of fuel being replaced by the difference in GHG emission factors between the conventional fuel and the biofuel.

Table 3. Biofuel Quantities and the Associated Emission Reductions from the Implementation Path

Year	Life-Cycle Emissions Savings, Gen-1 Biodiesel ($MMtCO_2e$)	Life-Cycle Emissions Savings, Algae Biodiesel ($MMtCO_2e$)	Total Life-Cycle Emissions Savings ($MMtCO_2e$)
2013	0.12	0	0.12
2014	0.12	0.08	0.20
2015	0.12	0.23	0.35
2016	0.12	0.38	0.50
2017	0.12	0.53	0.65
2018	0.12	0.69	0.81
2019	0.12	0.84	0.96
2020	0.12	0.84	0.96
Total	**0.96**	**3.59**	**4.55**

$MMtCO_2e$ = million metric tons of carbon dioxide equivalent.

The costs of this option are calculated on the basis of the difference in cost between conventional fuels and biofuels. The cost estimates for gasoline and diesel come from the EIA *Annual Energy Outlook 2013* (AEO 2020128). The cost for algae biodiesel was calculated based on the most conservative cost estimates from a study on algae biodiesel (Campbell et al., 2008). The costs of waste grease and soy biodiesel are projected into the future based on an EIA biodiesel report (Radich, 2004). For more information on how the biodiesel costs were calculated, see the discussion for AG-2. If biodiesel facilities can be located near a source of CO_2, then costs would be reduced. The total costs of each biofuel are shown in Table 4.

Table 4. Cost of Biofuels

Year	Additional Cost of Gen-1 Biodiesel (Million $)	Additional Cost of Algae Biodiesel (Million $)	Additional Cost of all Biofuels (Million $))
2013	11		11
2014	28	-16	12
2015	48	-37	11
2016	76	-38	38
2017	93	-33	60
2018	101	-30	71
2019	108	-24	84
2020	108	-27	81
Total			**368**

Gen-1 biodiesel has a lower energy content than traditional diesel fuel and is estimated to have relatively similar costs/gallon compared to traditional diesel fuel throughout the policy period. Algae biodiesel is more expensive than Gen-1 biodiesel and has positive costs throughout the policy period. The costs of fuel in 2015 and 2020 are shown in Table 5.

Table 5. Fuel Costs in 2015 and 2020

Year	Gasoline ($/gal)	Diesel ($/gal)	Gen-1 Biodiesel Cost (B100) ($/gal)	BioDiesel From Algae ($/gal)
2015	3.54	3.78	$3.50	$4.12
2020	4.71	3.97	$3.75	$4.38

Key Assumptions:
The difference between wholesale and retail costs is estimated based on the difference seen between wholesale and retail corn ethanol costs.

This analysis does not include the potential infrastructure costs of transporting and blending ethanol into gasoline at terminals in rural areas of Pennsylvania. While, historically, ethanol has been splash blended with conventional gasoline, it is expected to be match-blended by 2020. This same assumption was made by EPA in its RFS2 Regulatory Impact Analysis.

Key Uncertainties:
Fuel price estimates come from the AEO, which is the best and most widely available estimate of fuel price forecasts. There are significant uncertainties in predicting the cost of fuel over a long period of time. Depending on the cost difference between conventional gasoline/diesel fuel and biofuels, the cost figures for this option could change significantly. The prices of cellulosic ethanol and algae biodiesel are particularly difficult to estimate and are largely speculative, because they are not currently available on a commercial scale. Many factors—such as economic growth, political stability in oil-producing regions, efficiency improvements, oil production, and fuel switching—influence fuel price forecasts.

Emission factors for these fuels come from national estimates. Depending on the blending, components, and production practices, emission factors can be significantly affected.

Potential Overlap:
- PA Clean Vehicles
- Diesel Anti-Idle
- Alternative Fueled Transit Bus Fleets

References:
Campbell, Peter; Beer, Tom and Batten, David. "Greenhouse Gas Sequestration by Algae - Energy and Greenhouse Gas Life Cycle Studies". Transport Biofuels Stream, CSIRO Energy Transformed Flagship. 2008. http://www.csiro.au/resources/Greenhouse-Sequestration-Algae.html

NREL, 2008. “Cost of Adding E85 Fueling Capability to Existing Gasoline Stations”. http://www.afdc.energy.gov/afdc/pdfs/42390.pdf

Radich, Anthony. 2004. Biodiesel Performance, Costs and Use. US EIA. http://www.eia.doe.gov/oiaf/analysispaper/biodiesel/

EPA, 2009: U.S. Environmental Protection Agency, “Draft Regulatory Impact Analysis: Changes to Renewable Fuel Standard Program”, EPA-420-D-09-001, May 2009.