Alternatives to Oil in the Northeast

How Innovators Are Producing Clean, Local Fuels

ENVIRONMENT NEW YORK
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Executive Summary

Dependence on oil harms the Northeast's environment and economy. Innovators and entrepreneurs are working to develop the fuels of the future: clean alternatives to oil that are less polluting and can be produced right here in the region.

Those efforts can only take root and grow if Northeastern states make a firm policy commitment to integrating clean alternative fuels into our transportation fuel mix. Adoption of a regional Clean Fuel Standard will provide a critical shot in the arm to innovators and entrepreneurs in our region, while bringing the region closer to cutting our dependence on oil.

The Northeast's heavy reliance on oil pollutes our air and exacerbates global warming.

- Oil consumption contributes to global warming, which is predicted to have a heavy impact on the Northeast. By the end of the century, snow season could be half its current length. Summers will be hotter, with as many as 30 days per summer in Philadelphia with temperatures over 100° F. Higher sea levels could leave both New York City and Boston vulnerable to flooding during high tides and coastal storms like Superstorm Sandy.
- Oil consumption causes air pollution that harms human health. Using petroleum products creates ground-level ozone (smog) and particulate matter pollution (soot). Both of these pollutants can cause or aggravate a host of health problems, including

cardiovascular disease, asthma, and lung cancer. More than 38 million people in Northeastern states live in areas with unhealthy air.

Businesses and consumers in the Northeast suffer financially from our dependence on oil.

- In 2010, Northeastern consumers and businesses spent $121 billion on petroleum products, 99 percent of them from outside the region. The money was equal to more than 3 percent of all economic activity in the Northeast.
- Our heavy reliance on oil leaves consumers vulnerable to the impact of fluctuations in petroleum prices, such as this year's surge in gas prices to more than $4 per gallon. In the Northeast, where roughly one quarter of homes are heated with oil, many families are particularly vulnerable to jumps in oil prices.

Domestically produced, clean alternatives to oil exist today and companies across the Northeast are working to bring those fuels and technologies to consumers.

Northeastern entrepreneurs are working to make **vehicles powered by electricity** a clean and convenient alternative to oil-powered cars and trucks, by building the recharging infrastructure needed by electric vehicles.

- **Edison ParkFast** is installing electric-vehicle charging stations at its parking facilities in New York and New Jersey. Both commuters who need to recharge a vehicle for the commute home and apartment-dwellers who don't have a way to recharge their vehicle at home use the facilities installed by the New York-based company.

Entrepreneurs across the Northeast have developed **sustainable, locally produced biofuels** that they now are seeking to produce and market in bigger quantities.

- **Old Town Fuel & Fiber** processes waste from Maine's timber industry into bio-butanol that can be refined into jet fuel. With help from researchers at the University of Maine and with funding from the U.S. Department of Energy, Old Town Fuel & Fiber has designed and built a pilot plant that can be scaled up to produce and refine about 1.5 million gallons of jet fuel annually from wood waste. The company next intends to build a full-scale facility with 10 times the present capacity.
- New York City's thousands of restaurants generate waste cooking oil that can be purified and refined for use as biodiesel. Each month, **Tri-State Biodiesel** collects 250,000 gallons of waste oil from restaurants in New York City, as well as in Connecticut and New Jersey. The company then filters the oil before selling it to biodiesel refineries.
- **Matson Biofuels** in Pennsylvania has developed a biodiesel refining process that can produce biodiesel from both high-quality and low-quality feedstock. The new process allows more efficient production of biodiesel that increases yield, reduces water consumption during processing, and lowers costs.

Not all alternative fuels are clean. Some alternatives to oil also produce significant amounts of global warming pollution, while others raise new environmental concerns.

- Ethanol based on corn and biodiesel made from soybeans are energy-intensive to grow and process, and add to soil erosion and pesticide pollution.
- Natural gas produced by hydraulic fracturing ("fracking") may have higher emissions than petroleum.
- Algae that have been genetically engineered can produce large volumes of oil for refining into vehicle fuel. While this algae-based oil may deliver emissions benefits, the use of genetically modified organisms raises grave concerns about potential broader ecological impacts.

Adoption of a regional Clean Fuels Standard will speed the integration of alternatives to oil into the Northeast's fuel supply while ensuring that those alternatives deliver real benefits for the environment. Such a standard would require the use of an increasing amount of clean, alternative fuels and limit the amount of global warming pollution produced by a gallon of fuel. By adopting a Clean Fuels Standard, the region can hasten development of alternatives to oil here in the Northeast, and make sure that those alternatives contribute to a cleaner, healthier future.

Introduction

The Northeast's dependence on traditional sources of oil will come to an end—probably soon. The question is what will replace it.

The world is running out of easy-to-obtain oil, with more and more of our fuel coming from "unconventional" sources like Canadian tar sands.

One option is for the Northeast to rely on these and other fossil fuels, such as coal-to-liquids, tar sands, oil shale, or natural gas—swapping dependence on one polluting, finite source of energy with dependence on another. Some of these fuels may even be more polluting than the traditional sources of oil they replace.

Another option would be for the region to switch to other alternatives that, while not fossil fuels, come with their own environmental impacts. Corn ethanol, unsustainably produced biomass, and fuels produced with the help of genetic engineering may curb our dependence on oil, and in some cases even reduce global

warming pollution, but not without major potential impacts on important ecosystems and public health.

There is, however, a third path—one in which the Northeast commits to getting off oil and endeavors to do it the right way from the very start, by encouraging the use of clean, alternative fuels that are substantially better for the environment than oil.

Fuels like electricity (especially electricity from renewable sources) and sustainably sourced biofuels can help the Northeast move down that path to a cleaner future without dependence on fossil fuels. Innovators and entrepreneurs throughout the region are working on solutions that will bring that future closer to reality—developing new fuels, new vehicle technologies, and new ways of integrating clean alternatives into our transportation system.

In this report, we highlight technologies and practices with real promise for moving the Northeast beyond oil, and the people and companies in the region that are driving those innovations forward. By implementing a Clean Fuels Standard that moves the region toward alternatives to oil and ensures that those alternatives are good for the environment, the northeastern states can help bring those technologies and practices to scale and spark new waves of innovation that can help us break our dependence on oil once and for all.

Why We Need Alternatives to Oil … Now

The Northeast's dependence on petroleum damages our environment, contributing to habitat destruction, oil spills, air pollution, water contamination, and global warming. It also harms our economy.

Global Warming Pollution

The Northeast is highly dependent on petroleum. In 2009, the region consumed 1.1 billion barrels of petroleum products, 16 percent of the nation's total.[1] Oil consumption in the Northeast alone was responsible for 3.5 percent of the *world's* emissions of carbon dioxide (CO_2), the leading global warming pollutant, in 2009.[2]

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The bulk of the petroleum-related CO_2 emissions produced in the region comes from transportation, including personal travel in cars, light trucks and SUVs; freight shipping by truck and train; and airplane travel. Petroleum consumption in the transportation sector accounts for the largest portion (38

percent) of global warming pollution in the Northeast each year.[3] Oil burned for home heating is also a significant source of CO_2 emissions, accounting for 46 percent of all residential emissions.

The effects of global warming are already beginning to be felt in the Northeast. The average temperature in the Northeast has increased by more than 2° F over the last 40 years, and temperatures could rise by an additional 4° F in the coming decades if global warming pollution worldwide continues unabated.[4] Extreme weather events, such as heavy precipitation, have become much more common in recent years, especially in New England, where the number of extreme precipitation events between 1948 and 2011 increased by 85 percent.[5] Significantly for the Northeast's ski industry, a larger share of winter precipitation is falling as rain rather than snow and snowpack has been melting earlier in the year.[6]

The impacts of global warming will grow in coming years. Winters will be much less snowy, with the winter snow season half its current length in northern New England by the end of the century. Summers will be far hotter. Boston could have as many as 20 days per summer with temperatures over 100° F and Philadelphia could have 30 such days.[7]

With many of the Northeast's major cities located on the water and close to sea level, the region is vulnerable to rising seas and higher storm surges, with flooding such as that experienced from Superstorm Sandy becoming more common. By the end of the century, sea level could rise by 2.3 feet in New York City, and both New York City and Boston could be vulnerable to flooding during high tides.[8] Production of important crops could decline. It may not be possible to grow common varieties of blueberries, cranberries and apples in the Northeast, and maple syrup production may be limited to a very small area.[9]

It is already too late to prevent many of the impacts of global warming. It is not too late, however, to prevent the worst, most catastrophic impacts. The Northeast states have been leaders in taking action to curb global warming pollution, but the region's dependence on oil is a major constraint on our ability to reduce emissions.

Air Pollution

Petroleum combustion is a major source of health-threatening air pollution. Oil combustion creates nitrogen oxides (NO_x) and volatile organic compounds (VOCs). These pollutants contribute to ozone smog and particulate matter, which creates soot.

In 2008, oil consumption by highway vehicles caused 37 percent of NO_x emissions and 39 percent of VOC emissions in the Northeast. Consumption of oil for home heating produced additional ozone-forming pollution.[10]

Smog and soot harm the health of millions of Americans, causing cardiovascular problems, strokes, heart attacks, respiratory infections, inflamed lung tissue, and asthma attacks.[11] More than half of all counties in the Northeast—60 percent—received failing grades from the American Lung Association for unhealthy air from ozone pollution. More than 38 million people live in these areas. (See Table 1.)

Water Pollution

Oil spills from drilling rigs, refineries, tankers, pipelines and storage tanks can foul waterways and drinking water supplies. Spills from even a small amount of oil can contaminate large volumes of groundwater, rivers, lakes or coastal waters. In April 2003, an oil barge ran aground in Buzzards Bay, Massachusetts, spilling 98,000 gallons of

oil.[13] Approximately 500 birds died as a result of the spill, and, as of 2011, some areas of the bay remained closed to shellfishing.[14]

Leaking underground storage tanks, all too common across the Northeast, create myriad points of groundwater pollution and jeopardize drinking water supplies. Over the years, more than 100,000 underground storage tanks have leaked in the Northeast.[15] Though many of those have been cleaned up, with 100,000 active tanks still in the ground, new leaks will appear.

Economic Impacts

The Northeast imports 99 percent of all the oil it consumes: we have very few production facilities.[16] As a result, every dollar spent on oil is a dollar that leaves the region's economy. In 2009, consumers in the Northeast spent $121 billion on petroleum products for transportation, heating, and other activities.[17] That represents 3.7 percent of all economic activity in the region.[18]

Although alternative fuels may not be cheaper at the pump than petroleum (at least initially), they are home-grown. Shifting even a fraction of our oil consumption to locally produced fuels would put billions of dollars back into the region's economy.

Locally produced fuel means local jobs. In the Midwest, the typical biofuel refinery employs 35 people.[19] For the Northeastern states, investing in alternative fuels will mean jobs producing and distributing fuels, and building and maintaining the infrastructure needed to use alternative fuels.

In addition, reliance on fuel from outside the region leaves families vulnerable to price spikes. The global economic forces that rule the international market for oil can cause wild fluctuations in the price of petroleum in the Northeast, evidenced by this year's surge in gasoline prices to more

Table 1. Tally of Counties Receiving "F" Grades for Unhealthy Air and Affected Population, by State[12]

State	Number of Counties	Number of Counties Failing Ozone Standard	Population in Non-Compliance Areas
Connecticut	8	7	3,401,000
Delaware	3	3	885,000
Maine	16	2	255,000
Maryland	24	12	4,256,000
Massachusetts	14	9	4,711,000
New Hampshire	10	3	737,000
New Jersey	21	11	5,049,000
New York	62	16	9,292,000
Pennsylvania	67	20	8,626,000
Rhode Island	5	3	923,000
Vermont	14	0	0
Total	147	86	**38,135,000**

than $4 per gallon. When prices increase, most Americans are unable to reduce their demand for petroleum. Families must continue commuting to work and heating their homes. In the Northeast, where roughly one quarter of homes are heated with oil, many families are particularly vulnerable to jumps in oil prices.

In order to address the problems of the Northeast's heavy reliance on oil, we must find alternatives. Fortunately, sustainable, locally produced fuels are available, and innovators and entrepreneurs in the region are working hard to bring those new fuels to the market.

Bringing Electric Vehicles to Consumers

Electricity has the potential to displace much of the oil used for transportation while reducing air pollution and other environmental impacts. With infrastructure already in place for generating, transmitting and distributing electricity, it could enter widespread use quickly. In addition, electric-powered vehicles have a smaller environmental impact than vehicles powered by oil.

Hybrid-electric, plug-in hybrid and fully electric vehicles are becoming increasingly common sights on highways in the Northeast, and the number of those vehicles on the road is likely to grow as automakers launch new models of vehicles that run, in whole or in part, on electricity. Edison ParkFast is constructing public recharging stations for electric vehicles, helping to address drivers' concerns about recharging their vehicles away from home.

Building Public Recharging Stations: Edison ParkFast

The Northeast's dense urban areas are well-suited for electric vehicles. Most car trips are relatively short, and most drivers don't need a vehicle with a range of hundreds of miles. The biggest challenge of owning an electric vehicle for many city-dwellers may be figuring out how to recharge it, either during the day at work or overnight at a home or apartment without a garage. Edison ParkFast has

begun to address this challenge by adding electric vehicle charging stations to its public parking facilities.

Edison ParkFast is one of New York City's oldest parking services companies. Since its founding more than 55 years ago, the company has established dozens of parking locations in lots and garages in the New York metro area, including in northern New Jersey.

In June 2010, the company began outfitting all of its 24-hour parking locations with high-voltage charging stations for plug-in electric vehicles, with help from a U.S. Department of Energy program designed to accelerate the development and launch of electric vehicles (EVs) and electric vehicle charging infrastructure in nine regions across the country.[20]

According to Michael Guarnieri, district manager for the company, ParkFast's decision takes advantage of the program. Installing the charging stations was partially in response to New Yorkers' excitement about electric vehicles.

"In 2009, everyone was talking about electric vehicles. It was the focus of the city and of the mayor," Guarnieri said. "We figured there was no better place to offer charging stations for electric cars than at our parking locations throughout the city."

Edison ParkFast offers 220-volt or "level II" charging, which can charge a vehicle in 1-4 hours, at 19 of its 24-hour locations throughout the city and in New Jersey. The company offers 110-volt or "level I" charging, which

An Edison ParkFast electric vehicle charging station in New York. Photo: Edison ParkFast

charges vehicles in 10-12 hours, at these locations as well.

In New York City, the marriage of electric vehicle charging with parking services makes sense, Guarnieri said.

"In New York, you can't run an extension cord from your apartment on the 19th floor to your car parked on the street," he said. "Even if it's low-level charging, it still solves a lot of logistical problems for residents in places like Manhattan."

The level II stations are popular, according to Guarnieri. He said New Yorkers looking to buy electric vehicles often call him to ask him where the company's level II charging stations are located.

"They want to know that if they buy an electric vehicle, they'll be able to charge it at level II," he said. Due to these concerns about accessibility, Edison ParkFast prioritizes its 24-hour locations for charging station installation.

In New York, you can't run an extension cord from your apartment on the 19th floor to your car parked on the street.

– Michael Guarnieri, Edison ParkFast

"If someone is running out of charge downtown, we want them to have access to charging that will get them home," he said.

Since ParkFast installed its first charging station in 2010, it has provided electricity to all of its EV customers for free—regardless of the amount of electricity they use—in order to encourage more of them to be monthly customers.

Bringing Sustainable Biofuels to the Market

Biofuels, or fuels that come from renewable, biological sources rather than fossil deposits underground, can directly replace gasoline and diesel in today's combustion engines and have the potential to reduce harmful emissions from the transportation sector. Some biofuels, such as those produced from plant fiber or waste material, have a smaller environmental impact than gasoline or diesel. Ethanol produced from agricultural waste and biomass, and biodiesel from waste cooking oil produce less global warming pollution than corn- or soy-based fuels do. (See "Making Sure that Alternatives to Oil Are Good for the Environment" on p. 21 for a more complete discussion of the environmental impact of different fuels.)

Innovators and entrepreneurs in the Northeast already produce and sell sustainable, alternative fuels such as biodiesel and bio-butanol, but they are looking for ways to expand production. In Maine, Old Town Fuel & Fiber has developed a process to turn wood waste into jet fuel. New York's Tri-State Biodiesel collects waste cooking oil from restaurants for eventual processing into biodiesel. Matson Biofuels in Pennsylvania has created a technology to convert

many types of waste oils into biodiesel inexpensively.

Developing Renewable Jet Fuel: Old Town Fuel & Fiber

Old Town Fuel & Fiber, a wood pulp mill operating since the late 1800s on the Penobscot River, had struggled through two closures by the time Lynn Tilton, CEO of an investment group, bought it in 2008. Despite failed plans by the plant's previous owners to use some of the plant's waste wood product to produce cellulosic ethanol, Tilton decided to focus on producing bio-butanol and refining it into jet fuel.

"Lynn felt that ethanol wasn't the way to go," said Dick Arnold, president of Old Town Fuel & Fiber. "The long-term plan was always to produce jet fuel, and the pathway we discovered was through bio-butanol."

In contrast to ethanol, bio-butanol is not corrosive and can therefore be transported through existing pipelines. It can also be blended in higher percentages with gasoline without extensive modifications to existing engines.

The decision to produce bio-butanol at Old Town also provided an opportunity for vertical integration with another of Tilton's acquired companies, McDonnell-Douglas Helicopters (now MD Helicopters). The company was started in 1955 by Hollywood and aviation mogul Howard Hughes.

Tilton and her team, which included researchers at the University of Maine, earned a $30 million financial assistance package from the Department of Energy (DOE) for the demonstration project to produce bio-butanol at Old Town Fuel & Fiber. According to Arnold, the DOE vigorously supports development of alternative transportation fuels, particularly jet fuel.

Old Town Fuel & Fiber's facility on the Penobscot River in Maine has developed technology that enables the production of jet fuel from wood waste. Photo: Old Town Fuel & Fiber

With the DOE's assistance, Tilton's company designed and constructed a pilot plant at Old Town Fuel & Fiber capable of producing and refining bioproducts. That plant can be scaled to the demonstration project of 1.5 million gallons of jet fuel per year from bio-butanol generated from wood waste. The company can also apply the technology in use at the Old Town plant to other wood pulp mills in the region. Additionally, it can apply a process for completely converting a pulp mill into a full-scale jet fuel facility. Full scale facilities would be capable of generating around 15 million gallons of jet fuel annually, according to Arnold.

Currently, only the pilot plant at Old Town is operating. Before a full-scale production plant can be constructed, and before the company can export its technology to other plants, Old Town Fuel & Fiber must obtain capital financing from the DOE, according to Arnold.

"We need to qualify for 'procurement and construction' phase financing," he said. In order to qualify, the company must prove its technology at its pilot plant and demonstrate that it can effectively produce and sell jet fuel on the market without subsidies.

"Our biggest challenge is being first to the market. Leading-edge technology has a lot of risks attached to it; we're always going back to evaluate how much risk we're taking on," Arnold said. "But keeping technology in the U.S. and keeping manufacturing in the U.S. is really what drives all of this."

Collecting Local Feedstock: Tri-State Biodiesel

Biofuels don't just come from the farm or the forest. Sometimes they come from the heart of the city.

Biodiesel made from waste oil is environmentally beneficial and most readily available in big cities, making it an ideal fuel to develop in the densely populated Northeast. Biodiesel can be an attractive alternative to petroleum diesel; when feedstock supplies are grown sustainably or refined from recycled cooking oil, biodiesel produces far less carbon dioxide pollution than petroleum.[21]

New York-based Tri-State Biodiesel collects and filters more than 250,000 gallons of waste cooking oil every month from restaurants in Connecticut, New York and New Jersey. The company started after its founder, Brent Baker, toured restaurants in Northeastern cities for several years in his own biodiesel-powered bus, collecting waste cooking oil to demonstrate how it could be refined with the bus's on-board filtration system; his mission was to spread the word about biodiesel, according to company partner and sales manager Dehran Duckworth.

"We decided to scale up, to take it a step further. We built a business plan around collecting oil," Duckworth said. "You can have 100 biodiesel plants, but if you don't have the feedstock, it doesn't do any good."

Since Baker started the company in 2006, Tri-State's collection truck fleet has expanded to 15 vehicles. The company employs more than 60 people in the Bronx alone, and its other employees are based in Connecticut, New Jersey, Philadelphia and Washington, D.C.

Tri-State filters the waste oil it collects until it reaches the same quality as virgin oil, or oil derived directly from a plant crop. The company then sells the oil to major refineries in the Midwest that produce biodiesel, although Duckworth said the company may eventually open its own plant in New York or New Jersey. Collecting recycled material from local sources and processing that feedstock at a refinery in the region has the potential to yield a sustainable, low-emission fuel with a positive economic impact.

Biodiesel from recycled oil is even less polluting than biodiesel from virgin oil. Virgin oil produces 70 percent less soot and 50 percent less carbon dioxide pollution than petroleum diesel—even when emissions from cultivation, harvest, refinement, and transportation are considered, according to Duckworth.

Recycled oil exists in much smaller quantities than virgin oil from cultivated feedstock, but Duckworth estimated that recapturing every gallon of waste cooking oil in the U.S. would probably generate about 5 percent of the current petroleum diesel market.

In New York City, the company's primary base of operations, the biodiesel generation potential is huge. According to Duckworth, restaurants in the city waste more than 60 million gallons of cooking oil every year, even though they can be heavily fined—sometimes up to

$10,000—for dumping their waste oil down the drain. The oil causes severe problems for the city's sewer system, and both the mayor's office and the state Department of Environmental Protection are considering mandating oil collection within New York City, according to Duckworth. Restaurant owners are therefore happy to use a free collection service such as Tri-State's, he said.

In the meantime, Tri-State must conduct an ongoing public outreach campaign to educate restaurant owners in its multi-state service territory about biodiesel from cooking oil. Duckworth said this lack of public knowledge about the potential benefits of recycled oil is the company's largest barrier to expansion.

"The state of the industry is always improving. We're improving our capacity to collect, contain, and distribute [the oil]. Biodiesel creates jobs, protects the environment, and keeps money in the local community, rather than sending it overseas. Our challenge is figuring out the most effective way to spend our advertising dollars to raise awareness," Duckworth said.

Turning Waste Oil into Biodiesel: Matson Biofuels

To produce biodiesel, most companies seek out the highest quality feedstock they can afford. High-quality feedstock, such as virgin vegetable oil, contains fewer impurities that must be removed and therefore costs more than other feedstock. These price differences ultimately affect the way companies price the biodiesel they produce—and how competitive they can be.

Environmental engineers at Matson Biofuels, a Pennsylvania-based technology firm, have designed a biodiesel refining process that can produce biodiesel from both high-quality and low-quality feedstock. Low-quality feedstock generally costs 25-30 percent less than high-quality virgin oils. Because feedstock costs can account for 75-80 percent of total production costs, using a low-quality feedstock can result in significant savings, according to Matson Biofuels Project Manager Dr. Robert Parette.

"We focus on the cheapest, junkiest feedstock you can get; that's where we have an edge. Traditional processes can struggle with impurities … If you are able to process low-quality feedstocks with impurities, you have a cost advantage," he said.

Matson Biofuels was started about a decade ago by Jack Matson, a professor of environmental engineering at Pennsylvania State University, after he decided to partner with one of his graduate students, Dheeban Kannan, who chose alternative fuels development for his coursework. After Kannan left, the research continued through Matson's company.

Traditional biodiesel production uses large tanks to produce fuel in batches. In these tanks, the feedstock oil is mixed with a soluble catalyst, which triggers the chemical reaction that produces biodiesel. The problem is that this reaction produces unwanted byproducts that contaminate the end product and reduce the yield of biodiesel from the batch. Both the unwanted byproduct and the leftover catalyst must be "washed" from the biodiesel with great quantities of water. Sometimes, more of this effluent water is produced than biodiesel, and it must be treated before being discharged into the environment. If the original feedstock has many impurities, more unwanted byproduct is produced, the overall yield is less, and more washing is required.

Matson Biofuels' process uses unique chemistry to produce biodiesel more efficiently. It uses a patented solid catalyst, rather than a soluble one, to trigger the reaction to produce biodiesel as the feedstock flows through it—as opposed to being mixed with it in a large tank. This catalyst is special because it facilitates the production of biodiesel even when the feedstock is contaminated with impurities, and it prevents the generation of unwanted byproducts. As a result, more of the feedstock—no matter the quality—becomes biodiesel.

In addition to cost savings on feedstock purchases, Matson Biofuels claims numerous economic advantages from its production process. The process reduces the amount of money and effort required to remove impurities from the biodiesel, according to Parette. It also generates less waste. The patented catalyst also works very quickly, enabling virtually continuous production of fuel as feedstock flows through the catalyst. As a result, the Matson process requires less infrastructure to contain the reaction, and the entire "footprint" of the operation can be smaller and less costly, Parette said.

Plants that use the Matson process can be scaled up to produce just as much biofuel as a large facility—although Matson Biofuels has yet to build a pilot plant. The solid catalyst wasn't protected by patent until a few years ago, so Matson kept the research out of the public eye. Now, however, the company is seeking grants and other funding sources to build a pilot plant, as well as companies to which to license the technology.

Making Sure that Alternatives to Oil Are Good for the Environment

As the Northeast works to get off oil, the wise course is to do it the right way from the start by developing alternatives to oil that curb pollution and benefit the environment. Such fuels are more likely to be those produced from truly renewable sources and those that are made locally from sustainable feedstocks produced right here in the Northeast

Unfortunately, many alternatives to oil come with serious environmental strings attached.

Looking Beyond the Tailpipe: The Life-Cycle Impacts of Transportation Fuels

Typically, when we think of pollution from transportation, we think of emissions from a car's tailpipe. However, these emissions do not account for the full extent of the global warming, air and water pollution from transportation. As the Northeast pursues alternatives to oil, it needs to prioritize fuels that are cleaner over their entire life-cycle, from "well to wheels."

A comprehensive life-cycle evaluation includes impacts from the following steps:

- **Producing or extracting feedstock**. For biofuels, the production process influences the amount of global warming pollution released when soil is disturbed by tilling, emissions from farm equipment and pollution from fertilizers. Biofuels production also includes the benefit of carbon absorption by biomass. For fossil

fuels, this includes pollution related to extracting crude oil, coal or natural gas from the ground.

- **Transporting the feedstock to the refinery**. Both the distance and the method of transport affect emissions.
- **Refining or conversion**. For biofuels, this includes the conversion of crop material into biofuels, including emissions from burning coal, natural gas or biomass to dry the feedstock and process it. For electricity, this step would include the combustion of fossil fuels to produce electricity.
- **Transporting the fuel to market**. Both the distance to market and the method of transport—pipeline, tanker truck, or power lines—affect emissions.
- **Consuming the fuel in the vehicle**. Pollution released by the burning of biofuels is counted here. This step also includes adjusting for how much of the energy in the fuel is translated to propulsion. Electric motors, for example, are four times more efficient than gasoline internal combustion engines.[22]
- **Secondary impacts**. Secondary impacts are the broader changes that occur when a new form of transportation fuel is used. For example, biofuels create secondary impacts in land use when one farmer replaces a wheat field with corn for ethanol, and a second farmer responds by turning pasture into a tilled field to grow wheat. These effects are complex and can occur around the world. Other secondary impacts include increased emissions from fertilizer production and reduced emissions from replacing animal feed with byproducts from ethanol production. Fossil fuels have secondary impacts as well. Increasing natural gas use in vehicles might result in increased demand and higher prices, which could encourage switching from natural gas to coal to generate electricity.

A comprehensive life-cycle analysis also allows for consideration of other environmental impacts from fuels, such as whether growing a biofuel encourages deforestation, processing it strains water supplies, or burning it adds to air pollution. This broader level of analysis could consider how demand for biofuels might compete with food uses of some crops; or the environmental impacts of the production and disposal of batteries for electric vehicles.

Life-cycle analysis is complex and comes with some uncertainty. For example, different researchers might make different assumptions or make different choices about which secondary and tertiary impacts to include. Nonetheless, the estimates that researchers have produced for different fuels are valuable for guiding public policy toward fuels with lower emissions, and as life-cycle analysis matures, we will have access to better and more refined estimates of the impacts of various fuels on the climate.

As a result, some alternative fuels that might appear to be clean on the surface may cause significant environmental impacts—sometimes hundreds or thousands of miles away or in ways that are not necessarily obvious. The following section discusses several alternatives to oil that raise significant environmental concerns.

Corn Ethanol

The alternative fuel in most widespread use today is ethanol, a nearly pure grain alcohol produced from the fermentation of plant material, typically corn, sugar

cane, or cellulosic material. Ethanol use does reduce petroleum consumption but, depending on the feedstock and processing, the substitution of ethanol for gasoline may not provide any global warming benefit.[23]

Corn-based ethanol, which comprises the majority of the ethanol sold today, has higher global warming emissions than gasoline. California's Air Resources Board concludes that typical ethanol produced in the Midwest and refined using natural gas produces 4 percent more global warming pollution than gasoline.[24] A different analysis by researchers at Princeton and other universities suggests that life-cycle emissions from corn ethanol may be twice as high as gasoline.[25] That's because farmers around the world change their agricultural practices in response to rising demand for corn for fuel.

As the price of corn has risen, farmers have begun to cultivate pastureland or to cut down forests to create arable land. Disrupting previously untilled fields and wild areas releases vast amounts of stored carbon, causing the life-cycle emissions of ethanol made from that corn to skyrocket to levels equal to or above those of gasoline.[26]

Another serious consequence of using food as a feedstock for transportation fuel is disruption to world food markets. Soaring demand from fuel refiners for corn to process into ethanol has caused the price of corn to soar, raising the price of a staple food across the globe.[27]

Ethanol produced from plant fiber—called cellulosic ethanol—avoids some of the problems of producing ethanol from corn, depending on what sources of feedstock are used and how it is produced. Cellulosic feedstocks can be produced on marginal or abandoned croplands, reducing the impact on global food markets and on land use changes here and around the world. Restoring abandoned cropland by planting a mix of prairie plants including legumes and grasses can even increase the amount of carbon stored in the soil and in plant roots compared to previous use of the land.[28] A 2009 analysis by the National Academy of Sciences estimates that, excluding potential land use changes, production of cellulosic ethanol can increase the amount of carbon stored in soil. Such production has emissions close to zero.[29] Cellulose-based fuels also can be produced from crop waste, which incurs low emissions from feedstock production.

Both corn and cellulose-based fuels cause other environmental impacts. Cellulosic feedstocks cause less damage than corn and other food-crop feedstocks to water quality and quantity, soil fertility, air quality, and habitat diversity. However, such feedstocks present a risk of becoming invasive species that overrun native plants.[30] In addition, care needs to be taken to ensure that production of cellulosic feedstocks does not result in the conversion of important wilderness and wildlife habitat to fuel production.

Soy Biodiesel

Biodiesel often is derived from oil crops such as soybeans and canola, but also can be made from used vegetable oil and animal fats. In addition, diesel substitutes can be produced from non-fatty biomass using the Fischer-Tropsch process, in which the biomass is converted to a gas and then to a liquid. Like ethanol, the environmental impact of biodiesel depends heavily on the feedstock.

Biodiesel from soybeans, the most common feedstock for biodiesel, releases at least 50 percent more global warming pollution than conventional diesel when secondary impacts such as land-use change are included.[31] On the other hand, biodiesel made from waste cooking oil can have life-cycle global warming

pollution emissions as much as 98 percent less than conventional diesel.[32]

Many of the steps of the feedstock production and fuel refining process are the same for biodiesel as for ethanol. As with ethanol, powering the biodiesel refining process with coal, natural gas or biomass also will have a large impact on life-cycle global warming emissions.

Biodiesel from waste oil is very clean compared to petroleum diesel, but supplies are limited.[33] Another promising biodiesel feedstock with a modest environmental impact is waste material from cellulosic ethanol production. Wastes from the cellulosic ethanol process could be used to produce larger quantities of diesel substitute. Using waste as the feedstock would help lower the emissions of both biofuels.

Natural Gas

Natural gas, in compressed or liquefied form, has been used as an alternative to gasoline and diesel for decades. Its relatively low emissions of health-threatening air pollution have made it attractive in areas struggling to improve air quality.[34] However, new research suggests that natural gas may have a similar impact on global warming as petroleum, calling into question the wisdom of building new infrastructure to increase the use of natural gas as a vehicle fuel.

Conventionally produced natural gas has long been thought to release less global warming pollution than petroleum fuels. Typical analyses of the life-cycle global warming emissions of natural gas indicate that it produces 29 percent less global warming pollution than gasoline and 21 percent less than diesel.[35] In reality, emissions may be much higher.

Preliminary research conducted by the U.S. Environmental Protection Agency indicates that conventional natural gas production methods may result in more methane leaks than previously thought.[36] Methane is a potent global warming pollutant, causing 21 times more warming than the same amount of carbon dioxide.[37] Thus, even a modest increase in emissions during the production process can undercut the modest global warming benefit natural gas provides relative to gasoline and diesel.

A second, more recent study by researchers at Cornell University further suggests that the global warming benefit of natural gas is modest at best. Dr. Robert Howarth and two colleagues at Cornell estimated that unconventional production methods for natural gas—namely fracking, in which large quantities of chemical-laced water and sand are pumped into the ground under pressure to open up fractures and allow natural gas to be extracted—allow methane to escape into the atmosphere. Factoring in the climate effects of this escaped methane reveals an increase in the life-cycle emissions of natural gas. Fracking produces 30 to 100 percent more fugitive emissions than conventional natural gas production techniques. The net result is that the global warming emissions from natural gas produced by fracking may be equal to or greater than petroleum.[38]

Prior to the analysis by Dr. Howarth and his colleagues, several other scientific bodies warned that natural gas extracted through fracking may produce significantly higher emissions than conventionally produced natural gas. The Council of Scientific Society Presidents and the National Research Council have expressed concern that unconventional natural gas production techniques result in much higher emissions.[39]

As natural gas from fracking grows to provide a larger share of all natural gas consumed in the U.S., the global warming impact of natural gas will rise.

Production of natural gas from fracking is expected to triple by 2035, providing 46 percent of all natural gas consumed in the U.S.[40] As a result, natural gas consumed in vehicles may not be any cleaner than gasoline or diesel.

In addition, fracking has other environmental consequences, including contamination of drinking water supplies and destruction of habitat, that make it a poor replacement for petroleum. As the Northeast seeks fuels to replace petroleum and to support the region's future, the environmental impacts of natural gas make it a poor long-term choice.

Algae-Based Biofuels

One of the most promising new fuels on the market in recent years is algae-based fuel. The advantages of algae-based oil are that it can be integrated into existing fuel distribution infrastructure without risk of corrosion (which is a problem with ethanol) and it can be burned in internal combustion engines without engine modifications and without maintenance or performance problems.

However, the use of genetically modified organisms in algae-based biofuel production raises serious concerns about potential broader ecological impacts.

In the wild, algae grow when provided the right mix of sunlight, water, and nutrients. Algae are an important component at the base of the food chain—the oil and starch in phytoplankton, for example, anchor the marine food chain.

Researchers have found that genetically modifying algae can result in the production of prolific quantities of oil for refining into diesel and other fuels. Some modified algae can be grown in the dark and fed switchgrass, sugar cane, woodchips, or other cellulosic materials. These altered algae thrive on a diet of sugars, producing up to 1,000 times more oil than conventional algae grown in light.[41] Other algae are grown in open ponds.[42] The oil-heavy algae can be ruptured to harvest the oil, which can then be refined into a vehicle fuel, used as a dietary supplement, or added to personal care products.[43]

Algae-based biofuels may have much lower global warming emissions than petroleum-based fuels. For example, Solazyme, a leading manufacturer of algae-based biofuels, claims that its biodiesel is 85 to 93 percent less polluting than conventional diesel.[44] However, a comprehensive 2012 study by the National Academy of Sciences on algal biofuels finds that the emissions benefits of algae-based biofuels are not certain and vary depending on the production method.[45]

However, neither the scientists at biofuels companies nor academic researchers know much about the potential environmental impact if genetically modified algae were to escape from cultivated ponds or industrial facilities. Nor has a federal agency undertaken a thorough review of the risks of modified algae to the environment.[46]

Modified algae may be raised in open ponds, or in closed tanks; release of algae is possible from either setting. A gust of wind could pick up algae cultivated in open areas and carry them to nearby fields and waterways.[47] Even if genetically engineered algae are raised in closed tanks or contained systems, mechanical failure or human error could lead to the release of algae. Algae can easily become airborne, and could be carried out of their closed environment on clothing.[48] Some industry insiders believe that engineered algae have already escaped, while others believe it is merely a matter of time until a release occurs.[49]

Whether engineered algae will survive in the wild—and how well—isn't known, but algae do have the ability to reproduce quickly and to adapt to different environments. Algae modified for rapid growth could displace naturally occurring strains. Even if modified algae do not grow at the same intense rate as in a lab, they may be able to survive and crossbreed with other strains, creating new varieties with unknown behaviors. Given algae's position at the base of the food chain, altering its availability and behavior could have widespread consequences, such as harming fisheries or causing illness.[50]

Three different federal agencies play a role in monitoring genetic engineering: the Food and Drug Administration, the Environmental Protection Agency, and the Department of Agriculture. All are involved, but none keeps a registry of releases or of the consequences.

Given the environmental damage that could occur from the release of modified or non-native algae from a biofuel production facility, more study is needed before the use of algae-based fuels should be encouraged for use as an alternative to oil. Once scientists and the public understand the ecological risks from enhancing the oil-producing potential of algae, policymakers will be better able to find the right balance between environmental harm from algae versus that from our reliance on oil.

Policy Recommendations

The best way to support development and use of sustainable, alternative fuels is through adoption of state-level Clean Fuels Standards. A Clean Fuels Standard would require the use of an increasing amount of alternative fuels, and would include mechanisms to ensure that we transition to alternative fuels with the greatest environmental benefits.

A Clean Fuels Standard does not specify which fuels must replace gasoline and diesel. Instead, it establishes criteria to encourage use of fuels with lower global warming emissions and a smaller life-cycle impact than petroleum. Use of the dirtiest fuels, such as products from tar sands or ethanol from Midwestern corn, would be discouraged.

Fuels made locally from cleaner feedstocks would get a boost. Because transporting fuels from other regions increases their life-cycle global warming emissions, locally produced fuels would have lower emissions. For example, waste cooking oil collected from restaurants in the Northeast and refined at a regional refinery will have lower emissions than a fuel made from waste oil collected and refined farther away.

The impact of a Clean Fuels Standard will be greater if multiple states in the Northeast choose to adopt it. Similar policies adopted in neighboring states will build a regional market for fuel producers, giving them confidence that there will be demand for their fuels. A company is much more likely to build a large facility to process biomass into liquid fuel and to sign multi-year contracts with local farmers if it can be

assured of large enough demand for its product. Similarly, a company will be more willing to invest in electric vehicle charging stations in New Jersey if New Jersey, New York and Pennsylvania have all adopted a Clean Fuels Standard, establishing a bigger pool of potential electric vehicle drivers.

Overall, a Clean Fuel Standard that reduces the carbon intensity of transportation fuels by 10 percent would produce significant environmental and economic benefits to the Northeast region. Total oil use could decline by 14 to 40 billion gallons over the next ten years, while net global warming pollution from the transportation sector could drop by 4 to 13 percent.[51] Over 10 years, the regional Gross Domestic Product could increase by $7 to $29 billion.

To supplement a Clean Fuel Standard, states in the Northeast region can adopt additional incentives and regulations to encourage the use of alternative fuels. A Renewable Fuel Standard, if carefully constructed, can be an important policy to encourage sustainable biofuels blended into gasoline. Individual businesses may also benefit from production tax credits that will encourage investment in new technologies. These tax credits should likewise be geared towards those technologies that have proven life-cycle environmental benefits.

In addition, all states in the Northeast and Mid-Atlantic region should have a plan to encourage the production and use of plug-in vehicles, the most promising technology to replace oil in the near term. The 11 states in the Northeast region have recently signed on to a plan to create a Northeast Regional Electric Vehicle Network, which would create a distributed infrastructure of charging stations throughout the region, making plug-in vehicles more attractive for consumers and businesses. These infrastructure investments can support programs such as the Zero Emission Vehicle program, adopted by most Northeastern states, that will lead to the production of thousands of plug-in and battery-electric vehicles and slash pollution.

Notes

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