Biofuel Development and In-State Production Incentive Act and the Regional Low Carbon Fuel Standard

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. Pennsylvania is also working with ten other states in the Northeast and Mid-Atlantic States Low-Carbon Fuel Standard Program to study and design a regional Low-Carbon Fuel Standard (LCFS) and identify the benefits and drawbacks of adopting a regional standard.

Other Involved Agencies: PennDOT, Pennsylvania Department of Agriculture (PDA).

Implementation Steps: This option quantifies the costs and GHG savings of expanded biofuel production and use. The biofuel pathway used in this quantification represents the amount of fuel that Pennsylvania would require in order to meet its share of the federal Renewable Fuels Standard (RFS). The quantities of biofuel being considered in this analysis are shown in Table 2-1 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.

Additional Potential Measures: In addition to Act 78 and the federal RFS, several other measures could be implemented to help advance biofuels production and use in Pennsylvania. These measures include:

> **Establish a Next-Generation Renewable Fuels Feedstock Program:** This would encourage the sustainable production of next-generation bioenergy and biomass materials while reducing risk to landowners. For more information on the production of biofuels, see AG-2 - Leading a Transition to Next Generation Biofuels.

Create a Green Retailers Program (Tax Incentives for E85 and Biodiesel Sales): The state should establish a Green Retailers Program that rewards retail and wholesale outlets that attain benchmarks in the sale of biofuels. This would provide state recognition for achievement and important cost savings to both the seller and the consumer of biofuels. (To provide alternative fuel choice to consumers, promote state energy security needs and reduce GHG emissions.) Access to alternative fuels should address both gasoline and diesel fuels. A Green Retailer designation would be provided by the state to any retail outlet that sells a minimum level of gasoline biofuel (E85).[1]

A Green Retailer will receive incentives to support the infrastructure development needed for E85 and to help ensure that the retailer is able to provide value-based pricing for sustainable consumer use (ethanol's lower energy content requires a lower price per gallon to offset the fuel economy reduction). The applicable incentive will be a reduction in the payment of motor fuel tax on all gasoline sold at the facility. These incentives are needed in the early stages of E85 growth to accelerate the development of new production, distribution, and retail channels. The same incentives should apply to diesel transportation fuels. A Green Retailer designation would apply for similar minimum levels of B20 biofuel sales.

As an alternative to the application of incentives to the Green Retailer described above, a feebate approach could also be considered, where increases in the motor fuel tax (fee) could be used to create a fund that would provide Green Retailers with an incentive (rebate) amount for each gallon of E85 or B20 sold. Such a public–private partnership is critically needed to accelerate consumer access to alternative fuels and to support consumer value, setting the stage for increased use of renewable fuels in the transportation sector beyond low-level blends.

Background on Low-Carbon Fuel Standards and the Northeast and Mid-Atlantic States Low-Carbon Fuel Standard Program: To make an increase in biofuel production and consumption more effective, it is likely that a regional push toward biofuel use will be required. The Northeast and Mid-Atlantic states are working on a Low-Carbon Fuel Standard Program, which aims to study and design a regional LCFS and identify the benefits and drawbacks of adopting the standard.

The participating states (CT, DE, ME, MD, MA, NY, NH, NJ, PA, RI, and VT) signed a Memorandum of Understanding concerning the development of a regional LCFS .The LCFS could require fuel providers in the Northeast and Mid-Atlantic states to ensure that the mix of fuel they sell into the consumer market meets, on average, a declining standard for GHG emissions measured in CO_2-equivalent grams per unit of fuel energy sold. The standard will be measured on a life-cycle basis in order to include all emissions from fuel consumption and production, including the "upstream" emissions that are major contributors to the global warming impact of transportation fuels.[2]

An LCFS is envisioned to be a market-based, technologically neutral policy to address the carbon content of fuels by requiring reductions in the average life-cycle GHG emissions per unit of useful energy. Such a standard is potentially applicable not only in transportation, but also for fuel used for heating buildings, for industrial processes, and for electricity generation. An LCFS has the potential to ease the transition to a low-carbon economy if implemented in the context of a broader strategy to reduce GHG emissions. Unlike an RFS, it allows other fuels (besides ethanol) to be used for compliance, rewards fuels with the lowest life-cycle GHG emissions, and discourages the development of high-carbon fuels, such as liquid

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[1] The notations E85 and E100 are used to show the percentage of ethanol in a gallon of fuel. E85 contains 85% ethanol and 15% gasoline, while E100 contains 100% ethanol. B20 contains 20% biodiesel and 80% conventional diesel fuel.

[2] The Role of a Low Carbon Fuel Standard in Reducing Greenhouse Gas Emissions and Protecting Our Economy. P.1. January 7, 2007; available at: http://gov.ca.gov/index.php?/fact-sheet/5155/ .

coal. Fuels that may have the potential to reduce the carbon intensity of transportation include electricity and advanced bio-fuels that have lower life-cycle carbon emissions and are less likely to cause indirect effects from crop diversion and land-use changes than those on the market today.[3]

Reducing GHG emissions from transportation sources will involve controls on vehicles and fuels. Vehicle-borne technology is available to control GHG emissions from the petroleum-powered vehicle, but these controls will not reduce emissions sufficiently to meet projected LCFS reduction goals. Of all GHGs, controlling CO_2 emissions is the primary concern, because it is the most difficult GHG to control.

Just as emissions of criteria pollutants from transportation sources, such as PM, VOCs and NO_x, have been addressed by regulating vehicles and fuels, the same approach to curb GHG emissions should also be pursued. Vehicle-borne technology aimed at specifically controlling criteria pollutants (carbon monoxide, VOCs etc.,) comes in primarily two forms: after-treatment devices placed on the exhaust stream, and adjustments made to the engine operating parameters. These controls reduced criteria pollutant emissions from the tailpipe by up to 97 percent, and did not appreciably affect fuel economy In fact; vehicle-borne controls that regulate criteria pollutants are allowing greater engine efficiency improvements today. Installing after-treatment devices on the exhaust system of a vehicle is an impractical option when trying to control CO_2 emissions. Practically speaking, enhancing engine efficiency and operating characteristics are the best ways to control CO_2 emissions. Nevertheless, even with these improvements, the theoretical limit of efficiency for the internal combustion engine will soon be reached, and no more CO_2 reductions will be available. In all likelihood, this theoretical limit will be reached before the needed CO_2 reductions from the transportation sector occur. The need to control emissions from fuels will be even more necessary in the case of controlling CO_2 than criteria pollutants for the reasons outlined above.

Although the transition to an LCFS may prove difficult, the end result will derive many benefits. An LCFS can be developed to be market-oriented and consumer-friendly. Development of an LCFS, if structured properly, will serve to diversify the fuel supply by encouraging transportation fueled by electricity, biofuels, and technologies and infrastructure that will be developed in the future. An LCFS will reduce our dependence on foreign sources of energy and address some of the security concerns that this country faces over that dependence.

As stated, eleven Northeast states and Pennsylvania have signed a letter of intent to study the LCFS issue in depth, in order to develop a Memorandum of Understanding. The final LCFS, if adopted, will rely on many technologies and fuels to reach the intended reduction targets.

This analysis looks specifically at how biofuels could reduce the carbon content of fuel and, therefore, reduce overall transportation emissions. Electric propulsion was not considered in this analysis, although it could reduce the carbon content associated with fuels.

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 bio-diesel required is shown in Table 1. Cellulosic ethanol is specifically required in the RFS, whereas other advanced biofuels were assumed to come from

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[3] Northeast/Mid-atlantic States-Low Carbon Fuel Standard-Letter of Intent. P. 1. January 5, 2009; available at: http://www.mass.gov/Eoeea/docs/pr_lcfs_attach.pdf .

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)
2010	4	31	0
2011	9	40	0
2012	18	54	0
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

However, there are other demands on biodiesel resources from home heating oil. The Climate Change Advisory Committee's Residential/Commercial subcommittee is considering a policy that would require all home heating oil to contain 5 percent biodiesel. To avoid double counting biodiesel availability, it is assumed that all biodiesel will be going toward home heating oil, and then remaining quantities will be used in this analysis. It is possible that biodiesel would be imported from other states in this case, but such imported biodiesel will not be considered for GHG benefits in this analysis. The amount of biodiesel demand and remaining biodiesel supplies are shown in Table 2.

Table 2. Biodiesel Required for Home Heating and Remaining Quantities for Transportation

Year	Biodiesel Required for Home Heating (Million Gals)	Gen-1 Biodiesel Available (Million Gals)	Algae Biodiesel Available (Million Gals)
2013	41	23	0
2014	40	29	4
2015	39	36	15
2016	38	41	29
2017	38	45	45
2018	37	48	61
2019	36	50	78
2020	35	50	78

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 3.

Table 3. 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	129.50	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 4. 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 4. 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 4. Biofuel Quantities and the Associated Emission Reductions from the Implementation Path

Year	Life-Cycle Emissions Savings, Gen-1 Biodiesel ($MMtCO_2$e)	Life-Cycle Emissions Savings, Algae Biodiesel ($MMtCO_2$e)	Total Life-Cycle Emissions Savings ($MMtCO_2$e)
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**

$MMtCO_2$e = 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 2009* (AEO 2008). 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 5.

Table 5. Cost of Biofuels in T-2

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 6.

Table 6. 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 costs to produce each of the biofuels in this option come from the production costs in AG-2. 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. If fuel price estimates change dramatically in the next few years, then the cost-effectiveness of this option may be inaccurate. It is important to note that these costs are the best estimate that can be made for 2009, but as more data come out on fuel prices and production costs, better estimates can be made in the future.

> "Although R&D [research and development] on cellulosic ethanol has made progress in reducing estimated conversion costs, production costs remain too high for biomass-based

> fuels to compete in the marketplace. Transformational breakthroughs in basic and applied science will be necessary to make plant fiber-based biofuels economically viable."

Cellulosic ethanol and biodiesel-from-algae technology and production capacity have not yet been proven on a commercial scale. This raises concerns about the viability for volumes of cellulosic and biodiesel fuel.

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

Some service stations have had difficulties installing E85 pumps. Issues such as the potential for leakage, fire safety concerns, and uncertain fuel quality make some station operators uneasy with installing the new technology. Improved standardization and certification of E85 pumps might help reduce these concerns.

There is considerable uncertainty in modeling the indirect effects (land-use changes) of biofuel production.

Additional Benefits and Costs:

Other benefits or costs of increased biofuel use that are not quantified here include:

- The impact (positive or negative) on other air pollutants of concern.
- The sustainability of production.
- Flexibility to adjust based on the emergence of other technologies that might result in greater or more cost-effective GHG reductions.
- The impact on food prices.
- The impact on fuel tax revenue.
- The impact on the cost of goods delivery (i.e., fuel prices).
- Other environmental impacts, such as water quality and quantity, and conservation of land.
- Secondary land-use impacts.
- Security benefits from domestic fuel production.

Potential Overlap:

- PA Clean Vehicles
- Diesel Anti-Idle
- Public Transit

Subcommittee Recommendations:

Broadly, the committee felt that within the transportation sector, we not only need to be finding ways to decrease vehicle trips and increase the efficiency of those trips, but also decrease GHG emissions from the fuel itself. That's what this work plan encompasses. With regard to costs and benefits, this work plan was projected to accomplish some of the most significant GHG reductions of any of our subcommittee's work plans (14.8MMtCO2E for 2009-2020), while saving money overall.

One member noted that the way in which crops for cellulosic ethanol are grown and harvested can impact the GHG and environmental impacts of the fuel.

References:

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