APPENDIX L: SELECTED FUTURE PRODUCTION PATHWAYS IN NEW YORK

RENEWABLE FUELS ROADMAP AND SUSTAINABLE BIOMASS FEEDSTOCK SUPPLY FOR NEW YORK

Final Report

Submitted to
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Contract # 10994
NYSERDA Report 10-05

March 2010

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Acknowledgements

The authors acknowledge the efforts of the following people:

Contributors at the University of California, Davis - National Biorefinery Siting Model (NBSM) Development Team, Nathan Parker, Quinn Hart and Peter Tittman. The UC Davis team input the New York resource and technology data for lignocellulosic biomass resources and executed the siting optimization model runs for this key segment of the resource and industry. Nathan Parker also assisted the Antares team in interpreting the results of the NBSM model output for New York.

The New York Renewable Fuels Roadmap Modeling Team: Nathan Rudgers of the Western New York Farm Credit Bureau, James Winebrake of the Rochester Institute of Technology, Peter Woodbury of Cornell University, Tim Volk of the SUNY College of Environmental Science and Forestry, and David Swenson of Iowa State University for their input and guidance on key modeling decisions and assumptions.

TABLE OF CONTENTS

Section **Page**

1 SCENARIOS AND SENSITIVITY CASES FOR DEVELOPMENT OF A BIOREFINING INDUSTRY IN NEW YORK L-1
- 1.1 Scenarios and Sensitivities L-1
- 1.2 Scenario Analysis L-2
- 1.3 Sensitivity Analysis L-3

2 SCENARIO RESULTS FOR INDUSTRY DEPLOYMENT MODELING L-5
- 2.1 Results Overview L-5
- 2.2 Biofuel Price Sensitivity L-8
- 2.3 Technology Choices for Scenario Modeling and Interpretation of Results L-11
- 2.4 Feedstock Choices for Scenario Modeling and Interpretation of Results L-12
- 2.5 Biorefinery Siting Results L-13

3 REFERENCES L-20

APPENDIX L-A: CALCULATION OF GASOLINE EQUIVALENTS L-21

FIGURES

Figure **Page**

Figure L-1. Scenario Analysis as a Tool for Policy Development. L-1
Figure L-2. Gasoline Substitute Biofuels Production - Base Case. L-8
Figure L-3. Projected Increase in Biofuels Production - High Price Case. L-10
Figure L-4. Supply Shed Regions. L-13
Figure L-5. Siting Map for Lignocellulosic Feedstock Supply Sheds - Scenario 1. ..... L-14
Figure L-6. Siting Map for Lignocellulosic Feedstock Supply Sheds - Scenario 2. ..... L-15
Figure L-7. Siting Map for Lignocellulosic Feedstock Supply Sheds - Scenario 3. ..... L-16
Figure L-8. Siting Map for Grain Based Ethanol Production. L-17
Figure L-9. Siting Map for Soy Biodiesel Production. L-18
Figure L-10. Siting Map for Yellow Grease Biorefining. L-19

LIST OF TABLES

Table **Page**

Table L-1. Biofuel Conversion Technology Descriptions. L-11

ACRONYMS

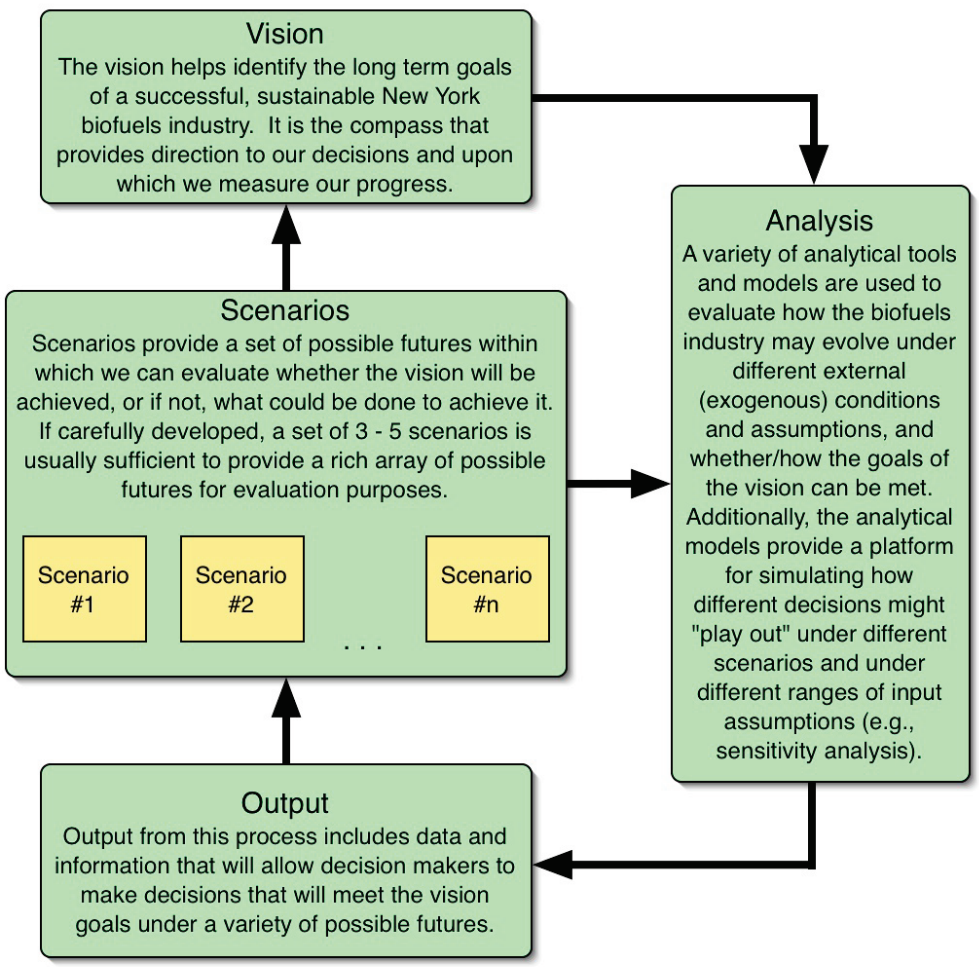
GREET Model	Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation Model – A model developed by Argonne National Laboratory for life cycle environmental analysis.
NYGREET Model	New York GREET model – A version of the GREET Model developed by Energy and Environmental Research Associates, LLC that uses input assumptions relevant for New York State.
NBSM	National Biorefinery Siting Model – A biorefining industry supply chain optimization model developed for the Department of Energy and the Western Governors' Association by UC Davis, Antares, and Dr. Richard Nelson.
GHG	greenhouse gases
MGY	million gallons per year
DOE EIA	Department of Energy , Energy Information Administration
Mbbl	thousand barrels
gge	gallon of gas equivalent

1 SCENARIOS AND SENSITIVITY CASES FOR DEVELOPMENT OF A BIOREFINING INDUSTRY IN NEW YORK

1.1 SCENARIOS AND SENSITIVITIES

No one can predict with certainty what combination of biomass feedstocks, conversion technologies and biorefining products will be in place by 2020, or the scale of production. For this project, scenarios allow analysts and policy makers the opportunity to envision structurally different ways that a biorefining industry might develop in New York. All of the scenarios represent possible futures for the biofuels industry and not just a "technical potential" that disregards economic and environmental sustainability. Sensitivity analyses examine different values (over a range) of a given input assumption within a scenario. In projects like this, sensitivity analyses are used to capture the influence of variations on key drivers. The diagram below Figure L-1 provides a perspective of how vision development and scenario analysis work together to produce a set of outputs that will inform decision makers in New York about the opportunities and challenges for developing a biorefinery industry.

Figure L-1. Scenario Analysis as a Tool for Policy Development.



1.2 SCENARIO ANALYSIS

The Roadmap Team constructed several scenarios that represent significantly different ways in which a biorefining industry might develop in New York. For each scenario a physically and spatially realistic model of the industry has been built using:

- The possible location and quantities of biomass feedstocks that could be produced and harvested in New York.
- The possible locations, technologies and capacities of biorefineries for processing feedstocks to fuels.
- The existing network of roads, rail and water routes over which feedstocks will be transported to biorefineries and then from the refinery to existing terminals for blending and dispatch to local retailers and fleets.

Costs associated with each element of the supply chain are built into the sub-models and datasets of the overall system model. This allowed the team to use an optimization program developed at the University of California, Davis (UCD).[1] The optimization program analyzes all of the components of the supply chain up to the blending terminals (distribution point). Depending on the scenario, the model is used to predict the location, the capacity, feedstock sources, and transport modes and routes of future biorefineries. The model is constrained to ensure that these sites will be profitable for any given wholesale price for the biofuels produced. By incrementing the price that might be paid for transportation fuels, a supply curve for biofuels production can be built that illustrates the relationship between price and quantity.

The analysis is a snapshot of a fully developed industry at any price point. Time is also a factor—how fast the industry actually grows will depend on economic factors, achievement of refinery and feedstock performance expectations, and on the state and federal policies in place that could encourage investment in biorefinery facilities and vehicle innovation. A full description of the optimization model is provided in a paper jointly authored by the NBSM development team (Parker 2008).

The characteristics of the model of the industry are used to evaluate the projected physical, economic and environmental footprint of the biorefinery industry under a given set of conditions. This provides a solid basis for examining the role of biofuels in the mix of energy resources for the State of New York. The scenario analysis emphasizes the possible outcomes for technologies to convert lignocellulosic feedstocks to biofuels, particularly ethanol. The analysis also includes the contributions of existing facilities for converting grain to ethanol and oil seeds or waste grease to biodiesel. Three scenarios are considered:

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[1] The model is currently a component of the National Biorefinery Siting Model (NBSM)

***Scenario 1 -* "Big Step Forward"**

This scenario represents rapid development of a lignocellulosic biofuels industry, circa 2020-2030. For this modeling exercise, rapid development of lignocellulosic feedstock resources is assumed on a portion of suitable and available rural lands.

***Scenario 2 -* "Giant Leap Forward"**

This scenario represents very rapid development of a lignocellulosic biofuels industry, circa 2020-2030, requiring very rapid advances in feedstock production and conversion technologies. The land base for feedstock production is greater because of the use of cropland, but only by the amount of land estimated to become available due to increases in crop yield and milk yield per cow such that current crop and milk production levels could be maintained.

***Scenario 3 -* "Distributed Production"**

This scenario envisions the same feedstock production and technology performance as for Scenario 2. However, this scenario models a distributed industry with no single biorefinery capacity exceeding 60 MGY, except for the existing grain ethanol biorefineries.

1.3 SENSITIVITY ANALYSIS

Sensitivity analyses provided insights into how scenario results might be affected by changes in key variables. The key sensitivity case evaluated in this assessment was the impact of increased wholesale fuel prices on the amount of biofuels that could be profitably produced. The base case was evaluated using the DOE EIA transportation fuel prices forecast for 2020, and a high fuel price case was developed based on the value of current incentives for biofuels. The cases and the price calculations are discussed in detail in the section below entitled "Biofuel Price Sensitivity". Key variables agreed upon by the Roadmap team include:

Economic Considerations – Variables such as petroleum prices, grain prices, and land rents can all be addressed in the model. The supply curve,[2] developed for each scenario, maps the relationship between the quantities of biofuels produced in the state and the marginal wholesale price offered for biofuels. For each increment in the marginal price paid for biofuels, the model calculates the increase in the quantities of biofuels that could be profitably produced and the feedstocks consumed to support that production, based on assumed feedstock and technology characteristics.

Increasing Competition for the Resource – This effect can be evaluated in each scenario in several ways. Increasing profitability for suppliers (landowners, growers, harvesters and aggregators) as demand moves up the

[2] For this modeling effort, a supply curve was not graphed; explicit data points were chosen for analysis.

supply curve will reduce the amount of biofuels produced for any given marginal price. Alternatively, segments of the forecast supply can be set aside and allocated to other end uses. This has the effect of increasing the costs of feedstocks by increasing hauling distances to acquire the same volume of feedstocks at a given plant. The net effect is to shift the supply curve for biofuels toward higher production costs over the entire curve. This effect was not quantitatively analyzed for this assessment. A more general treatment of competition for the resources is provided in Appendix O and P.

Increasing Land Base, Yields, Harvest Efficiency and Process Efficiency – These effects can all be varied within each scenario by adjusting the models for each step in the supply chain. For the scenario analysis, the land base for production and the process efficiency were both varied to capture those effects.

Greenhouse Gas Impacts – The greenhouse gas emissions for each element of the industry are examined in the NYGREET Model[3] for each scenario. It may be possible in future updates to develop supply curves that select systems with the lowest carbon footprint first, in order to build supply curves optimized for carbon emissions control.

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[3] This model is based on the national GREET model developed at Argonne National Lab, but uses input assumptions relevant for New York State, such as electricity mix, fuel transportation distances, and agricultural assumptions

2 SCENARIO RESULTS FOR INDUSTRY DEPLOYMENT MODELING

Model results for each scenario selected specific fuels and technology under a specific set of conditions and inputs that are forecast for circa 2020. The model does not take into account the time it takes to finance, permit and build projects of this magnitude. Rather, it provides a snapshot of the industry that has reached steady state and is profitably producing biofuels for the New York transportation fuel markets. The model also assumes that the plants will use the available feedstock resources within economic hauling range of the facilities (usually a distance of 100 miles or less). In every case the lignocellulosic feedstocks are the predominant future biomass resource, while existing soy crops and waste greases are used for biodiesel production. Corn crops already or potentially serving the two existing grain ethanol biorefineries are also included in the production estimates to provide a complete picture of the industry.[4]

To put production results for each scenario in perspective, they are compared to the DOE EIA reported transportation gasoline consumption in New York. Consumption was 136,714 Mbbl (thousand barrels) for 2007, which is equivalent to 5,741 MGY (EIA 2008). With the modest forecast growth of 0.4% per year projected by EIA, consumption would reach 6,048 MGY by 2020 (EIA 2009). Consumption of diesel fuel for transportation in New York was 1,170 MGY in 2007 (EIA 2008). With a forecast annual growth of 1.1%, total diesel fuel consumption is projected to be 1,348 MGY by 2020 (EIA 2009).

2.1 RESULTS OVERVIEW

The physical and spatial characteristics of the biorefinery industry were modeled for each scenario. In all the projections, the greatest potential for biofuels production by 2020 lies in the development and deployment of lignocellulosic biorefineries producing gasoline substitutes (ethanol). Among the scenarios analyzed, the projected ethanol production from lignocellulosic feedstocks varies between 350 and 1,300 MGY. There is additional ethanol production from the existing grain ethanol facilities in New York, which are projected to have a combined output of 154 MGY when operating at full capacity in 2020. No growth is projected beyond this current capacity for grain-based ethanol.

In addition to gasoline substitutes from biomass, a projection is provided for the contribution to diesel fuel substitutes derived from soy and waste greases. For the lower diesel fuel price sensitivity case (competing at the 2020 forecast price for diesel fuels and without any incentives), biodiesel production is not projected to grow at all. However, if the higher diesel fuel price sensitivity case is realized, biodiesel produced from these sources could supply up to 30 MGY in each scenario (9.6 MGY from soy crops and 18.7 MGY from waste greases). This would satisfy 2% of the projected diesel demand in New York.

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[4] Western New York Energy, LLC, is located in Medina, NY, currently operating and producing 54 MGY of corn ethanol, using 18.5 million bushels of corn, of which 80% is currently sourced from within New York. The second plant is located in Volney, NY. Sunoco Inc. purchased the plant from Northeast Biofuels in June 2009. It is anticipated that it will produce 100 MGY when it becomes operational.

Current Capacity for Biofuel Production

The existing grain ethanol facilities in New York, capable of producing 154 MGY in total when operating at full capacity, are projected to continue to produce biofuels in 2020. No further growth beyond that current capability for grain-based ethanol is projected in this assessment. One of those facilities is not operating now, but is scheduled to be refurbished and brought on line in the near future. For this production rate, the equivalent of 76% of the current corn grain crop would be required. There is also existing biodiesel capacity. Northern Biodiesel is located in Ontario, NY. The facility's commercial startup was in May 2008 and its current plant capacity is 10 MGY. Northern Biodiesel produces biodiesel primarily from yellow grease and choice white grease (pig fat), of which an estimated 25-30% is sourced locally and the rest is brought in from out of state. Buffalo Biodiesel has the capacity to produce biofuels, but is currently operating solely as a rendering plant. All scenarios represent additional development beyond this current capacity, using lignocellulosic resources produced in New York.

***Scenario 1* - "Big Step Forward"**

This scenario represents rapid development of a lignocellulosic biofuels industry, circa 2020-2030. For this scenario, rapid development of lignocellulosic feedstock resources is assumed on a portion of suitable and available rural lands. The available land base excludes all land currently in food production. Potential feedstock production is estimated to be as follows (millions of dry tons): Hardwood chips 3.44, softwood chips 1.37, warm-season grass 2.28, short-rotation willow 2.06, and corn stover 0.25. Wood chips are to be sourced from well-managed harvests primarily of low-value wood from existing forests. The grass and willow would use 0.98 million acres of land currently in herbaceous cover that is not required to meet current agricultural needs. Conversion technology is assumed to have met the cost and performance expectations for the first generation (near term) of lignocellulosic biorefineries (including biochemical and thermochemical systems).

In all scenarios, the base case is also the low fuel price sensitivity case - unsubsidized direct competition with petroleum based fuels. For this scenario's base case, four lignocellulosic biorefineries could be profitably built, producing ethanol at a total production capacity of 354 MGY. All four biorefinery sites are located central to the resource-producing regions of New York. The average capacity at these sites is approximately 90 MGY.

In addition to the lignocellulosic ethanol production, all scenarios also show that the current corn ethanol capacity in New York should continue to operate profitably, which adds 154 MGY of grain ethanol. With this addition, the total New York production of renewable gasoline substitutes would reach 508 MGY in Scenario 1. New York could therefore meet about 5.6% of its transportation gasoline consumption in 2020 with home grown biofuels.[5]

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[5] See Appendix L-A for details. In short, for Scenario 1, 508 MGY ethanol * 0.657 gasoline equivalents / 6,048 MGY (projected 2020 consumption) = 334 MGY gasoline equivalents, which is 5.6% of 2020 forecast consumption.

***Scenario 2* - "Giant Leap Forward"**

This scenario represents accelerated development of a lignocellulosic biofuels industry, circa 2020-2030, requiring very rapid advances in feedstock production and conversion technologies. The land base for feedstock production is greater because of the use of cropland. However, this includes only the land area estimated to become available because increases in crop yields (per acre) and milk yields (per cow) would allow current crop and milk production to be maintained. Potential feedstock production in this scenario is estimated to be as follows (millions of dry tons): Hardwood chips 4.70, softwood chips 1.72, warm-season grass 4.59, short-rotation willow 3.32, and corn stover 0.25. Wood chips would be from well-managed harvests primarily of low-value wood from existing forests, with greater harvesting rates than in Scenario 1. The grass and willow would use 1.68 million acres of land that is not required to meet current agricultural needs. In this scenario the advanced technologies for lignocellulosic biorefineries (including biochemical and thermochemical systems) are assumed to be ready for commercial deployment.

The base case results for Scenario 2 (unsubsidized direct competition with petroleum-based fuels) shows that lignocellulosic biorefineries producing ethanol at a total production capacity of 1,295 MGY could be profitably built and operated, which is about four times the capacity projected for Scenario 1. The production units are modeled to be built at the same four central sites as in Scenario 1, with total average capacity at each site approximately 325 MGY. In effect the model predicts that with the advanced conversion technologies all of the available resources would be consumed in production. ***This level of production is very unlikely if we were to incorporate competition for those resources in the modeling and accounted for the time it would take to build the infrastructure to supply these facilities. For this reason, this is a scenario that would take much longer to actually implement even if the technology improvements were achieved by 2020. Furthermore, constraints for site permitting and logistical issues would further limit the actual capacity built by this time.*** It is important to point out that each site could consist of one very large conversion system, or more likely multiple units operating at the same site (e.g. two 150 MGY units in the same area providing a total capacity of 300 MGY). In the Scenario 2 base case, the total New York production of renewable gasoline substitutes including the grain-derived ethanol would reach 1,449 MGY. With this production, New York could meet about 16% of its transportation gasoline consumption with home grown biofuels.[6]

***Scenario 3* - "Distributed Production"**

This scenario envisions the same feedstock production and technology performance as for Scenario 2. However, this scenario models a distributed industry with no single biorefinery capacity exceeding 60 MGY, except for the existing grain ethanol biorefineries. While grain ethanol facilities currently in the planning stages are reaching the 300 MGY mark, the plant size was constrained to 20% of that scale in order to draw upon local biomass resources

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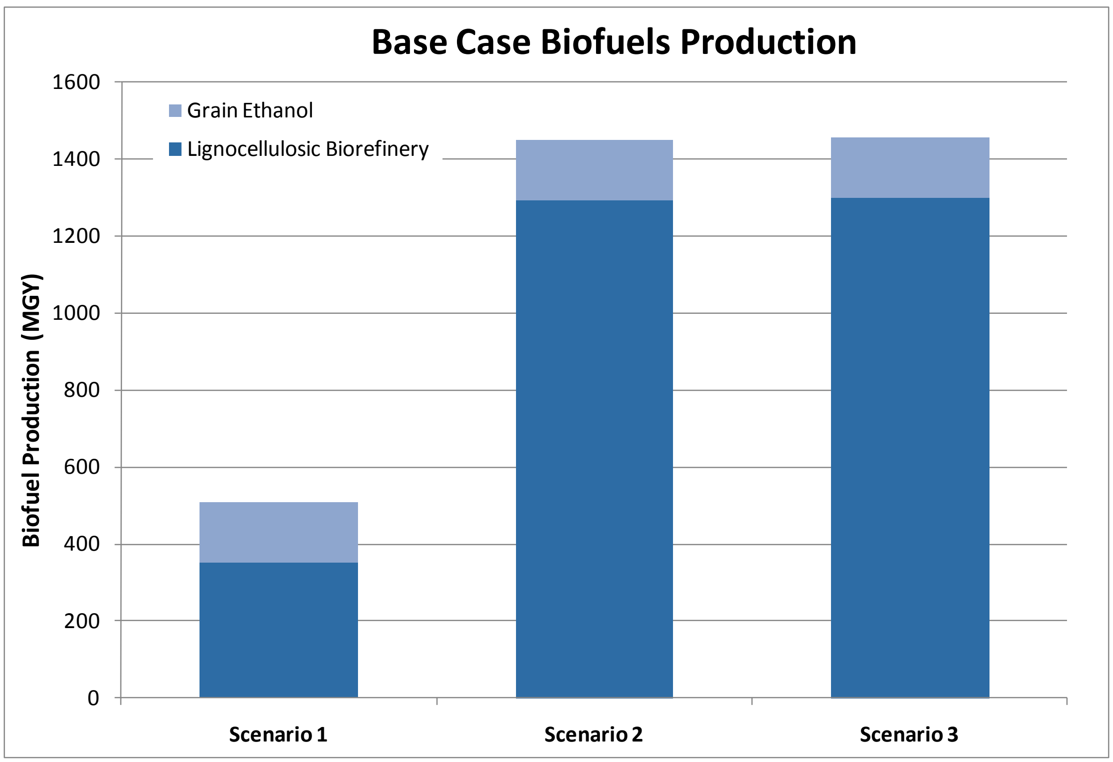
[6] See Appendix L-A for details. In short, for Scenario 2, 1,449 MGY ethanol * 0.657 gasoline equivalents / 6,048 MGY (projected 2020 consumption) = 952 MGY gasoline equivalents, which is 16% of 2020 forecast consumption.

(within typically a 50-mile radius) and to serve local markets or blending terminals. While smaller facilities are usually disadvantaged by both the economies of scale in physical plant and development costs, they represent less financial risk and tend to have proportionately lower impacts on local communities such as road traffic congestion. However, the same caveat about competing resource demand described in Scenario 2 also applies to this scenario. In this scenario, the model predicts that 24 biorefineries built throughout the state would achieve the same capacity as Scenario 2 (1,449 MGY).

The projected ethanol production capacities for all three base case scenarios are compared in Figure L-2. As discussed above, New York could triple its biofuels production capacity if feedstock availability and advanced conversion technologies meet their goals. The base case biofuels production scenario does not project any increase in biodiesel production in the state.

Figure L-2. Gasoline Substitute Biofuels Production - Base Case.



2.2 BIOFUEL PRICE SENSITIVITY

Predicting transportation fuel prices for 2020 is even more difficult than projecting technology and feedstock cost and performance gains. On the biofuels supply curve for New York, two price points were selected for detailed analysis. The EIA national forecast prices for gasoline and diesel fuel for 2020 are the basis for the base case prices (EIA 2009). This forecast is tailored for a New York-specific price projection by applying the ratio of current New York wholesale fuel prices to the national average. The expected price escalation is calculated as the ratio of the 2020 projected price to the actual prices for 2008 for the EIA updated reference case (EIA 2009). Since the biorefinery siting model calculates the price of biofuels delivered at the terminal for blending, the wholesale price is used to determine product value.

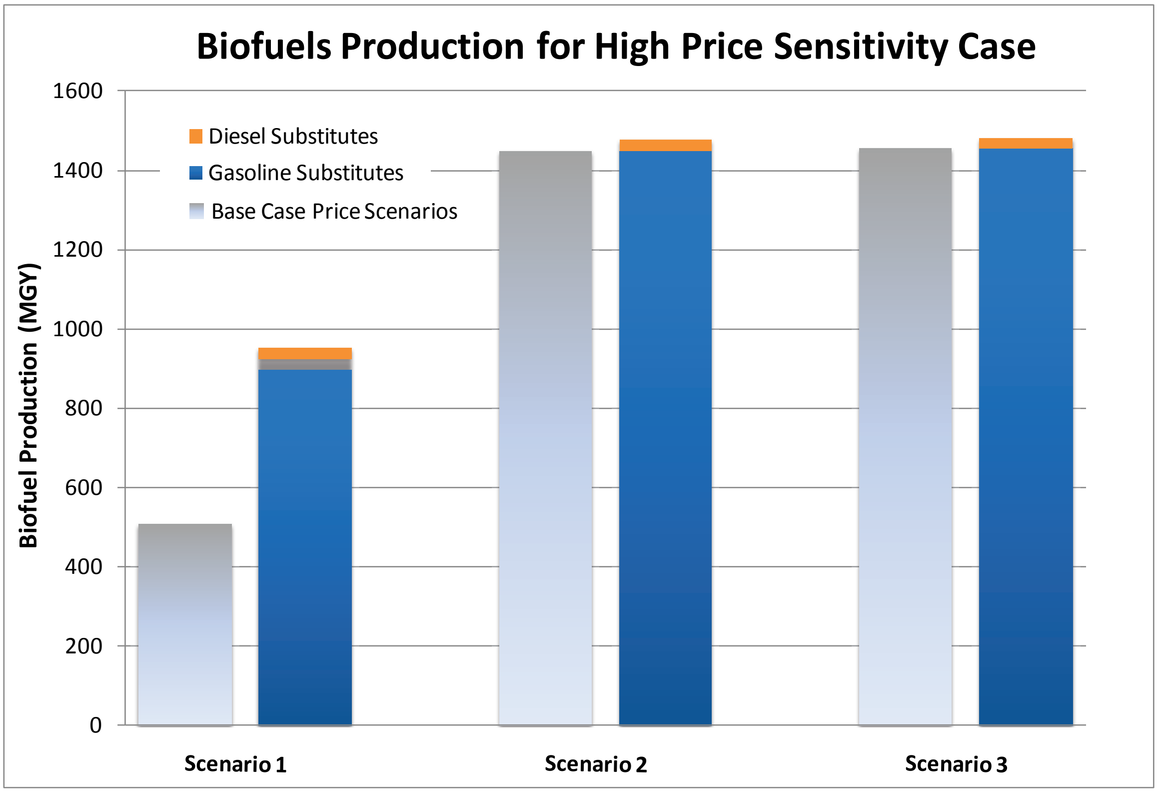
For the higher price sensitivity case, the forecast price was increased by $1.00 per gallon of gas equivalent (gge).[7] There are two ways to interpret the higher price forecast: (1) if EIA projections for modest price growth are correct, then the increase in the forecast price would equate to the biofuels subsidy or some combination of "green" fuel credits comparable to the current subsidy; or (2) if prices rise faster than the (New York tailored) EIA forecast, then the increased forecast price would sustain the predicted biofuels production without subsidy.

The forecast average wholesale price for gasoline[8] for New York in 2020 is $2.98 per gge, based on the EIA's projected national gasoline price escalating 8.4% from 2008 values. In contrast, diesel is forecast to decline 1.67% from the current 2008 level, to $2.94/gallon wholesale in 2020. This projected diesel price equates to $2.65/gge due to the higher heat content of diesel fuel. For each scenario, the impact of a $1.00/gge increase over the EIA forecast price for gasoline in 2020 was evaluated. For the higher price sensitivity case, this added value increases the forecast target price for gasoline and diesel substitutes to $3.98/gge and $3.65/gge, respectively. Figure L-3 shows the results for the high price sensitivity case for each scenario.

[7]The diesel price is converted to gallons of gasoline equivalent based on the ratio of higher heating values.

[8] Many factors (taxes, competition, location, demand) determine the retail versus wholesale pricing in a state and regions within the state. There is a reasonable correlation between averages for the two prices on a broad scale. Based on EIA data the average retail price could be between 20 and 60 cents per gallon above the wholesale price at any specific location.

Figure L-3. Projected Increase in Biofuels Production - High Price Case.



For Scenario 1, the impact of higher prices for fuel is significant. Biorefinery output is projected to increase from 508 MGY to 924 MGY, an increase of 82%. Since Scenario 1 represents the use of near term (first generation) technology and has a lower quantity of available biomass resources, it is clear that the additional value for a biofuel product would provide a powerful incentive for early expansion of the industry. For Scenarios 2 and 3 where advanced or second generation performance and cost improvements are incorporated into the production of biofuels, the higher price brings little or no increase in production. In these scenarios biofuels production is essentially resource limited. As such, if resources outside the state were considered it is likely that the facilities could profitably use resources with greater associated transportation costs and total New York production could increase. However, biorefineries in neighboring states and provinces are likely to be in competition for those resources. If the biorefineries can achieve the high level of performance modeled in Scenarios 1 and 2, they will be self-sustaining at the base forecast price and should compete directly with petroleum-based transportation fuels. The basis for these potential improvements in technology and feedstocks availability is discussed fully in Appendix H and Appendix E, respectively.

For biodiesel production, the change in price from $2.65/gge to $3.65/gge makes all the difference. At the lower price there is little incentive to increase production in the state. At the higher wholesale price, up to 30 MGY in each scenario (9.6 MGY from soy crops and 18.7 MGY from waste greases) is projected. Despite the significant increase, the projected biodiesel production is still just a fraction of the total biofuel production in the state, largely due to limited low cost resources.

2.3 TECHNOLOGY CHOICES FOR SCENARIO MODELING AND INTERPRETATION OF RESULTS

Table L-1 below identifies the technology choices that were used to represent biofuels production deployment by 2020 for each of the three scenarios. The yield and cost parameters for these technologies at various scales are described fully in the Conversion Technology Appendix H. The technologies with the greatest potential for industry expansion are the lignocellulosic biorefineries that are only now entering the pilot plant and demonstration stage of development. The key difference among scenarios is the role that the lignocellulosic biorefineries play in creating new biofuels production capacity.

Table L-1. Biofuel Conversion Technology Descriptions.

Conversion Technology Choices for Supply Chain Modeling			
Scenario	**1**	**2**	**3**
Representative Technology Choices	Corn ethanol production at existing dry mill facilities	Corn ethanol production at existing dry mill facilities	Corn ethanol production at existing dry mill facilities
	Biodiesel production via conversion of fatty acids to methyl esters	Biodiesel production via conversion of fatty acids to methyl esters	Biodiesel production via conversion of fatty acids to methyl esters
	Emerging technologies for lignocellulosic ethanol via hydrolysis and fermentation or thermochemical synthesis at greenfield facilities	Advanced technologies for lignocellulosic ethanol via hydrolysis and fermentation or thermochemical synthesis at greenfield facilities	Advanced technologies for lignocellulosic ethanol via hydrolysis and fermentation or thermochemical synthesis at greenfield facilities

All scenarios include biodiesel production at a limited scale. They also all project that the existing investments in grain ethanol production in New York will continue to be productive in 2020. At some point these plants may be retrofitted with improved unit processes for grain alcohol production or with additions of lignocellulosic biomass production capacity. These changes are not modeled directly but are discussed in the appendix on conversion technologies.

For Scenario 1, two emerging lignocellulosic biorefinery technologies were chosen to represent technologies with a high likelihood of achieving commercial scale deployment by 2020: biochemical conversion via hydrolysis and fermentation, and thermochemical synthesis. Both of these technologies are entering the commercial scale demonstration phase and both have a reasonable likelihood of success in achieving the cost and performance benchmarks used in our models. Although other new competing technologies for biofuels production are also discussed in the Appendix on conversion technologies, these two technologies best represent the near to mid-term potential for biorefining in terms of competitive cost and performance. The optimization siting model chose the thermochemical conversion process as the lower cost choice for Scenario 1. Comparing the cost performance attributes for the technologies shows that the two are very close in overall cost and performance though quite different in the details. For this reason, the "winning" technology is meant to be representative of what the industry may be capable of, but not to suggest that one technology is so far ahead that it will predominate in the long run.

For Scenario 2 and 3, the advanced lignocellulosic biorefinery technologies were modeled to represent what is possible to achieve if technology RD&D moves at a much faster rate. This will likely require significant government support. This is a more optimistic version of the progress the technology could make based on expectations for R&D already underway. The improvements in biorefinery operation and cost are based on extensive ongoing research and analysis on the biochemical conversion process. Similar improvements are possible with the other technologies. These improvements are critical to creating an economically sustainable industry. Feedstocks prices modeled in this study are an equally critical factor in the economic sustainability of the industry.

2.4 FEEDSTOCK CHOICES FOR SCENARIO MODELING AND INTERPRETATION OF RESULTS

Only New York land was considered when developing the resource forecasts for a biofuels industry in New York. In reality, biorefineries sited in New York currently already draw some feedstocks from outside New York borders. This is expected to continue for future biorefineries.

Three distinct classes of biomass feedstocks are included in the siting optimization analysis for the Roadmap:

- Lignocellulosic biomass (including sustainable harvests and harvest residues from existing forest stands, in addition to willow and switchgrass energy crops grown on available agricultural land)
- Grains and legumes (specifically corn and soybeans)
- Waste fatty acids (waste yellow grease)

The lignocellulosic biomass feedstocks account for the largest proportion of available feedstocks included in the production analysis for every scenario. Improvements to the establishment, management, harvesting, processing and transport of the lignocellulosic energy crops will be a vital element in achieving the production capacity projected in each scenario.

Scenarios 2 and 3 project increased availability of biomass resources for biorefinery development. As discussed in Appendix E, the most significant difference in resources between the scenarios is that in Scenario 1, none of the lands currently planted with row crops were included in the resource forecast. For Scenario 2 and 3, the current levels of agricultural crop production and milk are maintained, but historical increases in crop yield per acre and milk yield per cow were assumed to yield continued improvement during coming decades. Thus in the future, the same amount of production can occur on less land, making a portion of agricultural land available in these scenarios for either increased production of food and feed or biomass.

2.5 BIOREFINERY SITING RESULTS

Siting any industrial facility in New York is a complex process. The optimization model can only capture the highest level of measurable siting criteria by choosing potential sites to evaluate. Foremost of these is proximity to biomass resources. Unlike fossil resources, which are shipped long distances to refineries from around the world, for the foreseeable future biomass resources must be harvested and used nearby. Biomass converted to liquid fuels, electricity or densified into intermediate forms such as cubes and pellets can be used within larger regional supply sheds than unprocessed biomass. Optimizing the supply of raw feedstocks to potential biorefinery locations is one of the key features of the NBSM.

Lignocellulosic Biorefineries: New York has four prominent biomass supply sheds, as depicted in L-4 through L-7 by the contiguous areas of high feedstock production. These supply sheds are identified with names for the overall regions of New York (see Figure L-4 below).

Figure L-4. Supply Shed Regions.

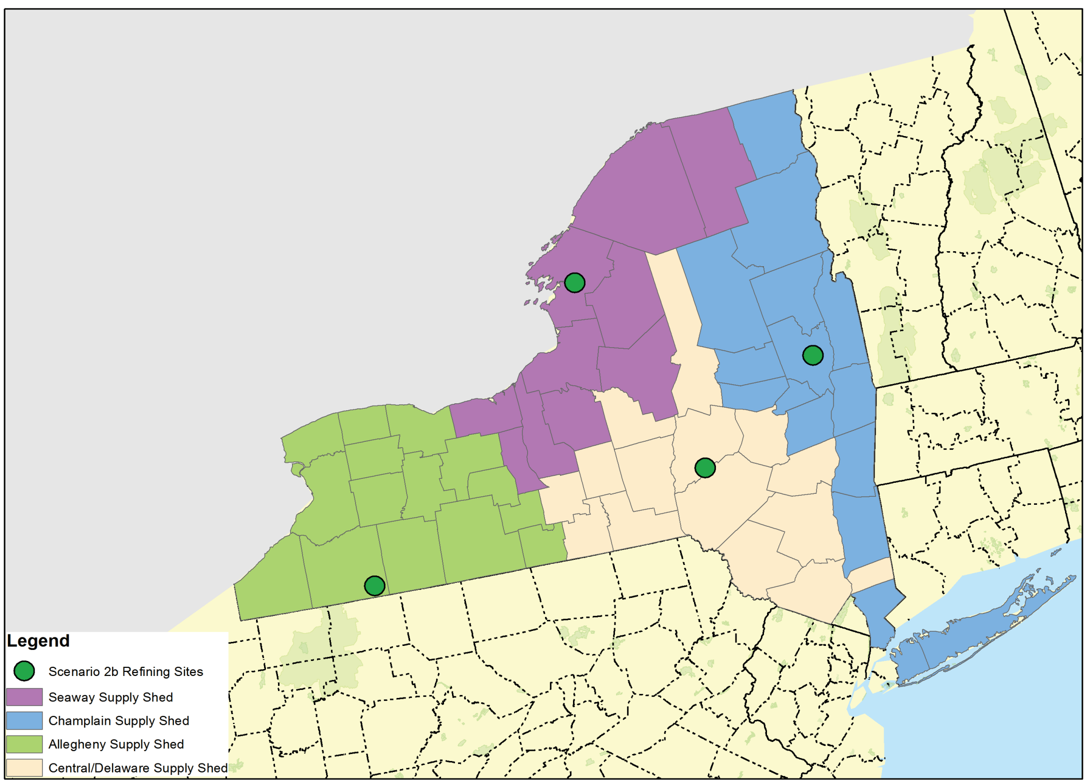
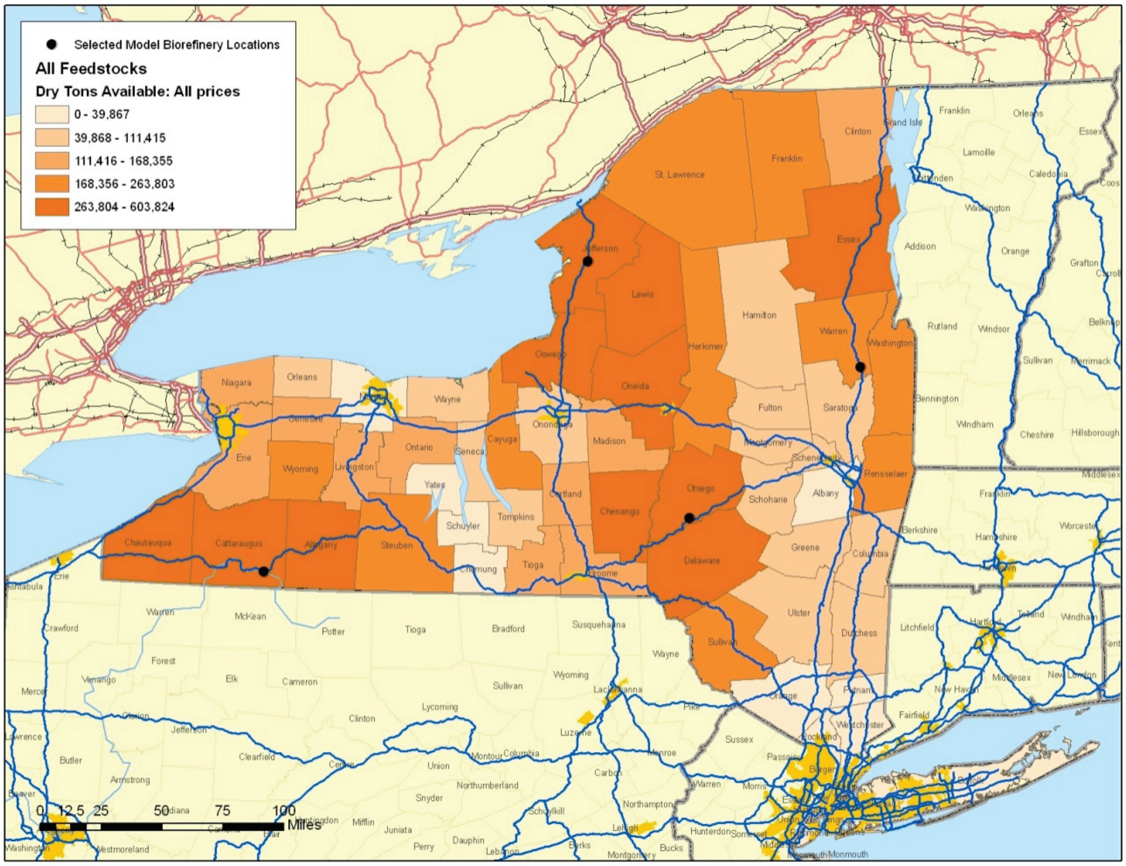
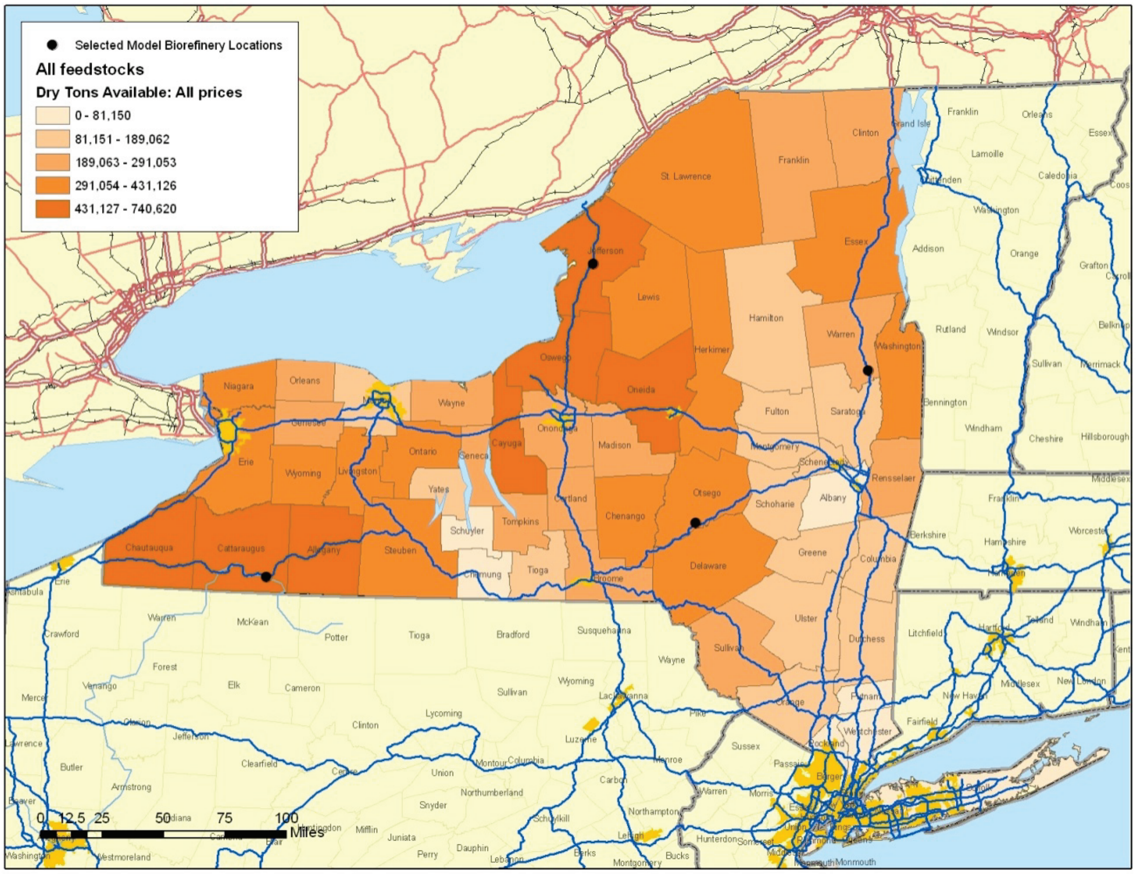


Figure L-5. Siting Map for Lignocellulosic Feedstock Supply Sheds - Scenario 1.



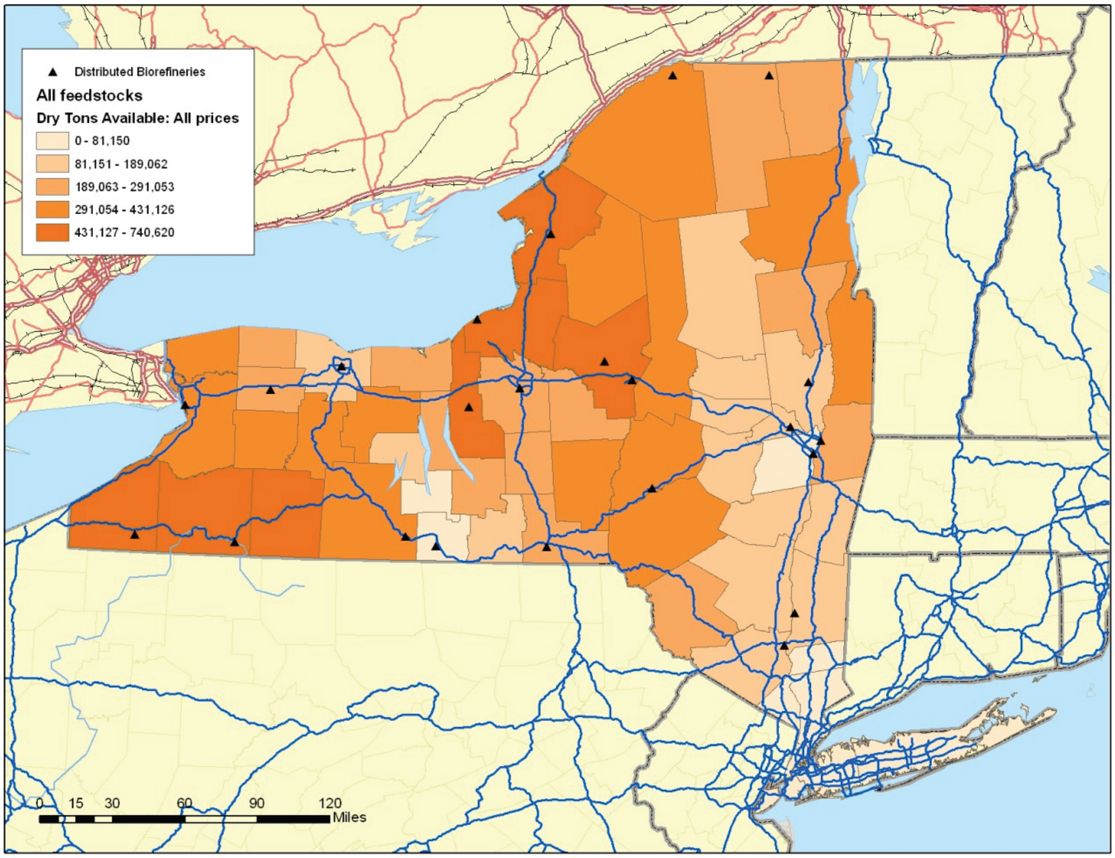
Within these supply sheds the model chooses potential biorefinery sites based on criteria for population (workforce and by proxy water supply infrastructure) and highway and rail access. Sites that would draw from the same supply shed are narrowed down to one site. For Scenarios 1 and 2, representative sites were selected that are central to the supply in each region. For Scenario 2, sufficient feedstock supply exists to build multiple process lines for refineries at the designated locations (Figure L-6). By choosing a specific site the model is able to select optimum transportation routes and modes for every biomass source, assuming feedstocks are loaded at the road at field edges. A centroid roadside location in each county represents the distribution of forests/fields in the county. ***The selection of specific site locations for each scenario is done to realistically determine transportation costs and impacts. Many alternate locations would produce similar results. The site selected for modeling purposes may not be the best actual site when all criteria for siting an industrial facility are considered.***

Figure L-6. Siting Map for Lignocellulosic Feedstock Supply Sheds - Scenario 2.



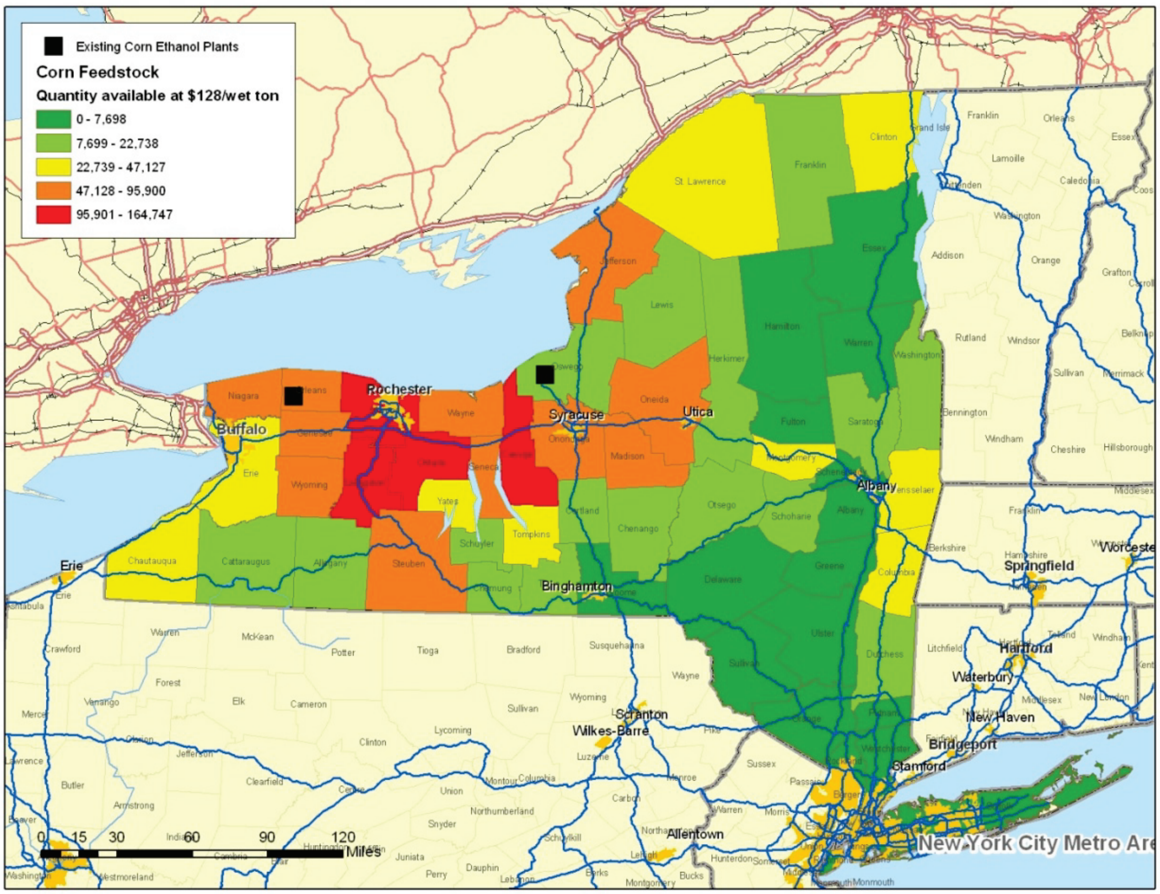
For Scenario 3, the distributed production case, the size of each biorefinery was constrained to a maximum capacity of 60 MGY. The analysis resulted in 24 biorefineries being sited over a wide geographic distribution in the biomass supply sheds. The results for this Scenario are shown in Figure L-7.

Figure L-7. Siting Map for Lignocellulosic Feedstock Supply Sheds - Scenario 3.



Grain Ethanol and Biodiesel Facilities. For the grain ethanol and biodiesel biorefineries, a very different approach was taken. Two corn ethanol plants already exist. One of these is operational, while the other is not (as of early 2010). The latter facility, currently under new ownership, will have new fermentation technology in place when it begins operations. The map in Figure L-8 shows the current corn supply shed for New York.

Figure L-8. Siting Map for Grain Based Ethanol Production.

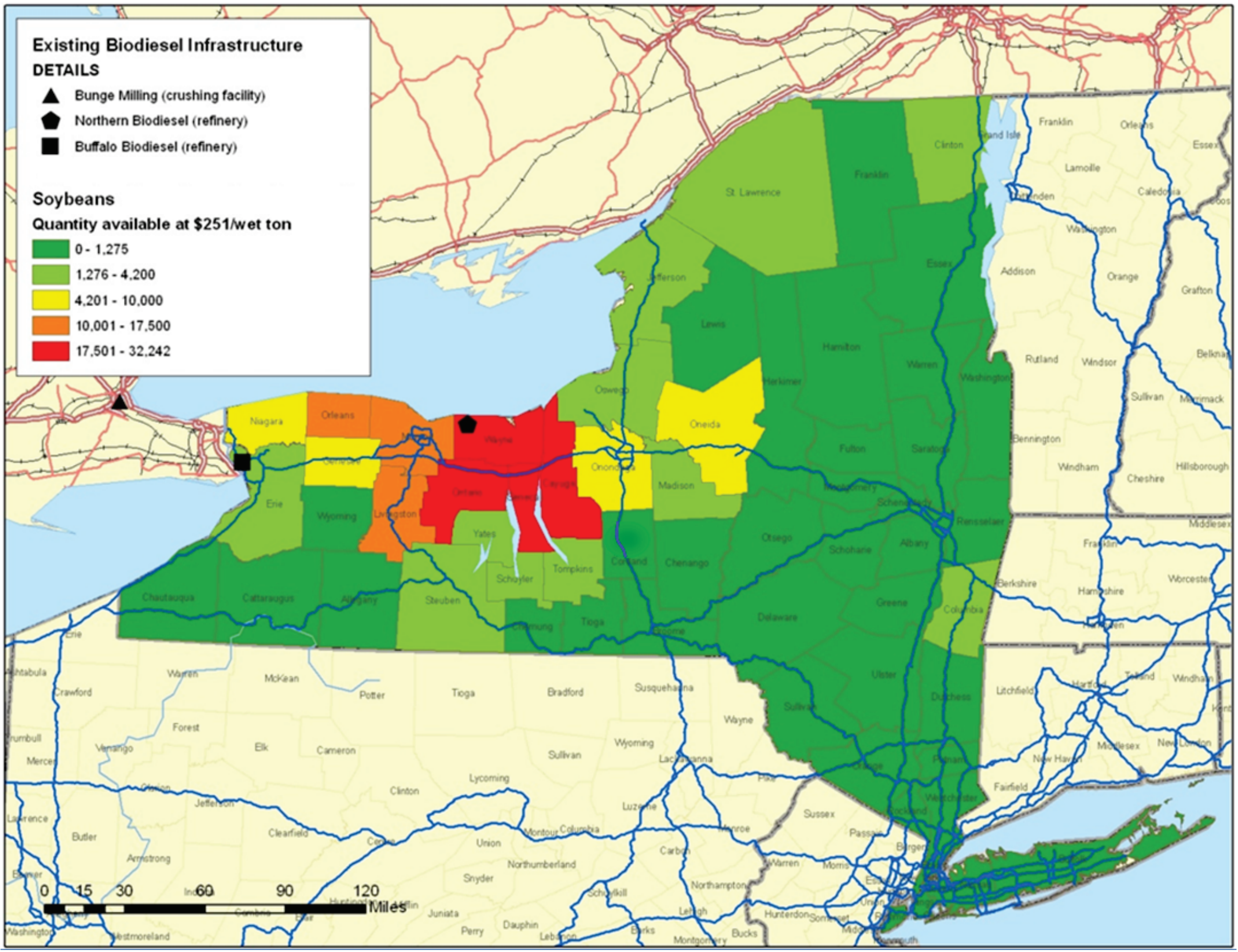


The operating grain ethanol biorefinery draws 80% of its total supply of corn from in-state. It was assumed that all feedstocks would come from within New York. In addition, counties were allocated to each biorefinery on the basis of shortest transportation routes, and transportation hauling mileages and costs were calculated accordingly.

A similar approach was used for the soy resources. There is some smaller scale crushing capacity in the State, however, current soy production in New York may not warrant construction of a new large-scale crushing mill. In fact, a large mill already exists in Hamilton, Ontario -- within relatively easy reach of the soy crop producing counties in New York; and an existing facility, Northern Biodiesel, may also use some of New York's soy feedstocks to produce biodiesel. Therefore, we sited the biodiesel conversion plant in the Buffalo area (Figure L-9).

This arrangement minimizes the capital risk while allowing New York to consider the potential for biodiesel production from soy.

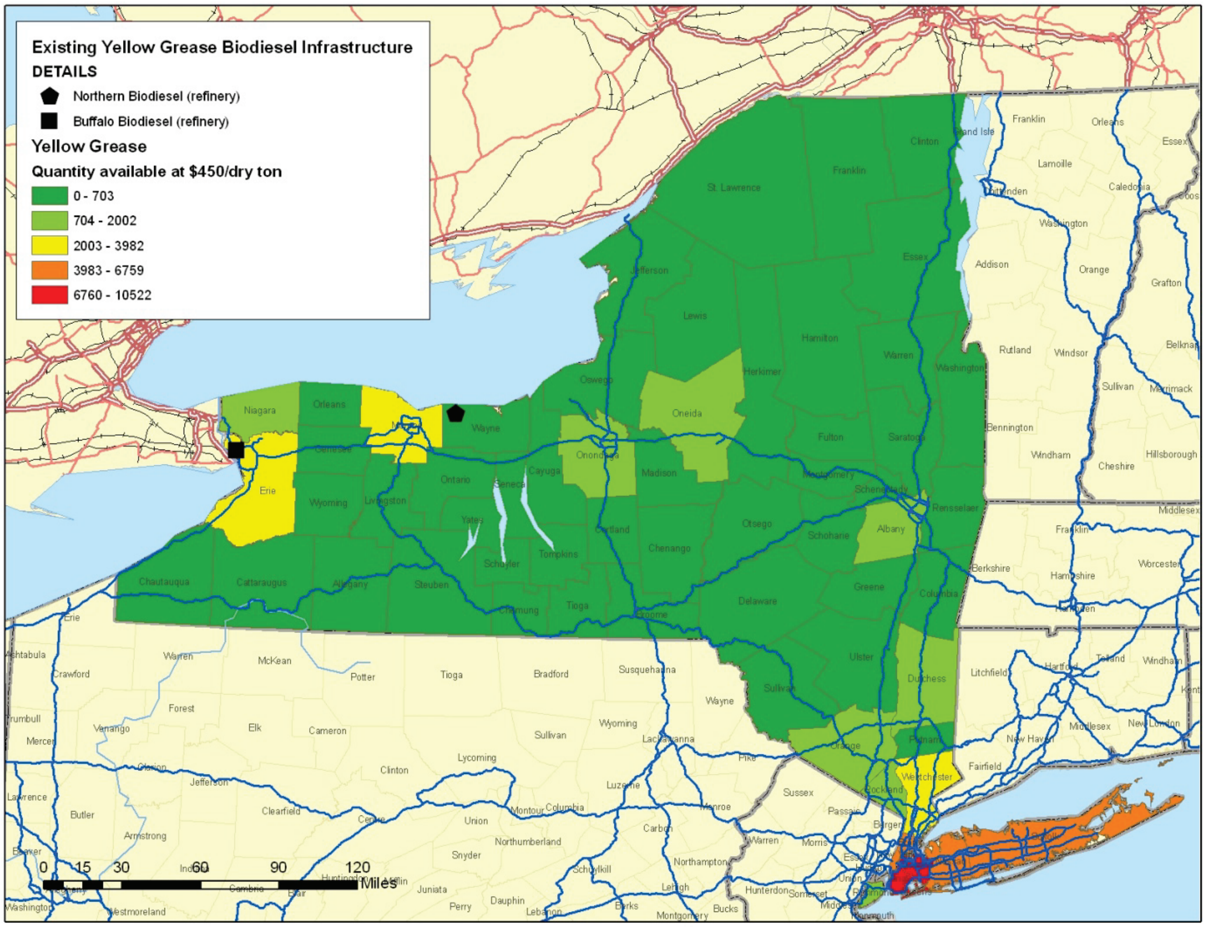
Figure L-9. Siting Map for Soy Biodiesel Production.



Finally, although the waste yellow grease resource is widely distributed throughout the state, there are key urban areas that are the major generators including the metropolitan areas of New York City/Long Island, Buffalo and Rochester (Figure L-10). For the industry modeling effort it was assumed that yellow grease biorefineries would continue to be built on a small scale near or within the major population centers in the state. Buffalo Biodiesel Inc. is an existing plant in Western New York, with the daily production capacity of 30,000 gallons of biodiesel, although at this time the plant is forced to operate primarily as a rendering facility due to difficulties encountered in the retail sale of biodiesel in New York.[9] Northern Biodiesel is producing biodiesel primarily from yellow grease and choice white grease (pig fat) with 10 MGY capacity.

[9] Per conversation with Buffalo Biodiesel General Manager Mike Fayle and President Sumit Majumdar, October 20, 2009.

Figure L-10. Siting Map for Yellow Grease Biorefining.



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EIA 2008 - Energy Information Administration, *Sales of Distillate Fuel Oil and Gasoline by End Use for New York,* U.S. Department of Energy, 12/23/2008 (www.tonto.eia.doe.gov/dnav/pet/pet_cons_821dst_dcu_SNY_a.htm)

Parker 2008 - Parker, Nathan, *Development of a Biorefinery Optimized Biofuel Supply Curve for the Western United States*, Proceedings of the 16th European Biomass Conference & Exhibition from Research to Industry and Markets, Valencia, Spain, June 2008

APPENDIX L-A: CALCULATION OF GASOLINE EQUIVALENTS

Ethanol: Production results for each scenario are compared to DOE EIA-reported transportation gasoline consumption in New York. Consumption was 136,714 Mbbl (thousand barrels) for 2007, which is equivalent to 5,741 MGY (EIA 2008). With the modest forecast growth of 0.4% per year projected by EIA, consumption would reach 6,048 MGY by 2020 (EIA 2009).

Biodiesel: Consumption of diesel fuel for transportation in New York was 1,170 MGY in 2007 (EIA 2008). With a forecast annual growth of 1.1%, total diesel fuel consumption is projected to be 1,348 MGY by 2020 (EIA 2009).

Scenario 1: In addition to the lignocellulosic ethanol production, all scenarios also show that the current corn ethanol capacity in New York should continue to operate profitably, which adds 154 MGY of grain ethanol. With this addition, the total New York production of renewable gasoline substitutes would reach 508 MGY in Scenario 1. Using the conversion factor of 0.657 for LCE dry and wet milling (see table, below) of gasoline equivalents, New York could meet about 5.6% of its transportation gasoline consumption in 2020 with home grown biofuels.[10]

Scenario 2 and 3: In the Scenario 2 base case, total New York production of renewable gasoline substitutes including grain-derived ethanol would reach 1,449 MGY. With this production, New York could meet about 16% of its transportation gasoline consumption with home grown biofuels.[11]

Fuel Type and LHV	BTU/gal	GE	BioConversion Routes
Conventional Gasoline	116,093	1	
Conventional Diesel	128,445	1.106	FAHC
Ethanol	76,330	0.657	LCE, Dry and Wet Milling
FT Diesel	123,669	1.065	LCMD
Biodiesel	119,553	1.03	FAME
Pyrolysis Fuels	66,384	0.572	LCG

[10] 508 MGY ethanol * 0.657 gasoline equivalents / 6,048 MGY (projected 2020 consumption) = 334 MGY gasoline equivalents, which is 5.6% of 2020 forecast consumption.

[11] 1,449 MGY ethanol * 0.657 gasoline equivalents / 6,048 MGY = 952 MGY gasoline equivalents, which is 16% of 2020 forecast consumption.