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Dutchess County

## Benefits, Costs, and Effectiveness of the Use of Ethanol as a Gasoline Additive in Dutchess County, NY

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A report written in cooperation with the  
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### Introduction

On September 11, 2006, the Dutchess County, NY Legislature passed resolution No. 206231, requesting the Environmental Management Council (EMC) of Dutchess County to investigate several issues, including:

- The benefits, costs, and effectiveness of the use of ethanol (or an alternate) as a gasoline additive in Dutchess County;
- The current status of air quality in Dutchess County; and
- The potential for production of biofuels in Dutchess County.

The Dutchess County Legislature requested the investigation as a result of several factors, including:

- Increased prices of gasoline in Dutchess County;
- Consumer concerns about those increased prices;
- Concerns that Dutchess County gasoline prices are higher than in some adjoining counties due to air quality requirements to use reformulated gasoline; and

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- Interest in the use of alternative fuels such as biofuels as a means of improving air quality and reducing dependency on gasoline.

The Legislature requested the EMC report back to the Dutchess County Legislature with an interim report by 1 March 2007. This report was researched and written by staff of Cornell Cooperative Extension Dutchess County's Environment Program, in collaboration with the Dutchess County EMC, in response to a request for assistance from the Dutchess County EMC dated 24 October 2006. The report addresses:

1. Overview of the Clean Air Act Requirements, and Requirements for the use of reformulated gasoline;
2. The current status of air quality in Dutchess County;
3. Reformulated Gasoline Requirements in Dutchess County;
4. Renewable Fuels and Potential Alternatives;
5. Preliminary information on the Benefits and Effectiveness of Ethanol Use;
6. Preliminary information on the costs of Ethanol Production and Use;
7. Current and Potential US Ethanol Production; and
8. Preliminary information on the Estimates of Biofuel Production Potential in Dutchess County.

## Overview of Clean Air Act Requirements

In order to understand the requirements for the use of ethanol (or an alternate) as a gasoline additive in Dutchess County, it is important to understand the basics of the Clean Air Act legislation. The principle statutory authority for controlling air pollution at the Federal and State level is contained in the Clean Air Act (CAA), which was enacted by Congress and signed into law in 1970. Although subsequently amended, the core provisions of the 1970 Clean Air Act are still in effect.

In Section 109 of the law, the US Environmental Protection Agency (EPA) is directed to establish National Ambient Air Quality Standards (NAAQS) for six specific criteria pollutants:

1. Carbon Monoxide
2. Lead
3. Nitrogen Dioxide (NO<sub>x</sub>)
4. Ozone (or smog)
5. Particulate Matter and
6. Sulfur Dioxide (SO<sub>2</sub>)

One of the most critical criteria pollutants, ground level ozone, is the main harmful component of smog. Ground level ozone is produced by the combination of pollutants from many sources, including smokestacks, cars, paints and solvents. According to the EPA, when a car burns gasoline, releasing exhaust fumes, or a painter paints a house, smog-forming pollutants rise into the sky.<sup>1</sup>

For each of the six criteria pollutants, NAAQS are set by EPA at a level designed to protect public health with an adequate margin of safety.<sup>2</sup> One set of limits, the primary standard, protects health. Another set of limits, the secondary standard, is intended to prevent environmental and property damage.<sup>3</sup>

The initial NAAQS for ozone was a 1-hour standard of 0.12 parts per million (ppm).<sup>4</sup> In 1997, the EPA established a new NAAQS for ozone. The 8-hour ozone NAAQS was set at 0.08ppm daily maximum 8-hour average over 3 years to protect against longer exposure to ozone.<sup>5</sup>

Under section 110 of the Clean Air Act, each state is required to submit a “State Implementation Plan,” commonly known as the “SIP” to the EPA, which details how the state will implement, maintain, and enforce the primary and secondary NAAQS in each air quality control region within the State.<sup>6</sup> As the regulatory authority for New York State, the Department of Environmental Conservation (DEC), working with local authorities, drafts the SIPs for submission to the EPA to meet the requirements of the Clean Air Act in New York State.

Upon passage of the CAA Amendments of 1990 Amendments, several changes were put in place, including new designation of areas of the country not meeting the NAAQS for each criteria pollutant, also known as Areas of Non-Attainment. Under the CAA, a geographic area that meets or does better than the primary standard is called an Attainment Area; areas that do not meet the primary standard are called Non-Attainment Areas.<sup>7</sup> For areas that are in Non-Attainment for any one of the six NAAQS for criteria pollutants, Title 1 of the 1990 CAA Amendments imposes deadlines for meeting the NAAQS that vary with the severity of pollution problems, and requires states to submit revised SIPs – which require that the states make “measurable progress” in meeting the NAAQS.

### CAA Requirements for the Use of Reformulated Gasoline

Another new requirement of the CAA Amendments of 1990 was put in place when Congress added the Clean Fuels Provisions to establish two different clean fuel programs.<sup>8</sup> One program requires the use of Reformulated Gasoline (RFG) in areas that are in Non-Attainment for Ozone, in order to reduce emissions of smog-forming and toxic pollutants.<sup>9</sup> Reformulated Gasoline must meet certain requirements concerning benzene content, heavy metals, lead content, detergents, aromatic hydrocarbons, oxides of nitrogen, VOC emissions and toxic emissions.<sup>10</sup>

According to EPA, “the federal RFG program was introduced in 1995; RFG is currently used in 17 states and the District of Columbia. About 30 percent of gasoline sold in the U.S. is reformulated (see Figure 1 below). Each oil company prepares its own formula that must meet federal emission reduction standards.”<sup>11</sup> Although required in areas that are in Non-Attainment for Ozone, other cities or regions with smog problems may choose to “opt-in” to the program.

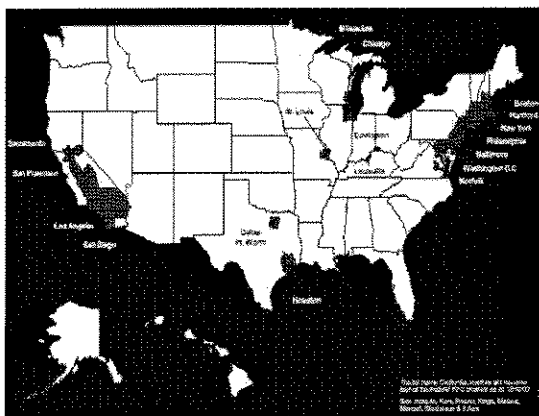


Figure 1. Map of Current RFG Areas in the United States.<sup>12</sup>

The second component of the program required the use of oxygenated gasoline, which reduces carbon monoxide emissions, in regions of the country in non-attainment for carbon monoxide. The Act specified that Reformulated Gasoline contain 2 percent oxygen by

weight. Two of the most common substances used in RFG as oxygenates are MTBE (methyl tertiary butyl ether) and ethanol. With the passage of the Energy Policy Act of 2005, Congress removed the oxygen content requirement for reformulated gasoline (RFG) in section 211(k) of the Clean Air Act (CAA), effective on May 5, 2006.<sup>13</sup>

According to the EPA, despite the fact that the oxygenate requirement for reformulated gasoline has been eliminated, many refineries are still operating under contract with ethanol blenders. Some refiners may continue to add oxygenate (ethanol) to all their RFG based on octane volume, toxic performance requirements, or favorable economics.<sup>14</sup>

Regardless of the elimination of *one component* of the Reformulated Gasoline Program - the oxygenated requirement - the other requirements of the Reformulated Gasoline program remain in effect under the CAA in order to reduce harmful emissions of Ozone, NO<sub>x</sub>, Toxics, and Volatile Organic Compounds (VOCs).<sup>15</sup>

Another factor that will continue to drive the increased use of renewable fuels, including ethanol, in the United States, is the Renewable Fuel Standard Program under the Clean Air Act, as amended by Section 1501 of the Energy Policy Act of 2005.<sup>16</sup> The EPA is required to promulgate regulations implementing a renewable fuel program. The proposed rule specifies that the total volume of renewable fuels required to be blended into gasoline, will start at 4.0 billion gallons in 2006, and increase to 7.5 billion gallons by 2012.<sup>17</sup>

The critical change with this new program is the requirement that renewable fuels be increasingly blended into gasoline sold throughout the United States, as opposed only to those areas in Non-Attainment previously. The proposed rule (September 2006) has not yet been finalized. It contains compliance tools and a credit and trading system that is integral to the overall program, which would allow renewable fuels to be used where they are most economical, while providing a flexible means for industry to comply with the standard.<sup>18</sup>

### Status of Air Quality in Dutchess County

The United States EPA and New York State Department of Environmental Conservation (DEC) maintain a network of air quality monitoring for the United States and New York State, respectively. According to EPA, the EPA's ambient air quality monitoring program is carried out by State and local agencies.<sup>19</sup> The New York State DEC measures air pollutants at more than 80 sites across the state, using continuous and/or manual instrumentation, as part of the federally-mandated National Air Monitoring Stations Network.<sup>20</sup>

Continuous air quality monitoring of DEC's Region 3 - the Hudson Valley - occurs at several sites, including White Plains in Westchester County, Mt. Ninham in Putnam County, Newburgh in Orange County, and Belleayre Mt. in Ulster County. The only monitoring station in Dutchess County, is site #132801 maintained at the Institute of Ecosystem Studies in Millbrook, NY. The DEC's Division of Air Resources maintains accurate hourly, daily, monthly and yearly air quality data and forecasting, and information is available from the DEC website (<http://www.dec.state.ny.us>).

According to the DEC, Dutchess County is currently classified as a non-attainment area for the 8-hr ozone requirements under the NAAQS. In June, 2004, the Poughkeepsie ozone non-attainment area was classified as a moderate non-attainment area for the ozone 8-hour standard (see Table 1 below).<sup>21</sup>

Table 1. Comparison Between NYS Ambient Air Quality and Ambient Air Quality Standards for Calendar Year 2005 Ozone for NYSDEC Region 3, 1995-2005.<sup>22</sup>

Comparison Between NYS Ambient Air Quality and Ambient Air Quality Standards for Calendar Year 2005												
Station	Site No.	One Hour Averages							4 <sup>th</sup> Highest Daily Maximum 8-Hour Average -Not to exceed an avg of 0.08 ppm during the last 3 years*			
		Observations			Highest Values, PPM							
		Total Obs.	% Avail	>.12 PPM	1 <sup>st</sup>	2 <sup>nd</sup>	3 <sup>rd</sup>	4 <sup>th</sup>	2003	2004	2005	Avg
White Plains	5902-04	8,655	99	1	.133+ [06/26, 15]	.123 [08/12, 17]	.119 [07/27, 14]	.118 [07/26, 16]	.091 [07/04]	.078 [08/20]	.095 [08/13]	.088 +
Valley Central (Oper. 03/25-11/02)	3527-01	5,225	98	0	.107 [07/12, 17]	.107 [09/07, 18]	.105 [07/26, 19]	.102 [06/09, 17]	.087 [07/15]	.078 [07/01]	.087 [08/21]	.084
Millbrook	1328-01	8,541	98	0	.111 [06/09, 17]	.102 [08/12, 19]	.090 [06/25, 14]	.089 [08/04, 20]	.081 [07/02]	.076 [07/01]	.082 [06/25]	.079
Mt. Ninham (Operated 03/25-12/31)	3951-01	6,605	98	1	.141+ [08/12, 18]	.119 [07/27, 14]	.118 [09/13, 17]	.114 [06/09, 16]	.082 [07/07]	.082 [06/08]	.096 [06/25]	.086 +
Belleayre Mtn.	5565-03	8,433	96	0	.093 [06/24, 18]	.089 [06/25, 11]	.086 [06/09, 21]	.085 [04/07, 17]	.082 [07/03]	.076 [08/10]	.080 [09/22]	.079

As noted above, the 8-hr ozone standard is not to exceed an average of 0.080 ppm, during the last three years, based on a determination from the fourth highest daily maximum 8-hour average reading. According to DEC, the measurements at the Millbrook monitoring station for the period 2002-2004 averaged 0.089, which exceeded the standard.<sup>23</sup> 2006 Air quality data are not yet available from the NYS DEC. Dutchess County has been designated by the US EPA as part of the Poughkeepsie, NY 8-Hour Ozone Moderate Non-Attainment Area for Ozone, which also includes Orange and Putnam Counties (see Figure 2 below).<sup>24</sup>

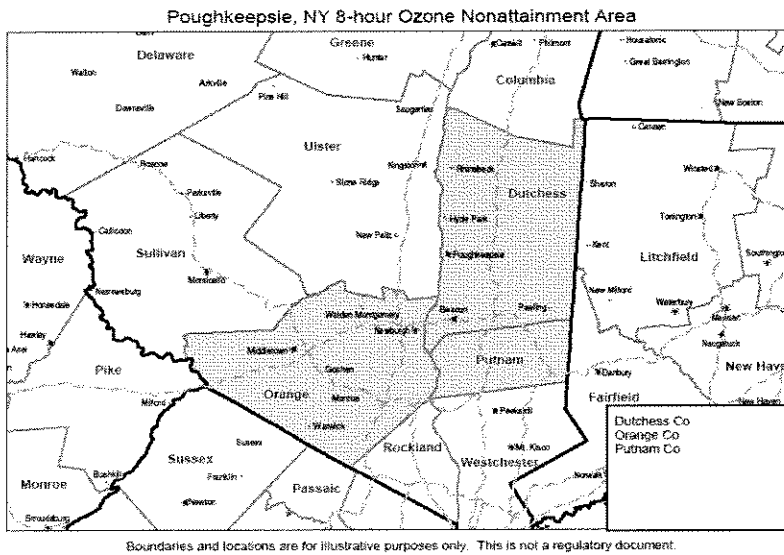


Figure 2. US Environmental Protection Agency, 2007<sup>25</sup>

### Reformulated Gasoline Requirements in Dutchess County

In New York State, the use of Reformulated Gasoline RFG is required in the New York Metropolitan area and surrounding counties (Bronx, Kings, Nassau, New York, Orange, Putnam, Queens, Richmond, Rockland, Suffolk and Westchester Counties).<sup>26</sup> However, RFG is also required to be used in Dutchess County under the CAA as an “Opt-in Area,” based on a petition from New York State Governor to the EPA to include the area in the Reformulated Gasoline Program.<sup>27</sup>

In order to meet the requirements of NAAQS under its State Implementation Plan (SIP), New York State included the requirement to use RFG in Dutchess County as one of the policy measures used to reduce ozone emissions and make “measurable progress” in achieving the NAAQS for Ozone.<sup>28</sup> The requirement to use RFG in Dutchess County was included in the SIP because the County contributes to the non-attainment of ozone in the New York Metropolitan area due to airborne transport of pollutants and the transportation corridor between Dutchess County and New York City.<sup>29</sup>

The USEPA maintains data on Reformulated Gasoline (RFG) Properties and Emissions for certain areas of the country which are using RFG, based on data from surveys conducted by the RFG Survey Association, an association of refiners, importers and blenders, as a requirement of EPA regulations. EPA maintains RFG property and performance averages for the Poughkeepsie, NY area, during the winter and summer months (see Table 2 and 3 Below).

Table 2. RFG Property and Performance Averages during the Summer Months for Poughkeepsie, NY.<sup>30</sup>

Summer	Years & Standards: Simple Model			Phase I Complex		Phase II Complex					
	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Data											
Number of surveys	1		2	2	2	2	2	2	2	2	2
Average of oxygen (w%)	2.10		2.08	2.02	2.03	2.04	2.06	1.99	2.01	3.56	3.58
Average of benzene (v%)	0.543		0.685	0.558	0.663	0.542	0.622	0.604	0.686	0.617	0.654
Average of rvp (psi)	7.90		7.91	7.91	7.96	6.82	6.79	6.85	6.81	6.97	6.93
Average of aromatics (v%)	22.53		27.18	25.99	23.85	21.11	21.98	22.45	22.37	21.65	22.47
Average of sulfur (ppm)				171	172	117	98	91	76	58	49
Average of olefins (v%)				12.78	10.59	11.25	12.66	12.72	12.09	11.85	12.43
Average of E200 (%)				49.3	50.3	46.8	46.4	46.7	46.4	46.3	46.2
Average of E300 (%)				82.8	85.3	84.6	84.6	84.3	84.0	84.0	84.8
Average of T50 (F)				202.0	200.1	206.7	208.0	207.2	207.9	210.6	211.0
Average of T90 (F)				333.4	321.6	325.4	324.7	326.6	327.8	327.8	323.6
Average of MTBE (w%)	10.90		10.98	10.76	10.43	10.21	10.54	10.13	9.59	0.20	0.05
Average of ethanol (w%)	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.14	10.29
Average of TAME (w%)	0.36		0.37	0.40	0.83	1.12	0.93	0.87	1.65	0.00	0.00
Average of ETBE (w%)	0.04		0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00
Average of TBA (w%)	0.02		0.00	0.00	0.01	0.02	0.04	0.04	0.04	0.00	0.00
Average of NPA (w%)	0.01		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Average of DIPE (w%)	0.23		0.00	0.00	0.01	0.00	0.00	0.02	0.00	0.00	0.01
Average of methanol (w%)	0.03		0.05	0.02	0.03	0.02	0.03	0.03	0.01	0.00	0.00
Average Ethanol Volume%							0.00	0.00	0.00	9.57	9.75
Average Specific Gravity										0.750	0.752
Phase I Complex Model VOC Reduction (%)				21.81	21.48						
Phase I Complex Model Toxics Reduction (%)				34.93	34.84						
Phase I Complex Model NOx Reduction (%)				4.20	5.69						
Phase II Complex Model VOC Reduction (%)				16.47	16.87	27.66	28.15	27.61	27.94	27.35	27.68
Phase II Complex Model Toxics Reduction (%)				29.55	30.11	34.22	33.10	32.95	32.52	30.71	30.18
Phase II Complex Model NOx Reduction (%)				4.11	5.71	9.09	9.06	8.99	10.02	11.27	11.07

Table 3. RFG Property and Performance Averages during the Winter Months for Poughkeepsie, NY.<sup>31</sup>

Winter	Years & Standards: Simple Model			Phase I Complex		Phase II Complex					
	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Number of surveys	1		2	2	2	2	2	2	2	2	2
Average of oxygen (w%)	2.45		2.41	2.52	2.25	2.12	1.91	1.90	2.74	3.68	3.65
Average of benzene (v%)	0.536		0.655	0.615	0.596	0.644	0.646	0.615	0.736	0.731	0.767
Average of aromatics (v%)	21.97		20.52	22.69	22.68	20.18	19.64	18.57	20.40	20.55	21.03
Average of sulfur (ppm)				201	180	167	151	147	121	112	93
Average of olefins (v%)				11.84	11.82	11.72	13.93	13.29	11.89	11.10	10.06
Average of E200 (%)				55.3	54.8	54.7	57.1	56.8	56.4	56.9	54.2
Average of E300 (%)				84.0	84.4	86.5	87.6	87.1	87.5	84.9	86.9
Average of T50 (F)				186.0	187.3	188.0	182.7	182.5	179.7	169.0	179.6
Average of T90 (F)				329.9	327.6	317.4	312.6	314.7	311.3	325.2	314.1
Average of MTBE (w%)	12.89		12.05	12.50	11.01	9.78	9.54	9.20	5.14	0.11	0.10
Average of ethanol (w%)	0.13		0.33	0.32	0.38	0.71	0.30	0.32	5.05	10.51	10.45
Average of TAME (w%)	0.16		0.66	0.84	0.73	0.56	0.49	0.76	0.06	0.02	0.00
Average of ETBE (w%)	0.00		0.00	0.00	0.00	0.00	0.00	0.01	0.18	0.01	0.01
Average of TBA (w%)	0.03		0.01	0.01	0.01	0.03	0.03	0.04	0.03	0.00	0.00
Average of NPA (w%)	0.02		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Average of DIPE (w%)	0.04		0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.01	0.00
Average of methanol (w%)	0.04		0.02	0.02	0.03	0.02	0.02	0.02	0.03	0.00	0.00
Average Ethanol Volume%							0.27	0.29	4.70	9.74	9.73
Average Specific Gravity										0.736	0.740
Phase I Complex Model VOC Reduction (%)				6.77	7.15						
Phase I Complex Model Toxics Reduction (%)				24.43	24.61						
Phase I Complex Model NOx Reduction (%)				4.78	5.39						
Phase II Complex Model Toxics Reduction (%)				25.10	25.10	26.33	26.84	27.83	24.88	23.11	23.32
Phase II Complex Model NOx Reduction (%)				4.91	5.52	7.09	6.27	7.32	8.23	9.42	10.69

The data in Tables 2 and 3 reveal that ethanol was not being used in reformulated gasoline in the Poughkeepsie, NY area (including Dutchess County) in the summer months prior to 2004 (and very small amounts of ethanol were used in the winter months prior to 2004), since MTBE was the primary additive being used. Beginning in 2004, New York State banned the use of MTBE due to water contamination concerns. As a result, the percentage of ethanol in reformulated gasoline sold in the Poughkeepsie, NY area in the summer months of 2004 and 2005 increased to 10.14% 10.29% respectively, and 10.51% and 10.45% in the winter months of 2004 - 2005.<sup>32</sup>

As long as the Poughkeepsie, NY area (including Dutchess County) is in non-attainment for ozone, the use of Reformulated Gasoline will likely continue to be one of the policy measures used to come into compliance with the ozone NAAQS for reasons noted below. According to a USEPA Region II official, NYDEC will be working with the Metropolitan Planning Authority to submit a revised SIP to USEPA by June 2007, although it is unlikely that the revised SIP will change the Poughkeepsie, NY non-attainment designation for ozone or

the policy measures currently being used to reach attainment. Any designation change in the SIP would require that DEC provide data showing achievement of the NAAQS for ozone for a two-year period, and also prove that any changes in policy measures would not result in a decrease in air quality.<sup>33</sup>

At the local and regional level, the Poughkeepsie-Dutchess County Transportation Council (PDCTC) works in cooperation with federal and state agencies to develop conformity determinations for all long-range clean air and energy planning, and congestion management plans. A 2006-2007 report is available from Dutchess County.<sup>34</sup>

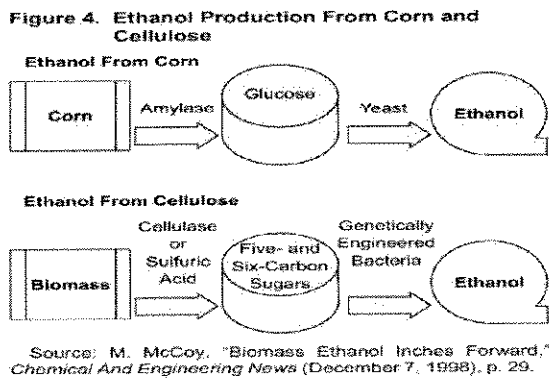
## Renewable Fuels including Ethanol and other Biofuels

According to the Worldwatch Institute...

The world is on the verge of unprecedented growth in the production and use of biofuels...due to many factors, including rising oil prices, national security concerns, the desire to increase farm incomes, and a host of new technologies and incentives, which are sparking investment.<sup>35</sup>

- **Biofuels** are defined by the US Department of Energy as “any fuels derived from at least 80% minimum content by volume of biomass, or recently living organisms or their metabolic byproducts.” Biofuels are a renewable source of energy, unlike other natural resources such as petroleum, natural gas or coal, and are biodegradable, and are thus less harmful to the environment if spilled. These biologically produced fuels can include methanol, biodiesel, ethanol, and less commonly, propanol and butanol.<sup>36</sup>
- **Biodiesel** is defined by the National Biodiesel Board, as “a domestic, renewable fuel for diesel engines derived from natural oils like soybean oil, which meets the specifications of ASTM D 6751. Biodiesel can be used in any concentration with petroleum based diesel fuel in existing diesel engines with little or no modification. Biodiesel is **not** equivalent to raw vegetable oil. It is produced by a chemical process which removes the glycerin from the oil.<sup>37</sup>
- **Renewable fuels** are defined in the Energy Policy Act of 2005, primarily on the basis of the feedstock used to produce them. In general, renewable fuels must be produced from plant or animal products or wastes, as opposed to fossil fuel sources. The Act specifically identifies several types of motor vehicle fuels as being encompassed by the definition, including cellulosic biomass ethanol, waste-derived ethanol, biogas, and biodiesel.<sup>38</sup>
- **Ethanol** can be produced from various feedstock: primarily corn in the United States and sugarcane in Brazil. Compared with unleaded gasoline, ethanol is a fuel-source that combusts cleanly with oxygen, forming reaction products including carbon dioxide and water, without emitting particulates.<sup>39</sup> Currently, the United States is the second largest world producer of ethanol, behind Brazil. In 2006, the US produced 5.6 million gallons of ethanol.<sup>40</sup>
- **Cellulosic Ethanol** – While ethanol is typically produced from the starch contained in grains such as corn and grain sorghum, it can also be produced from cellulose - which is the main component of plant cell walls and is the most common organic compound on earth. Examples of cellulosic ethanol inputs include many materials now regarded as wastes, as well as corn stalks, rice straw and wood chips, or energy crops of fast-growing trees and grasses.<sup>41</sup>

Figure 3 below (notation as Figure 4) depicts the different production technologies of ethanol from corn and cellulose.<sup>42</sup>



Although cellulosic ethanol holds great promise in the future, it is currently not a commercially available technology. According to a Department of Energy (DOE) report on biomass-based ethanol, "significant barriers to the success of cellulose-derived ethanol remain. For example, it may be difficult to create strains of genetically engineered yeast that are hardy enough to be used for ethanol production on a commercial scale. In addition, genetically modified organisms may have to be strictly contained. Other issues include the cost and mechanical difficulties associated with processing large amounts of wet solids. Proponents of biomass ethanol remain confident, however, that the process will succeed and low-cost ethanol will become a reality."<sup>43</sup> One of the greatest future benefits of cellulosic ethanol is that the feedstock can include fast-growing crops that are native to an area, like switchgasses, or excess timber, which would ease reliance on edible grains such as corn.<sup>44</sup>

## Potential Alternatives to Ethanol

According to the Worldwatch Institute, "the two primary biofuels in use today are ethanol and biodiesel, both of which can be used in existing vehicles. Ethanol is currently blended with gasoline, and biodiesel is blended with petroleum-based diesel for use in conventional diesel-fueled vehicles. Ethanol accounts for about 90 percent of total biofuel production, with biodiesel making up the rest."<sup>45</sup>

Alternatives to ethanol or other gasoline additives would have to meet strict requirements, including performance standards for automobiles, and environmental standards, including the RFG Requirements, Mobile Source Air Toxic (MSAT) requirements, and California Air Resources Board (CARB) Gasoline Standards. According to the Renewable Fuels Association, the only practical alternatives to ethanol which could meet these standards are petroleum products – alkylate and iso-octane - both of which are expensive and in short supply.<sup>46</sup>

Other alternative fuels, such as butanol, may eventually offer an effective substitute to ethanol, but they are not currently commercially available, and their development on a large scale has been impeded by the lack of technology to make them economically viable, due to low production yields. However, butanol holds promise as an excellent alternative to ethanol or gasoline, due to its higher energy content, its decreased evaporative properties, ability to be shipped through existing fuel pipelines (whereas ethanol must be transported via rail,

barge or truck), and the fact that it can be used as a replacement for gasoline without significant modifications to the automobile engine.<sup>47</sup>

### Benefits and Effectiveness of the use of Ethanol

According to the EPA, the use of Reformulated gasoline (RFG), including RFG containing ethanol, is beneficial to the environment. The more stringent standards of Phase II RFG requirements put in place in 2000 are designed to reduce smog pollutants by 105,000 tons per year in RFG areas, for a combined equivalent of eliminating the smog-forming emissions from about 16 million vehicles. The RFG program also reduces emissions of toxic air pollutants such as benzene, a known human carcinogen. Phase I and Phase II RFG combined reduce toxic pollutants by about 24,000 tons per year in RFG areas, the equivalent of eliminating the toxic emissions from over 13 million vehicles. The requirement to use reformulated gasoline has been effective and beneficial in terms of lowering emissions of criteria pollutants including Volatile Organic Chemicals (VOCs) and Nitrogen Oxides (NOX). It is important to note, however, that RFG in NY State primarily contained MTBE until its ban in 2004; therefore it is unclear if RFG containing primarily ethanol as an additive will result in similar air quality benefits in Dutchess County as those noted above.<sup>48</sup>

According to EPA, based upon its preliminary analysis, the increased use of ethanol under the Energy Policy Act of 2005 (the new renewable fuels standard program) will result in a reduction of (1) petroleum consumption, (2) carbon monoxide emissions, (3) benzene emissions and (4) carbon dioxide equivalent greenhouse gas emissions.<sup>49</sup> Specifically, the Renewable Fuels Association asserts that the use of ethanol in reformulated gasoline reduces tailpipe carbon monoxide emissions by as much as 30%, toxics content by 13% (mass) and 21% (potency), and tailpipe fine particulate matter (PM) emissions by 50%. A factor that will be increasingly important is the impact on greenhouse gas emissions. According to Argonne National Laboratory, the use of 10% ethanol blends reduces greenhouse gas emissions by 12-19% compared with conventional gasoline. In 2005, ethanol use in the U.S. reduced CO<sub>2</sub>-equivalent greenhouse gas emissions by approximately 7.8 million tons, equal to removing the annual emissions of more than 1.18 million cars from the road.<sup>50</sup>

At the same time, according to the EPA, based upon its preliminary analysis, the increased use of ethanol under the Energy Policy Act of 2005, may result in an increase in vehicle emissions of NOx and VOC depending on region and certain other factors.<sup>51</sup> The specific impact of increased use of ethanol on Dutchess County air quality will depend on regional factors and the particular transportation technologies which are utilized. Such an assessment is beyond the scope of this report.

In terms of the net energy balance of the use of conventional ethanol, there is wide discrepancy of opinion on whether the production of the fuel requires more energy inputs (particularly fossil fuel energy) than is ultimately contained in the biofuels themselves.<sup>52</sup> Some scientists argue that more fossil energy is used to produce corn-based ethanol than the energy contained within it. David Pimental at Cornell University and Tad W. Patzek at UC Berkeley argue that corn ethanol's energy balance is negative, that it takes more energy to make ethanol from grain than the combustion of ethanol produces because of the many energy inputs that go into corn production that are not traditionally accounted for. "In terms of renewable fuels, ethanol is the worst solution," notes UC Berkeley Geo-engineering Professor Tad W. Patzek. "It has the highest energy cost with the least benefit." Patzek argues that if one takes into account the energy required to grow the corn and convert it into ethanol, burning the biofuel as a gasoline additive actually results in a net energy loss of 65 percent.<sup>53</sup>

Others argue that while ethanol has had a negative energy balance in the past, the production technologies have improved in recent years, and most observers now agree that

corn ethanol has achieved a positive energy balance.<sup>54</sup> For example, the U.S. Department of Agriculture and researchers at the University of Minnesota, argue that ethanol now delivers a modest positive net energy balance, a conclusion recently endorsed by a 2006 study from University of Minnesota researchers.<sup>55</sup>

When cellulosic ethanol becomes commercially viable, it will have a very different net energy balance - because the entire plant (corn or switchgrass) will be used as feedstock, and it would rely on biotech enzymes to break down the cellulose, rather than heat, meaning that the production of cellulosic ethanol will require less energy inputs to achieve the same energy output.<sup>56</sup>

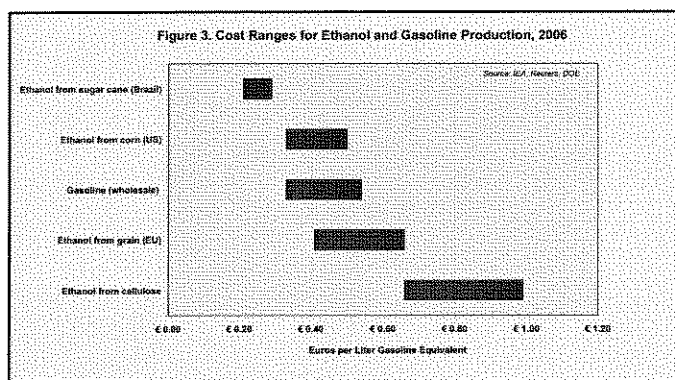
### Costs of Ethanol Production and Use

Regarding costs of ethanol use, some have argued that the requirements for ethanol blending in certain regions have resulted in increases in gasoline prices, while the Renewable Fuels Association has argued that ethanol actually results in a lower cost fuel, which is readily available, than other alternatives would.<sup>57</sup>

The cost of ethanol production will vary from company to company, depending on the cost of feedstock, such as corn, as well as site location, transportation costs (rail service), and economies of scale. For example, a bio-refinery in the Midwest could have a much lower cost compared to some smaller scale farmer cooperatives in the Northeast. The cost effectiveness of ethanol production may be a concern, given the doubling in price of raw materials inputs in the last year (primarily corn) from \$2.00 to \$4.00 per bushel.

The production of ethanol from corn is a mature technology and there is unlikely to be significant reductions in production costs using this technology. According to one report from the US DOE, the ability to produce ethanol from low-cost biomass will be key to making ethanol competitive as a gasoline additive. If DOE goals are met, the cost of producing ethanol could be reduced by as much as 60 cents per gallon by 2015 if cellulosic conversion technology is achieved.<sup>58</sup>

The Worldwatch Institute has calculated cost ranges for ethanol and gasoline production as of 2006 (see Figure 6 – noted as Figure 3 - below), which show that ethanol from sugar is the most cost effective fuel compared to gasoline, while ethanol from cellulose is a bit less costly. The future costs of cellulosic ethanol are still hypothetical, but would need to decrease in order to be viable commercially.<sup>59</sup>



Source: Worldwatch Institute.<sup>60</sup>

## Current and Potential US Ethanol Production

According to the Renewable Fuels Association, which maintains the most up-to-date information on ethanol facilities and production, there were 95 ethanol plants online in the United States in 2006, with a total production capacity of 4.3 billion gallons per year.<sup>61</sup> The surge in ethanol production from corn has resulted in an increasing percentage of the corn consumed by ethanol, from 9.8 billion bushels in 2001 to 11.8 billion bushels in 2006. As a result ethanol production used 20% of the US corn crop in 2006. There is room to increase ethanol production, but only to a certain point – most estimates acknowledge a limit of 15 billion gallons per year.<sup>62</sup>

Most of these facilities are located in the “corn-belt” mid-west region of the United States, which has the highest production capability for corn. The ethanol produced at US facilities must be transported to users via rail, barge or truck, since it cannot be shipped through existing fuel pipelines. This adds to the cost of ethanol production and use, and any considerations over manufacturing facilities must take this factor into account.

### ETHANOL INDUSTRY OVERVIEW

Year	January 1999	January 2000	January 2001	January 2002	January 2003	January 2004	January 2005	January 2006	present
Total Ethanol Plants	50	54	56	61	68	72	81	95	97
Ethanol Production Capacity	1701.7 mgy	1748.7 mgy	1921.9 mgy	2347.3 mgy	2706.8 mgy	3100.8 mgy	3643.7 mgy	4336.4 mgy	4481.4 mgy
Plants Under Construction	5	6	5	13	11	15	16	31	33
Capacity Under Construction	77 mgy	91.5 mgy	64.7 mgy	390.7 mgy	483 mgy	598 mgy	754 mgy	1778 mgy	1893 mgy

Source: Renewable Fuels Association, 2007.<sup>63</sup>

There are currently no ethanol production facilities in New York State. However, as of 2007, there are four ethanol production plants currently planned and/or under construction in New York state, although there are no concrete dates for when they will be opened. These include plants: 1) in Fulton (110 mmg capacity); 2) Shelby (50 mmg); Caledonia (55 mmg); and the Seneca Army Depot (55 mmg). It is projected that these plants will consume 90 million bushels of corn, of which 14-18 will be produced locally<sup>64</sup>

Of the total US ethanol production, New York State use of ethanol as a fuel additive was 224 million gallons in 2004.<sup>65</sup> According to the Farm Credit Association, New York represents the second largest ethanol market in the US.<sup>66</sup>

According to a recent report from researchers at Carnegie Mellon University, published in the May 1, 2006 issue of the American Chemical Society's Journal Environmental Science and Technology, ethanol derived from the dry, brown switchgrass, a cellulosic ethanol, could be made in sufficient quantities to deliver 16 percent ethanol fuel to all consumers in the U.S. Researchers said this would likely lead to significant decreases and stability in the price of gasoline. "It's a renewable resource," Griffin said. "Rather than taking a depletable resource from the ground, switchgrass can be grown again and again."<sup>67</sup>

However, current estimates are that the capitol costs of getting a cellulosic ethanol plant online would cost five times that of a corn ethanol production plant.<sup>68</sup> The Logen

Corporation is planning to break ground in approximately one year on the world's first cellulosic ethanol plant in Southeast Idaho, which will make ethanol from straw. They are currently developing the enzymes needed to break down the cellulose. A Logen Corporation representative states that the energy costs will be much lower using the cellulosic ethanol process, and they will be able to produce a gallon of ethanol for under \$1.50.<sup>69</sup>

### Estimates of Biofuel Production Potential in Dutchess County

There are very few studies of the potential for biofuel production in New York State or Hudson Valley. Most experts agree that cellulosic ethanol will not be commercially viable for 5-7 years.<sup>70</sup> Scientists at Cornell University have stated that New York State has approximately 1.5 million acres of under-utilized crop-land, where biofuels could potentially be grown. They argue that managed grass could be economically grown on 96% of this acreage, producing a total of appraising 6 million tons of biomass.<sup>71</sup>

Cornell Cooperative Extension Dutchess County has been facilitating a Biofuels Working Group in Dutchess County since 2006, which meets quarterly to discuss the production of biofuels and cellulosic ethanol in the region. Members of the Cornell Cooperative Extension Dutchess County Biofuel Working Group have made preliminary calculations about how much farmland in Dutchess County could be used to grow cellulosic ethanol. One current estimate is that 3,000 acres of land could be converted to agriculture biomass production in the near future in Dutchess County, with the potential to convert 10,000 acres of land in the future if the economic benefit of production is proven to farmers.<sup>72</sup> The current research is exploring switchgrass, but also other native grasses that will grow easier in the Hudson Valley. To be economically viable, cellulosic ethanol production would need to be able to use a variety of native crops, as compared to a monoculture that is not native to the area.

The CCEDC Agriculture Program is also involved with implementing a grant program to grow switchgrass, a native grass that can be processed into ethanol. The switchgrass is being grown at two farms in Dutchess County and a public demonstration site at Extension's office on Route 44 in Millbrook, NY. In addition, three educational programs at these sites are being planned for the summer and fall of 2007.<sup>73</sup> There are no accurate current estimates of how much feedstock could be potentially grown in the Hudson Valley; the first test plots at CCEDC were only planted in summer 2006, and it will take three years for the crops to reach maximum yield.<sup>74</sup> Results of these studies will be made available to the public as they are completed.

A draft feasibility study of a pilot biodiesel plant for the Hudson Valley was completed with funding from the Dutchess County IDA, following a Biodiesel conference held at Marist College in June 2004. The draft Executive Summary finds that the direct cost to build a 275-gallon biodiesel processor, retrofitting an existing facility in the County, with the ability to produce over 70,000 gallons of biodiesel annually, would be \$60,000 for equipment and training. This facility would initially be fueled by waste vegetable oil as the energy input, with the eventual goal of using locally grown virgin crops.<sup>75</sup> There have no feasibility studies conducted to date focusing on the construction of a cellulosic ethanol plant in Dutchess County.

### Conclusions

Due to requirements to show "measurable progress" to achieve the National Ambient Air Quality Standards (NAAQS) for ozone under the Federal Clean Air Act, New York State has included Dutchess County (as part of the Poughkeepsie, NY 8-Hour Ozone Non-Attainment Area) as an "Opt-in Area" to the Reformulated Gasoline Program. The use of Reformulated Gasoline is one of the policies currently required under the NY State Implementation Plan

(SIP) to meet the ozone NAAQS. Practically, since the use of MTBE has been banned in New York State, ethanol is the only option available for RFG, and currently makes up about 10% of the Reformulated Gasoline used in the Poughkeepsie, NY area (see data from Table 2).

Regarding the potential to produce biofuels in Dutchess County, Dutchess County farms could potentially produce a portion of the feedstock necessary for an ethanol production plant in the County. The maximum cost effective operations of an ethanol production facility in the County, however, would likely require raw material inputs from outside the region. Dutchess County farmers are currently growing switchgrass, a potential feedstock for cellulosic ethanol production, at three experimental sites in the County through a grant to Cornell Cooperative Extension Dutchess County. However, the production of ethanol from cellulose is not expected to be a commercially available or economically viable technology in the United States for 5-10 years.<sup>76</sup>

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