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Careers in Biofuels

Emily Richards

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In 2010, there were about 250 million registered vehicles on U.S. highways.[1] Most of these vehicles have engines that use oil-based fuel, such as gasoline or diesel. Even hybrid-electric cars use gasoline to power their internal combustion engines, although they use less fuel than traditional automobiles.[2]

The use of oil-based fuels has both economic and environmental impacts. Both consumers and businesses are affected by fluctuations in oil prices. Fuel prices have been trending upward, with the annual average price of a gallon of gas increasing by about 170 percent between 2002 and 2012.[3] And vehicles powered by oil-based fuels release emissions that are harmful to the environment, including greenhouse gases (GHGs).

Consequently, the nation's scientists and engineers have sought ways to develop alternative fuels, such as biofuels. Biofuels are defined as fuels composed of or produced from biological raw materials.[4] Biofuels can reduce the use of oil-based fuels and can be more environmentally friendly. The biofuels industry provides career opportunities for a vast array of workers, who do such tasks as developing biofuel technologies, growing crops, and processing and selling the fuels.

This report provides information on careers in biofuels. The first section describes the manufacture of biofuels and the reasons for expected growth in the industry. The remainder of the report specifies key occupations in the biofuels industry. The information for each occupation includes a brief job description; the credentials needed to work in these occupations, such as education, training, certification or licensure; and wage data.

Emily Richards is an economist in the Office of Occupational Statistics and Employment Projections, BLS. Emily is available at (202) 691-6558 or **richards.emily@bls.gov.**

What are biofuels?

Biofuels are produced from biomass, which are materials derived from a living or recently living organism, including plants, grains, vegetable oils, and animal-based oils. These types of materials are commonly referred to as feedstocks.

First-generation biofuels are made from biomass such as sugars and starches—materials that are often a food

source for people or animals. Second-generation biofuels, known as cellulosic biofuels, are made from nonfood materials. Cellulosic biofuels are not yet widely available.

Most liquid transportation biofuels are classified as either ethanol or biodiesel. Currently, most ethanol on the commercial market is produced from starches, most often corn; biodiesel is derived from plant oils, often soybean oil, or from animal fat or recycled greases.

From feedstock to fuel

Although production processes can vary by manufacturer, many manufacturers use a production process known as a sugar pathway to produce ethanol. The process is made up of two main stages: hydrolysis and fermentation. During hydrolysis, a chemical is used to break down the feedstock into sugar. Yeast or bacteria are introduced during the fermentation process to consume the sugar. The output of that process is then distilled in order to separate the ethanol from any waste product. Lastly, the ethanol is dehydrated, producing the ethanol in its purest form.

Biodiesel is produced through a chemical process called transesterfication, in which oil or fat feedstocks are combined with alcohol and a catalyst, causing a reaction that allows the glycerin to be separated from the oil. Alternatively, some companies may choose a production process known as a thermochemical pathway, which uses high temperatures to convert biomass into ethanol or biodiesel.

Biofuel as an alternative fuel

Biofuel proponents believe that these alternative fuels offer a number of economic and environmental benefits over traditional oil-based fuels.

Because biofuels are derived largely from plants, these fuels are a renewable resource that can be replenished naturally with the passage of time, unlike crude oil. They can be produced in the United States, which reduces our dependence on foreign oil and helps to shield American consumers from fluctuating global oil prices.

Moreover, proponents assert that biofuels may offer an environmentally friendly option for fueling our nation. Depending on which feedstocks are used and how they are converted, biofuels may produce fewer greenhouse gases (GHGs) than oil-based fuels.

But biofuels have critics as well. The carbon impact from biofuels largely depends on how crops are cultivated and how fuels are produced. Some argue that the carbon impact from producing biofuels is no better than that from oil-based fuels. Further, some critics claim that biofuel production may result in more GHGs released into the environment, depending on the production method.

In addition, there is a debate over the use of certain feedstocks, commonly referred to as the food-versus-fuel debate. Opponents of biofuels argue that making fuel using feedstocks that traditionally have another purpose, such as corn, directly impacts the supply of that crop in the food chain. These detractors argue that land is being used for growing fuel feedstocks, rather than for feeding people or livestock. This additional source of demand can drive up prices for that crop.[5]

Cellulosic biofuels

Cellulosic biofuels are made from a wide variety of nonfood biomass, such as wood chips, agricultural and municipal waste, or perennial grasses. Because they are made from nonfood feedstocks, they do not directly compete with crops used for food. Scientists and researchers are working to develop additional feedstocks that could be used to make biofuels, along with production processes that are safe for the environment and affordable on a large scale.

Cellulosic biofuels may be better for the environment

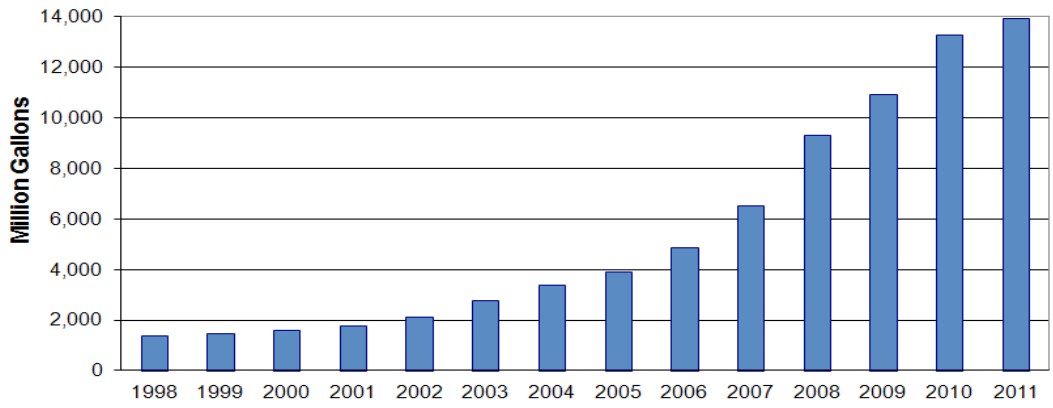
than first-generation biofuels. A 2009 study by scientists from the Center for Transportation Research at the Argonne National Laboratory, the Department of Energy, and Purdue University compared GHG emissions from production of cellulosic ethanol and of corn ethanol. The study found that cellulosic ethanol production resulted in a reduction in GHG emissions by an estimated 77 percent to 107 percent as compared with gasoline; corn ethanol production resulted in a 24-percent emissions reduction as compared with gasoline.[6]

Although cellulosic biofuels may offer a solution to many of the criticisms of first-generation biofuels, more research and development is needed before cellulosic biofuels are made widely available to the public. Production of cellulosic biofuels is still very expensive compared with the cost of making traditional gasoline or many of the first-generation biofuels.

Government initiatives

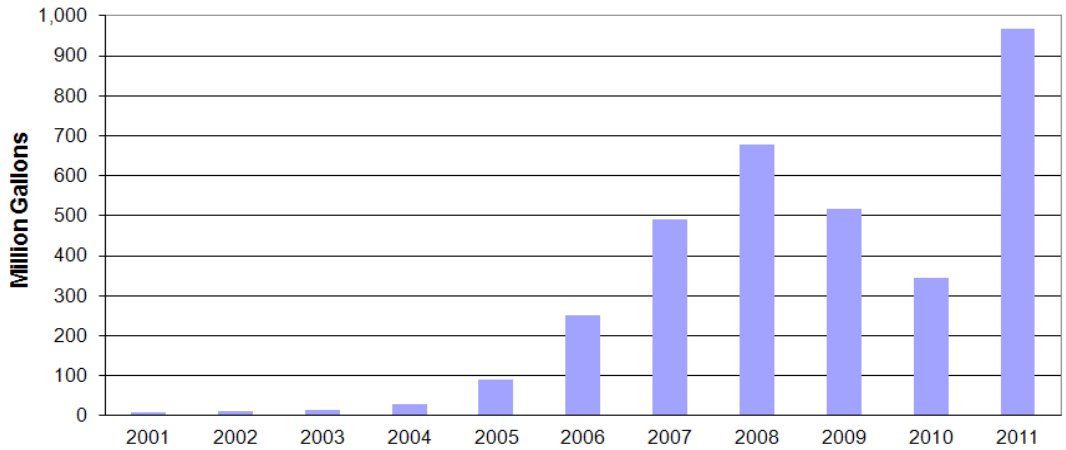
As the biofuels industry continues to grow, Congress has passed laws to provide funding for research and development of alternative fuels, and government agencies have established best practices for implementing use of such fuels. The Environmental Protection Agency (EPA) has implemented mandates for how much renewable fuel must be blended with fossil fuels.[7] The Renewable Fuel Standard (RFS) mandate was passed in 2005. And in 2007, an expanded mandate, known as RFS2, was passed to include cellulosic biofuels. Both mandates have helped to increase demand for biofuels, with 13.9 billion gallons of ethanol and 967 million gallons of biodiesel produced in 2011, up from 3.4 billion gallons of ethanol and 28 million of biodiesel in 2004, the year before the mandate was first passed. (See charts 1 and 2.)

Chart 1. U.S. ethanol production, in millions of gallons, 1998 — 2011



Source: U.S. Department of Energy, Energy Efficiency & Renewable Energy, Alternative Fuels Data Center.

Chart 2. U.S. biodiesel production, in millions of gallons, 2001 — 2011



Source: U.S. Departmen of Energy, Energy Efficiency and Renewable Energy, Alternative Fuels Data Center.

In addition to the RFS mandates, the military is working to harness the power of biofuels. The Department of Defense has set a goal of obtaining 25 percent of its energy from alternative sources by 2025. To do so, the Air Force, Army, and Navy are investing in the development of alternative fuels.[8]

Infrastructure

To meet the requirements set by the RFS2 mandate, more cellulosic biofuels must be produced, the fuels must be sold at a price that is competitive with traditional gasoline, and the fuels must be widely available to consumers.

As technology continues to improve and cellulosic biofuels can be made in larger quantities, more biorefineries will be needed to produce the fuels for commercial use. As of June 2012, 212 biorefineries producing ethanol were active or under construction, and more than 150 plants were producing biodiesel. (See maps 1 and 2.) The vast majority of these plants are producing first-generation biofuels.

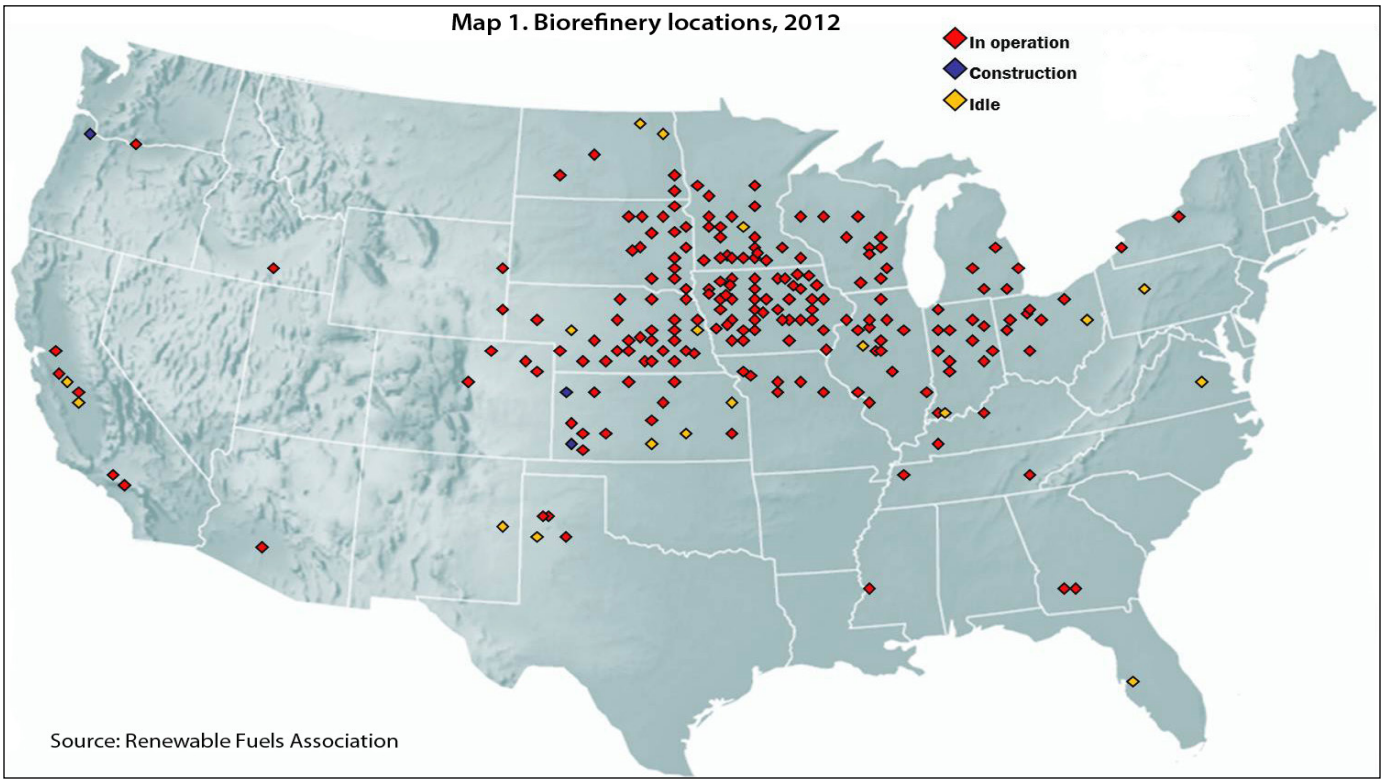
More and more processing plants are working to produce cellulosic biofuels at an affordable cost, but these fuels are not yet ready to be sold commercially. Some improvements to infrastructure must be made before there can be large-scale commercial use of cellulosic biofuels.

First, there needs to be a greater number of cars on U.S. roads that can run on higher blends of ethanol. Most cars on the road today can run on gasoline that contains up to 10 percent ethanol. This type of gas is commonly known as E10, and it is the most common gasoline sold today. The EPA recently approved the use of E15, a gasoline that contains up to 15 percent ethanol, for model year 2001 and newer vehicles.[9]

Flexible fuel vehicles (FFVs) are vehicles that can run on fuel blends containing up to 85 percent ethanol, E85. According to the Energy Information Administration, there were more than 8 million FFVs on the road in 2010.[10] That figure may rise as the demand for fuel-efficient vehicles grows. A Consumer Reports study found a "growing willingness of shoppers to consider alternative powertrain technologies, especially E85 ethanol."[11]

As more consumers look into cars that can run on higher blends of biofuels, more gas stations will need to be able to supply these fuels. As of December 2012, only 11 percent of retail gas stations that offered alternative fuels in the United States offered E85 fuel.[12]

Flex fuel pumps, also called blender pumps, are gas pumps that draw from more than one fuel tank. They



Map 2. National Biodiesel Board member plants, 2012

allow a station to carry more than one type of blended fuel. Blender pumps need to be added to more stations for higher blends of ethanol gas to be available on a large scale. The Department of Energy estimates that 60,000 retail outlets will be needed to sell all of the ethanol proposed by the RFS mandate, and 90–110 million FFVs will need to be on the road.[13]

Biodiesel is available at a limited number of retail locations. According to the Department of Energy, there were 696 retail fuel locations in the United States offering biodiesel in December 2012.[14] As with ethanol, blender pumps capable of offering various biodiesel blends will need to be added to more stations for biodiesel to be used on a larger scale.

Biofuels occupations

The biofuels industry employs a wide range of workers in a variety of occupations. Scientists and engineers conduct research and development; construction workers build plants and update infrastructure; agricultural workers grow and harvest feedstocks; plant workers process feedstocks into fuel; and sales workers sell the biofuels.

The Bureau of Labor Statistics (BLS) does not have data specific to biofuels. However, BLS does have information on green jobs from its Green Goods and Services (GGS) survey. As the name suggests, GGS jobs are those associated with producing green goods or providing green services. The GGS survey found that, in 2010, private sector employment for GGS jobs in the basic chemical manufacturing industry was 11,970.[15] The basic chemical manufacturing industry includes the manufacture of biofuels; however, the GGS figure includes all jobs in the basic chemical manufacturing industry that meet the green jobs definition, not just those in biofuels.

There are workers in other industries that help to bring biofuels to market, too. For example, scientists and engineers who work on biofuels are often employed by scientific research and development or engineering services firms, so they are included in data for those industries.

A 2012 study by the Renewable Fuels Association found that ethanol production supported 401,600 jobs in 2011.[16] A National Biodiesel Board study found that the production of 1 billion gallons of biodiesel supports 39,027 jobs.[17]

Following are descriptions of some of the most common jobs in the biofuels industry, along with information

on the duties associated with the jobs and the credentials needed to attain a job in the field. Wage data also are included in the occupation descriptions. Although BLS does not have wage data specifically for occupations in the biofuels industry, BLS does have wage data for the basic chemical manufacturing industry, which includes production of chemicals from organic raw materials. Wage data do not include benefits or other compensation.

Occupations in scientific research

Scientists work to find the best, most cost-effective way of turning feedstocks into fuel. They conduct experiments, document their results, and maintain various instruments in a laboratory setting. Scientists and researchers often work for a wide variety of organizations, such as colleges, private and nonprofit companies, and government agencies. Scientists generally work in offices or laboratories, though some may work in a production plant.

Biochemists and biophysicists study the chemical and physical principles of living things and biological processes. Those who work in alternative fuels may research various technologies that can be used to break down feedstocks into fuel.

Chemical or laboratory technicians use special instruments and techniques to assist scientists and engineers in researching, developing, and producing chemical products and processes. They conduct research, test for quality control, and perform analyses based on their experiments. Technicians may blend various chemicals for processing or to test the quality of a batch of fuel.

Chemists study the properties, structures, compositions, and reactions of matter. They study various chemical processes that can be used to more efficiently produce biofuels. Chemists blend various compounds to see what inputs yield the best quality blends of fuel at a reasonable cost. Based on their findings, they develop new protocols for blending fuels to ensure quality control.

Microbiologists study the growth, structure, development, and characteristics of microscopic organisms, such as bacteria, algae, or plant cells. They may use their knowledge of various forms of bacteria to improve the fermentation process used to make ethanol or to develop new ways of cultivating algae to use as a feedstock.

Soil and plant scientists conduct research on soil, crops, and other agricultural products to find new and improved ways to use various agricultural products for fuel. A plant scientist may test several types of perennial grasses to see which can be most efficiently broken down into simple sugars. Plant scientists also work to improve crop yields by using techniques that could enhance feedstock production efforts.

Credentials

Most scientist positions require a bachelor's degree from a program that includes both coursework and laboratory hours. A scientist who is leading a research team or conducting independent research may need a master's or doctoral degree to do so. Biochemists and biophysicists typically need a doctoral degree to enter the occupation. It is common for scientists to pursue a specialized degree in a subfield, such as bacteriology or toxicology.

Although some lab technician jobs typically require an associate's degree or 2 years of postsecondary training, a bachelor's degree in science is sometimes preferred. Technician jobs generally require some laboratory experience and a strong background in math and science.

Analytical skills are important for those conducting experiments and determining an outcome or a reasonable

way to continue an experiment. Scientists and technicians also need oral and written communication skills because they often work as part of a team and must effectively communicate the results of their analysis to others. In addition, scientists and technicians must be detail-oriented when conducting experiments and recording data.

Wages

BLS currently does not have wage data specific to the biofuels industry. However, BLS does have wage data for the basic chemical manufacturing industry group; the following table shows wages for selected science occupations in that industry group for May 2011. The wages shown are median annual wages for the United States as a whole; wages vary by employer and location.

Selected science occupations	Median annual wages, May 2011[1]
Biochemists and biophysicists	$63,530
Chemical technicians	49,920
Chemists	75,550
Microbiologists	57,350
Soil and plant scientists[2]	58,940

[1] Occupational Employment Statistics data are available at **www.bls.gov/oes**. The data do not include benefits.
[2] Wage data for soil and plant scientists are not available for the basic chemical manufacturing industry group. The data here represent wages for the occupation as a whole.

Occupations in engineering

Engineers use scientific and technological research to develop commercial applications and economic solutions. They design and test various products and machinery. In the biofuels industry, many engineers are involved in much of the same work as scientists, evaluating both existing and potential feedstocks, and examining which sources provide the best energy at a reasonable cost. However, they also may work on processing facility design and be familiar with industrial equipment.

Engineers develop project plans and establish budgets. At processing plants, engineers work to ensure quality control and a steady flow of materials. They also ensure that federal, state, and local safety regulations are met and company standard operating procedures are followed.

Agricultural engineers apply technological advances to farming. These engineers are experts in agriculture and horticulture, and they study existing and potential feedstocks to determine which plants can be best used to produce fuel. They must consider the best time of year for various feedstocks to be grown and the best location to cultivate them, as well as the waste products that will be generated in their production. Agricultural engineers also may design processing plants and other structures involved in storing and processing feedstocks.

Chemical engineers apply the principles of chemistry, biology, and physics to solve problems. They design plant equipment and establish various processes and protocols for manufacturing biofuels as well as the chemicals that are used to convert raw materials into fuel.

Some chemical engineers receive additional training or education to become biochemical engineers. In addition to the basic chemical engineering principles, biochemical engineers have in-depth knowledge of biological systems, such as the production of specific products using enzymes or microorganisms. Chemical engineers and biochemical engineers often work together in a biofuel production facility. For instance, biochemical engineers develop and implement a fermentation process for production of ethanol from sugars, and chemical engineers distill and purify the compound.

Civil engineers design and supervise the construction of biofuel processing plants. When designing a plant, they consider a number of factors, including costs, government regulations, potential environmental hazards, and proximity to feedstocks. They may need to retrofit an existing petroleum plant or convert a biofuel plant so that it can process additional types of feedstocks.

Electrical engineers research, design, develop, or supervise the manufacturing and installation of electrical equipment, components, or systems for commercial, industrial, or scientific use. Within a biofuel plant, electrical engineers may work with various motors, power generation equipment, lighting, or any electrical controls for industrial equipment that are needed for the plant to run.

Environmental engineers use the principles of engineering, soil science, biology, and chemistry to develop solutions to environmental problems. They work to improve waste treatments and water systems, and to find ways to limit emissions from fuel processing. For instance, an environmental engineer may work to minimize the natural

gases that are released while burning materials at a plant, thereby preventing or reducing the degradation of the atmosphere or local soil and water systems.

Industrial engineers find ways to eliminate wastefulness in production processes. They may work to determine the most efficient way to use workers, machines, materials, information, and energy to make biofuels using a given feedstock or chemical process.

Mechanical engineers research, design, develop, build, and test mechanical devices, including tools, engines, and machines used in a processing plant. They also may oversee installation, maintenance, and repair of equipment. Mechanical engineers often provide a plan for the layout of equipment at a new plant, or they provide suggested plans for implementing new equipment. For instance, a mechanical engineer may work on developing precursor equipment that can begin the process of breaking feedstocks down into sugar before they are transported to a processing plant.

Credentials

Engineering jobs typically require a bachelor's degree in a related engineering field. However, some jobs, particularly those involved in research and development or those at the managerial level may require advanced degrees or work experience. Many engineer jobs also require a professional engineer (PE) license, which requires a degree, work experience, and passing written exams. Civil engineers who exercise direct control of a project or those who supervise other engineers must have a license.

Engineers should enjoy problem solving because they must constantly look for new and improved ways to develop a product or process. Communication skills are also critical for engineers because they must be able to clearly explain their instructions to production staff to avoid costly mistakes.

Wages

BLS currently does not have wage data specific to the biofuels industry. However, BLS does have wage data for the basic chemical manufacturing industry group; the following table shows wages for selected engineering occupations in that industry group for May 2011. The wages shown are median annual wages for the United States as a whole; wages vary by employer and location.

Selected engineering occupations	Median annual wages, May 2011[1]
Agricultural engineers[2]	$74,630
Chemical engineers	96,870
Civil engineers	96,370
Electrical engineers	85,350
Environmental engineers	89,070
Industrial engineers	79,530
Mechanical engineers	88,320

[1] Occupational Employment Statistics data are available at **www.bls.gov/oes**. The data do not include benefits.
[2] Wage data for agricultural engineers are not available for the basic chemical manufacturing industry group. The data here represent wages for the occupation as a whole.

Occupations in construction

Construction workers build the processing plants where biofuels are made. Much of the future construction needs from the biofuels industry will be driven by cellulosic technology, using nonfood biomass to create biofuels. The advances in processing additional feedstocks have created demand for processing plants that can convert multiple crops into fuel. Construction workers are also needed to convert existing infrastructure at gas stations so that they can support higher blends of fuel. There may also be career opportunities in the design and construction of feedstock pre-processing facilities to condense biomass feedstocks before transportation to fuel production plants.

Construction managers plan, coordinate, budget, and supervise construction projects from early development to completion. They oversee new construction of biofuel and feedstock processing plants as well as the retrofitting of existing plants. Construction managers work with various specialists, such as architects and engineers, to get the plant built on time and within a budget.

Construction laborers perform tasks that require physical labor on construction sites, many of which are physically demanding. They build new biofuel plants and convert existing plants so that they can also produce fuel using cellulosic feedstocks. And as more ethanol blend fuels are made available, these workers will build new tanks to hold them or install blender pumps to existing tanks.

Construction equipment operators drive, maneuver, or control the heavy machinery used in construction. They operate various types of equipment, such as bulldozers, forklifts, and cranes. They use these machines to build processing plants and to install new fuel tanks at gas stations.

Credentials

Most construction managers have a bachelor's degree in construction science, construction management, architecture, or engineering. However, a combination of work experience and an associate's degree may meet the qualifications of some employers. Managers must have time-management skills and decision-making skills to ensure that each task involved in a project is assigned to the appropriate party and that each task is completed on time.

Most employers hiring construction laborers do not have a formal education requirement. The majority of laborers learn their skills through on-the-job-training, either informally or through an apprenticeship program. Construction workers must have strength and stamina for lifting heavy objects and performing other strenuous tasks throughout the day.

Construction equipment operators may learn the skills needed for their job through on-the-job training, an apprenticeship, or at a trade school. A high school diploma and a commercial driver's license may be required. They should have good eye-hand-foot coordination because they control powerful machinery.

Wages

BLS currently does not have wage data specific to the biofuels industry. However, BLS does have wage data for the chemical manufacturing industry group; the following table shows wages for selected construction occupations in that industry group for May 2011. The wages shown are median annual wages for the United States as a whole; wages vary by employer and location.

Selected construction occupations	Median annual wages, May 2011[1]
Construction managers	$101,970
Construction laborers[2]	29,730
Operating engineers and other construction equipment operators	33,440

[1] Occupational Employment Statistics data are available at **www.bls.gov/oes**. The data do not include benefits.

[2] Wage data for construction laborers are not available for the chemical manufacturing industry group. The data here represent wages for the occupation as a whole.

Occupations in agriculture

Farms are needed to grow corn, soybeans, and the other feedstocks used in making biofuels. These crops must be planted and cultivated before they are harvested and transported to grain elevators and processing plants.

Farmers and other agricultural managers, sometimes called growers, run establishments that produce crops that are used to make fuel. They supervise work being done by laborers and make decisions about where and when to plant various crops. They oversee the day-to-day operations of the farm or agricultural establishment.

Agricultural laborers maintain the quality of farms and crops by doing manual labor under the supervision of agricultural managers. They plant, cultivate, and harvest crops, which are used as fuel feedstocks.

Agricultural equipment operators operate farm equipment, such as tractors and combines, to sow seeds, and maintain and harvest crops.

Credentials

Farmers and agricultural managers typically need a high school diploma or equivalent, although some may have a degree from an agricultural college. Prospective farmers

and agricultural managers typically train and gain experience under more experienced workers. Those farmers and agricultural managers who don't have any postsecondary education may take a longer time to learn some aspects of the job.

Most agricultural laborer and equipment operator positions do not have a formal education requirement. Workers typically learn through on-the-job training. It is important for these workers to have strength and stamina because the work can be physically demanding. Good hand-eye coordination is often needed to harvest crops and operate farm machinery.

Wages

BLS currently does not have wage data specific to the biofuels industry. However, BLS does have green goods and services (GGS) wage data for occupations in agricultural production. The table that follows shows GGS-OCC wages for selected agricultural occupations in November 2011, for establishments that receive all of their revenue from green goods and services. The wages shown are GGS-OCC median annual wages for the United States as a whole; wages vary by employer and location.

Selected agriculture occupations	Median annual wages, November 2011[1]
Farmers, ranchers, and other agricultural managers	$52,180
Farmworkers and laborers, crop, nursery, and greenhouse	19,130
Agricultural equipment operators	21,340

[1] Green goods and services occupations data are available at **www.bls.gov/ggsocc**. The data do not include benefits.

Occupations in plant operations

Managers and technicians at processing plants convert feedstock into fuel through various technologies. They perform a wide variety of tasks, from blending chemicals to operating industrial equipment to testing fuel quality. Workers must follow a number of standard operating procedures and abide by all safety protocols. Staff may keep records or logs during each shift, noting any plant activities and reporting any problems to supervisory staff.

Plant managers, also known as industrial production managers, run daily operations at the plant. Managers coordinate and plan the activities needed to create biofuels. They supervise employees in completing their tasks and provide feedback on employees' job performances. They ensure compliance with all federal, state, and local laws and safety requirements. Managers must be able to solve problems quickly, adjust procedures when issues arise, and maintain detailed records on processing plant production.

Plant operators, also known as fuel makers, are chemical equipment operators and tenders. They operate or tend equipment that controls chemical changes or reactions in the processing of industrial or consumer products.

In addition to operating industrial equipment, plant operators may also inspect tanks, clean pumps and other equipment, and dispose of waste products. Some plant workers may conduct quality control checks, testing samples from a batch of fuel. Others may be involved in shipping and receiving materials at the plant. They must follow all safety procedures, including reporting any problems to supervisory staff.

Industrial machinery mechanics test, maintain, and repair plant equipment and other industrial machinery, such as conveying systems, production machinery, and packaging equipment. When malfunctions occur, they need to disable a piece of equipment, locate and fix the broken piece, and reassemble the machine.

Credentials

Plant manager positions often require a bachelor's degree in a related science, engineering, or business administration. Many manager positions require between 1 and 5 years of work experience, while others may

require up to 10 years of related experience. In addition, some employers want their managers to have previous experience as a supervisor. Most production managers must complete company-specific training. Many managers opt to earn various certifications to show a higher level of competency in their field.

Most plant operators need to have a high school diploma, and many employers prefer workers with a degree from a college or vocational school. Many employers value strong math and science skills and related work experience. Moderate on-the-job training is necessary because of the complex equipment and specific safety procedures of each company.

Industrial machinery mechanics generally need at least a high school diploma, though many employers prefer to hire candidates who have completed postsecondary training in industrial technology. Mechanics who have not taken postsecondary courses may need a year or more of on-the-job training to learn the necessary mechanical and technical skills.

Most plant employees work in shifts, as plants operate around the clock. They usually must wear safety equipment, such as gloves or goggles. Work in a plant can be physically demanding because workers may have to lift heavy objects and control large machinery. Individuals working in a plant must complete training to learn all of a company's standard operating and safety procedures.

Wages

BLS currently does not have wage data specific to the biofuels industry. However, BLS does have wage data for the basic chemical manufacturing industry group; the following table shows wages for selected production occupations in that industry group for May 2011. The wages shown are median annual wages for the United States as a whole; wages vary by employer and location.

Selected production occupations	Median annual wages, May 2011[1]
Industrial production managers	$99,770
Chemical equipment operators and tenders	49,060
Industrial machinery mechanics	54,380

[1] Occupational Employment Statistics data are available at **www.bls.gov/oes**. The data do not include benefits.

Occupations in sales

Once the biofuels have been produced, sales workers are needed to keep supply chains running. Sales workers establish contracts so that goods can be bought and sold, and they help to keep biofuel production on schedule.

Purchasing agents buy farm products for further processing or for resale. They evaluate suppliers, negotiate contracts, review product quality, and monitor inventories. Purchasing agents develop budgets based on when and how much of a given feedstock is needed at a plant. They also establish contracts with suppliers, to ensure a steady flow of a given feedstock is transported to the plant to keep production on schedule.

Wholesale and manufacturing sales representatives sell goods—such as fuel, by-products from fuel production, or industrial equipment—for wholesalers or manufacturers to businesses, government agencies, and other organizations. They ensure that there are customers to buy the fuel, negotiate prices of these sales, and prepare contracts. They are often very knowledgeable about the products that they sell, but they may also work with an engineer who has more expertise.

Credentials

Some purchasing agent jobs may only require a high school diploma. However, jobs at large-scale commercial plants generally require a bachelor's degree. Some positions, especially those at the managerial level, may require advanced degrees. Degrees related to engineering, business, economics, or applied sciences are preferred. On-the-job training may take up to 1 year.

Wholesale and manufacturing sales representatives generally need a bachelor's degree, though some positions may only require a high school diploma. Most companies have on-the-job training programs that a sales representative must complete; these programs usually include time spent shadowing a more experienced employee as they complete day-to-day work. Sales representatives may also choose to earn a certification. The Certified Professional Manufacturers' Representative (CPMR) certification and the Certified Sales Professional (CSP) certification are offered by the Manufacturers' Representatives Education Research Foundation.

Wages

BLS currently does not have wage data specific to the biofuels industry. However, BLS does have wage data for the basic chemical manufacturing industry group. The following table shows wages for selected sales occupations in this industry group for May 2011. The wages shown are median annual wages for the United States as a whole; wages vary by employer and location.

Selected sales occupations	Median annual wages, May 2011[1]
Buyers and purchasing agents, farm products	$51,380
Wholesale and manufacturing sales representatives, technical and scientific products	83,100

[1] Occupational Employment Statistics data are available at **www.bls.gov/oes**. The data do not include benefits.

Conclusion

Americans continue to rely on cars for their transportation needs, and biofuels offer a domestically produced alternative to petroleum-based fuels. A wide variety of workers are needed to research and produce biofuels, making them an important aspect of the green economy. With the government mandate enforcing the use of alternative fuels, there will be continued demand to produce alternative fuels such as ethanol and biodiesel from both traditional feedstocks and cellulosic feedstocks.

Biofuel-related occupations require a broad range of education and experience levels. Although some occupations require a bachelor's or higher degree, there are opportunities for those with less than a college degree and for individuals with prior related work experience.

Notes

[1] "Table 1-11: Number of U.S. Aircraft, Vehicles, Vessels, and Other Conveyances," Bureau Transportation Statistics, (U.S. Department of Transportation, 2012), **http://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/publications/national_transportation_statistics/html/table_01_11.html**.

[2] For information on careers in electric vehicles, see "Careers in Electric Vehicles," (U.S. Bureau of Labor Statistics, September 2011), **http://www.bls.gov/green/electric_vehicles/electric_vehicles.pdf**.

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