Careers in Electric Vehicles

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Electric vehicles have come a long way since General Motors produced the first modern electric automobile in 1996. With the recent introduction of the Chevrolet Volt and the Nissan Leaf, manufacturers of electric vehicles have made great strides in terms of technology and consumer acceptance. Electric cars are considered to be an important step towards reducing petroleum dependence, protecting the environment, and improving transportation sustainability. Many manufacturers have made major investments in electric automobile technology. The production of these vehicles will provide employment opportunities for many workers, particularly those with automotive manufacturing experience.

This report provides information on the relevant career fields in the production and maintenance of electric vehicles, including hybrids, plug-in hybrids, and all-electric vehicles.[1] The first sections explain the components and types of electric autos, followed by a section that profiles key occupations in the electric vehicle industry. This report focuses on occupations in research and development, manufacturing, maintenance, infrastructure development, and sales. 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.

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Brief history of electric vehicles

Electric vehicles have been around in one form or another since the invention of the automobile. Many of the first automobiles were powered by a battery and not by gasoline. Electric vehicles even outsold gasoline-powered vehicles in the early 20th century. However, with improvements to gasoline engines and the availability of cheap fuel, electric vehicles fell out of favor. Throughout the 20th century, several models of electric vehicles were produced, but none became widely adopted by consumers.

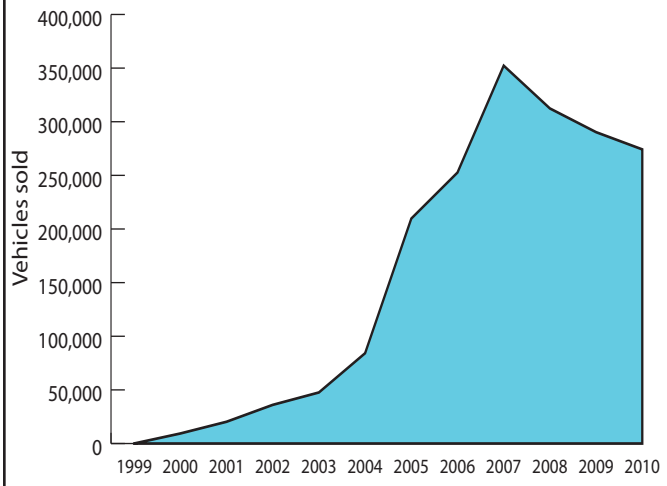
The 1990s saw a renewed interest in electric vehicles because of increasing concerns about the environment and higher fuel costs. General Motors introduced the EV-1 all-electric vehicle and began leasing the vehicles in 1996. However, the EV-1 was discontinued after several years. In 2000, hybrid-electric vehicles hit the market when Honda introduced the Insight in the United States, and Toyota followed with the highly successful

Nissan Leaf, all-electric vehicle

Prius several months later. In 2011, General Motors began selling the Chevrolet Volt, a plug-in hybrid, and Nissan began selling the Leaf, an all-electric vehicle.

With these and other models, electric vehicles are rising in popularity and sales. In the United States, electric car sales increased from near zero in 1999 to a high of about 350,000 units in 2007. Sales of all motor vehicles, including electric ones, were affected by the 2007–2009 recession. Electric vehicle sales fell to about 250,000 vehicles in 2010. (See chart 1.)

Chart 1. Sales of Hybrid Electric Vehicles, 1999–2010



Source: U.S. Department of Energy, National Renewable Energy Laboratory

Many consumers purchased electric vehicles in order to qualify for tax incentives from the federal government and some states. The tax credits and rebates were created by the federal government in an effort to reduce dependence on petroleum and build U.S. leadership in electric vehicle technologies.[2] From July 2005 until December 2010, federal tax credits were available for hybrid vehicles; these have since expired and have been replaced with similar rebates for plug-in hybrid and all-electric vehicles. Federal tax credits are currently available for up to $7,500 for vehicles, plus an additional $2,000 for the stations used to charge all-electric vehicles and some hybrids. The federal government has also invested in vehicle technologies to support the electric vehicle industry, including research and development of batteries and charging stations.

Tax credits are offered by some states. For example, California offers tax credits of up to $5,000 on an electric vehicle purchase. In addition, some states that operate high occupancy lanes, known as HOV or carpool lanes, allow electric vehicles to use them regardless of the number of passengers.

The popularity of electric vehicles can be partially attributed to the rising price of gasoline. As gasoline prices increase, more consumers are turning to hybrid or electric vehicles as a method to lower their expenses.

The Bureau of Labor Statistics (BLS) does not have data on employment in the electric vehicle industry. However, BLS is currently in the process of collecting data to measure green jobs, including those jobs relevant to the electric vehicles industry. Data should be available in 2012.[3]

Differences between electric and traditional vehicles

Electric vehicles share many of the same basic components found in traditional automobiles, but they have unique components that separate them from conventional vehicles, such as the lithium-ion battery and electric motor.

Batteries

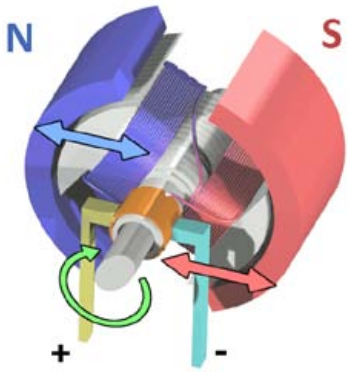
Most conventional gasoline-powered vehicles use lead-acid batteries. Electric vehicles, however, require large lithium-ion batteries or other batteries that use new technologies that provide more power and weigh less than older batteries of a similar size. Batteries in electric vehicles must also supply a much greater amount of electricity and recharge faster than those in conventional vehicles. Thus, electric vehicle batteries are much larger than conventional vehicle batteries; they usually weigh several hundred pounds, need to be replaced after several years, and can cost thousands of dollars. Scientists and engineers continue to develop new technologies to create smaller, lighter batteries that last longer and provide more power.

Electric vehicle battery

Electric motors

Electric motors have been used for over a century; in fact, they were used in some of the earliest cars. Electric motors are powered by an electric current that creates a magnetic charge and turns a driveshaft. (See diagram 1.) Electric motors waste less energy in the form of heat than do internal combustion engines, so they are more efficient. Torque (a measure of the turning force on an object) and revolutions per minute (RPM, or the speed that the motor turns) can be controlled by the electric motor as it adjusts the electrical current fed through the motor, even making a transmission unnecessary in some vehicles.

Diagram 1 — Inner workings of an electric motor



Internal combustion engines

Most hybrid vehicles contain an internal combustion engine as the primary source of power, with a battery and electric motor acting as secondary power sources. Because power is also available from the battery and electric motor, these engines are typically smaller than those found in regular automobiles. Internal combustion engines in hybrid vehicles can also be used to recharge the battery. Plug-in hybrids get most of their power from the electric system and use the internal combustion engine to recharge the battery or to power the vehicle after the battery runs out.

Types of electric vehicles

Electric vehicles can be classified as hybrids, plug-in hybrids, and all-electric vehicles. Each type of vehicle works in a different way and has its own advantages and disadvantages.

Hybrid electric vehicles

Hybrid electric vehicles, commonly called hybrids, are powered by a combination of an internal combustion engine and an electric motor. There are several types of hybrid vehicles, and they vary depending on whether the engine or the motor is the primary source of power. Some are powered primarily by an internal combustion engine with additional power supplied by an electric motor. Others are powered by the electric motor with a gasoline engine as backup.

The electric motor is powered by a battery and generator. The generator, which receives power from the internal combustion engine, charges the battery and the battery powers the electric motor. In all cases, having an electric motor allows for a much smaller gas engine, which saves fuel and lowers tailpipe emissions. These vehicles may also employ regenerative braking, in which energy captured from the brakes is used to recharge the battery. This allows the vehicle to get better gas mileage when driving in the city and in stop-and-go traffic. These are currently the most popular type of electric vehicles in use today. Models are available from many manufacturers, including the Toyota Prius, Honda Civic Hybrid, and the Ford Escape Hybrid.

Diagram 2 — Powertrain of a hybrid electric vehicle

Plug-in hybrid vehicles

Plug-in hybrids have an electric motor and a gasoline engine like other hybrids, but they have a larger battery and can be charged from a secondary power source when they are in a resting state. Plug-in hybrids can drive anywhere from 10 to 40 miles using just electricity before the battery runs out and the internal combustion engine

turns on to power the vehicle. The Chevrolet Volt is an example of this type of vehicle.

Diagram 3 — Powertrain of a plug-in hybrid vehicle

All-electric vehicles

All-electric vehicles, also called battery electric vehicles, are powered by only a battery and an electric motor, and they do not contain a gasoline engine at all. When their power runs low, all-electric vehicles must be plugged in to an external source of electricity, such as a charging station, to recharge their batteries. Because their batteries are larger than batteries in other electric vehicles, all-electric vehicles can drive for about 100 miles before they must be recharged. However, they have no gasoline engine to take over when the battery runs low, so these vehicles have a lower overall mileage range than other types of electric vehicles. The major benefit of all-electric cars is that they consume no gasoline and have zero tailpipe emissions. The Nissan Leaf is an example of this type of vehicle.

Diagram 4 — Powertrain of an all-electric vehicle

Converted electric vehicles

Some traditional gas-powered vehicles that have internal combustion engines are converted to electric vehicles that use electric propulsion. Because of the limited number of electric vehicle models on the market, conversion companies often perform vehicle conversions for consumers who prefer a certain type of vehicle not currently available with an electric motor. Businesses also do vehicle conversions for specific types of vehicles that are required for business, such as light trucks or passenger vehicles.

Electric vehicle occupations

Workers from a variety of educational and employment backgrounds are employed in the electric vehicle industry, such as the scientists who conduct research in electric drive technology, the manufacturing workers who build the vehicles, and the automotive maintenance technicians who repair the vehicles. Most of these occupations require specialized training or work experience in electric vehicle manufacturing and maintenance.

This section describes some of the most common jobs in the electric vehicle industry; for each occupation, job duties are listed, along with the credentials needed for the occupation, including education, training, certification, or licensure. Certification demonstrates the candidate's competency in a skill or set of skills, typically through work experience, training, the passage of an examination, or some combination of the three. Licensing is done by individual states, and typically requires the candidate to pass an examination and to fulfill certain eligibility requirements, such as a minimum level of education, work experience, training, or the completion of an internship, residency, or apprenticeship.

Wage data are also included in the occupation descriptions. Although BLS does not currently publish wage data specifically for electric vehicle occupations, the wages listed represent the larger industry or industry group that would employ the electric vehicle workers, when applicable. Wage data do not include benefits or other compensation.

Employment growth is expected in most occupations in the electric vehicle industry in the next few years, according to a study by the Center for Entrepreneurship and Technology at the University of California, Berkeley. Growth is expected in manufacturing industries and the domestic energy sector as the need for batteries and

charging stations increase.[4] New types of automobile manufacturing jobs will also be created; however, many of these jobs will be filled by current manufacturing employees or those that were displaced by recent downsizing of the automobile manufacturing industry. The transportation subsector itself accounted for a significant portion of the jobs lost in the manufacturing sector during the 2007–2009 recession.[5]

Occupations in scientific research

Scientists in this industry search for new knowledge and conduct research to improve electric vehicle technology. Both chemists and materials scientists conduct research on improving battery life and recharging time. Materials scientists also research and develop new materials for use in electric vehicles.

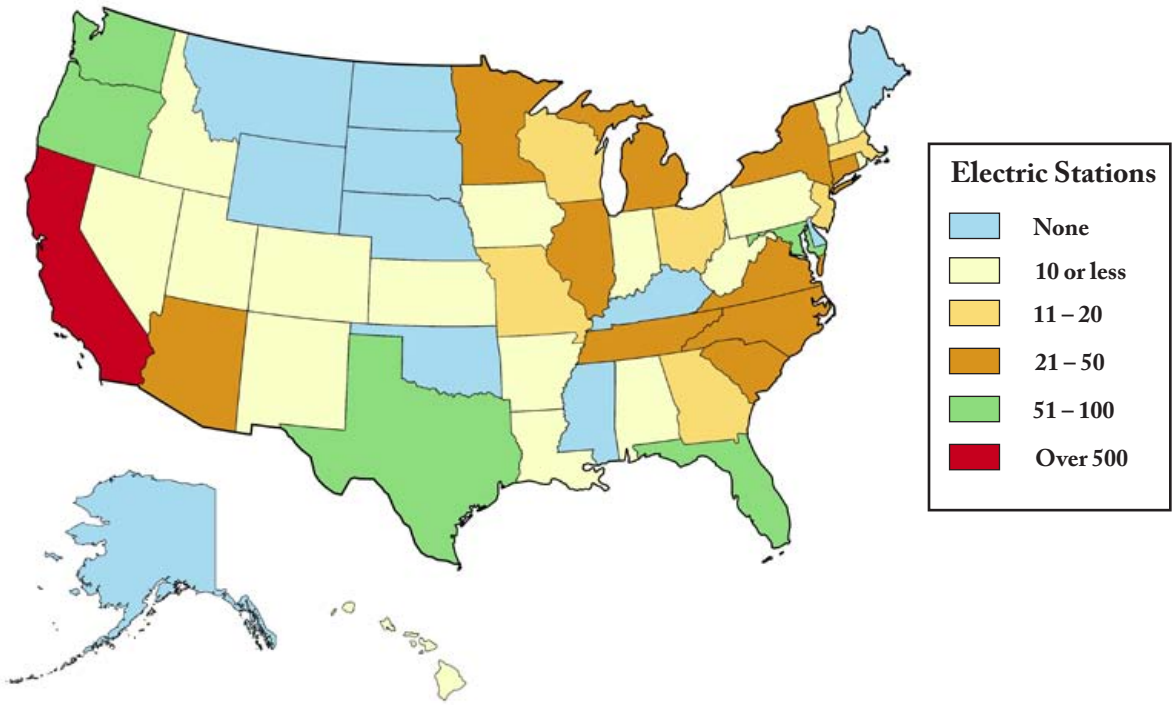
Drivers who are considering the purchase of a plug-in or an all-electric vehicle must take into account how far the vehicle can drive before requiring a recharge. Because of the limited availability of electric vehicle charging stations, drivers will need vehicles that they can drive long ranges before needing a recharge. According to the National Renewable Energy Laboratory, 11 states had no public charging stations at all as of June 2011, and 16 states had 10 or fewer. (See map 1.) Because electricity storage is the major limiting factor for electric vehicle adoption, many scientists working on electric vehicles are focused on improving battery technology to allow for larger capacity.

To make electric vehicles a viable alternative to traditional ones, scientists also strive to make batteries that recharge faster. Nonelectric vehicles can be filled with gas in a matter of a few minutes, while most current batteries require several hours to fully charge.

Scientists also work on batteries to improve a hybrid vehicle's fuel economy. The longer a vehicle can be driven on battery power alone, the less fuel it will consume. Improved batteries will allow vehicles to rely more on electric propulsion and less on fossil fuels.

Scientists usually work in offices and laboratories. Research and development (R&D) scientists work in offices, where they do research, and they plan, record, and report on their lab research. Some laboratories are small, and others are large enough to incorporate prototype chemical manufacturing facilities and advanced testing

Map 1. Public electric vehicle charging stations in the United States, June 2011



Source: U.S. Department of Energy

equipment. Scientists often work with engineers and processing specialists in industrial manufacturing facilities.

Job duties

Chemists investigate the properties, composition, and structure of matter, and the laws that govern the reactions of substances to each other. Using this knowledge, chemists working on electric vehicles find new chemicals to use in batteries or ways to make existing batteries work better. They work closely with engineers and other scientists to develop new batteries and other technologies.

Materials scientists study the structures and chemical properties of various materials to develop new products or enhance existing ones. For electric vehicles, materials scientists are heavily involved in battery research, but also develop materials for other parts of the vehicle. Structural and mechanical components made out of lighter or stronger materials will be needed to make vehicles more fuel efficient and reliable. These materials also may improve the safety of vehicles as well as the environmental impact. In the United States, some vehicles already have interior components, such as seats and upholstery, made out of plant-based and recycled materials that were developed by materials scientists.

Credentials

A doctoral degree is a necessity for scientists who conduct original research and develop new products. However, other scientific workers may find jobs with a bachelor's or master's degree. Computer skills are essential for scientists to perform data analysis, integration, modeling, and testing. Certification or licensure is not necessary for most of these scientists.

Wages

BLS currently does not have wage data specific to the electric vehicle industry. The table shows wages for selected scientist occupations for May 2010. The wages shown are median annual wages for the United States as a whole; wages vary by employer and location.

Selected scientist occupations	Median annual wages, 2010[1]
Chemists	$68,320
Materials scientists	84,720

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

Occupations in design and development

Workers who design and develop electric automobile technology include engineers, engineering technicians, and drafters; software developers; and industrial designers. Engineers apply the principles of science and mathematics to develop economical solutions to technical problems. Their work is the link between scientific research and commercial applications. Many engineers specify requirements, then design, test, and integrate components to produce designs for new products. After the design phase, engineers are responsible for evaluating a design's effectiveness, cost, reliability, and safety. Engineers use computers extensively to produce and analyze designs and to simulate and test systems. Computers are also necessary to monitor quality control processes.

Most engineers work in offices, laboratories, or industrial plants. Engineers are employed by most companies that manufacture electric vehicles and their components. Engineering is one of the most sought-after occupations in the automobile manufacturing industry. Engineers work in teams with other engineers, scientists, and industrial production managers to create new processes or devices for the manufacture of electric vehicles—or to improve existing ones.

In addition to engineers, several other occupations are important to the design and development process. Engineering technicians and mechanical drafters assist engineers with design work and other tasks. Software developers create the software that is used to control the various systems of the vehicle, including the engine, battery, generator, and electric motor. Finally, industrial designers are responsible for the overall design of the vehicle and major components.

Job duties

Chemical engineers apply the principles of chemistry to design or improve equipment or to devise processes for manufacturing chemicals and products. Because the batteries of electric vehicles store power through chemical processes, chemical engineers are responsible for developing new battery designs and improving current battery technologies. They are also vital in designing equipment and processes for large-scale manufacturing and in planning and testing the methods of battery manufacturing.

Electrical engineers design, develop, test, and supervise the manufacture of electrical components. They are responsible for designing the electrical circuitry that

Chevrolet Volt, plug-in hybrid

allows a gas engine to charge the battery and distribute the electricity from the battery to the electric motor. Electrical engineers also might work on the heating and air-conditioning systems, vehicle lighting, and visual displays.

Electronics engineers design, develop, and test electronic components and systems for vehicles. These engineers are primarily focused on the control systems and additional electronic components for the vehicle. They are different from electrical engineers in that they do not focus on the generation and distribution of electricity.

Industrial engineers determine the most effective ways to use the basic factors of production—people, machines, materials, information, and energy—to manufacture vehicles. They are concerned primarily with increasing productivity through the management of people, use of technology, and improvement of production methods. Because many electric vehicles require original manufacturing plans, industrial engineers design innovative manufacturing processes and retool plants that formerly made different models of cars.

Materials engineers are involved in the development, processing, and testing of materials used in electric vehicles. Many electric vehicles are made of newer materials that are lighter and stronger than those in traditional cars. Materials engineers may also incorporate environmentally friendly materials that are derived from plant-based materials or recycled materials.

Mechanical engineers design, develop, and test the tools, engines, machines, and other mechanical devices in electric vehicles. These devices may be components of electric vehicles, or machines that are used in the manufacture or repair of these vehicles. These engineers may focus on engines, electric motors, or other mechanical devices, such as transmissions, drivetrains, or steering systems.

Mechanical engineering technicians assist engineers with solving technical problems in research, development, manufacturing, construction, inspection, and maintenance. Their work is more narrowly focused and is more oriented toward applications than that of engineers or scientists. Engineering technicians will build or set up equipment, prepare and conduct experiments, collect data, and calculate or record results. They may also help engineers or scientists to make prototypes of newly designed equipment or assist with computer-aided design and drafting (CADD) equipment.

Mechanical drafters prepare detailed drawings that show how to assemble machinery and mechanical devices. They are responsible for producing visual guidelines that illustrate the construction methods for mechanical components of vehicles. Most drafters use CADD systems to prepare drawings.

Software developers design and create software. They apply the theories of computer science and mathematical analysis to create and evaluate software applications and systems that make the computers run. Modern vehicles are extensively computer-controlled, and software developers create the software that controls these vehicles. In addition, hybrid and electric vehicles use on-board computers to produce and distribute the proper amount of electricity to power the vehicle in given conditions. The on-board computer also determines when to use the gasoline engine to power the vehicle and when to use the engine to recharge the battery.

Commercial and industrial designers are responsible for the style, function, quality, and safety of vehicles. When they are designing a vehicle or vehicle component, designers must take into account the preferences of potential consumers as well as the production abilities of

manufacturers. The designers must work with engineers and other members of the production team to ensure that the vehicles meet specified requirements. They then prepare sketches or diagrams, usually with the aid of computers, and work with engineers and other designers to improve a design.

Credentials

Engineers typically enter the electric vehicle industry with a bachelor's degree or higher in engineering. However, some positions require previous experience or an advanced degree. Entry-level engineers may begin their career as an assistant to a more senior engineer until they develop the skills needed to work independently. Engineers are also expected to complete continuing education courses to keep up with rapidly changing technology.

Specialized programs for engineering students who wish to work on electric or alternative fuel vehicles are available through the Department of Energy's Graduate Automotive Technology Education (GATE) program. The GATE program has educational programs at centers at eight universities nationwide.[6]

Engineers are usually required to be certified in specific systems and technologies, depending on the systems used by a particular manufacturer. Licensure as a professional engineer (PE) is highly desired by employers and is often required for anything higher than an entry-level position.

Engineering technicians and drafters usually have an associate's degree or certification from a community college or a technical school. Technicians and drafters participate in on-the-job training and are closely supervised by engineers.

Software developers typically need at least a bachelor's degree in computer science or a related discipline, combined with experience in computer programming and software design.

Commercial and industrial designers also typically have at least a bachelor's degree in engineering or industrial design, and they usually receive some on-the-job training.

Wages

BLS currently does not have wage data specific to the electric vehicle industry. The table shows wages for selected engineers, mechanical engineering technicians, drafters, software developers, and commercial and industrial designers in the transportation equipment manufacturing industry group for May 2010. The wages shown are median annual wages for the United States as a whole; wages vary by employer and location.

Selected design and development occupations in transportation equipment manufacturing	Median annual wages, 2010[1]
Chemical engineers	$97,480
Electrical engineers	87,580
Electronics engineers, except computer	100,450
Industrial engineers	77,160
Materials engineers	89,000
Mechanical engineers	81,290
Mechanical engineering technicians	52,950
Mechanical drafters	53,840
Software developers, applications	94,680
Commercial and industrial designers	67,790

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

Occupations in manufacturing

Manufacturing electric vehicles is a complex process that requires a large, skilled workforce. Electric vehicle systems are more complex than a traditional internal combustion engine, so they require special manufacturing processes. Many of the workers involved in the manufacture of electric vehicles have previously worked in traditional vehicle manufacturing. Automotive manufacturing occupations tend to be clustered around traditional industrial centers in the Great Lakes region and the Midwest. The largest concentrations of these jobs are in Michigan and Ohio, but automobile manufacturing plants are located in other states as well. Manufacturing jobs in the electric vehicle industry include various assemblers, machine tool operators, machinists, and industrial production managers.

Finished vehicles are manufactured by a few large auto companies, but many of the vehicles' parts are made by smaller companies that specialize in individual components. These smaller pieces are then sold to the larger auto manufacturers.

Many of the occupations involved in manufacturing electric vehicles are also involved in the manufacture of vehicle charging stations, which are necessary for most types of plug-in hybrid vehicles and all types of battery-electric vehicles. These stations are usually purchased along with the vehicle and installed at the

owner's home or workplace. In addition, commercial charging stations have been installed throughout the country. (See map 1.) These stations are owned by private companies or government agencies and are available for electric vehicle owners to recharge their vehicles when away from home or work.

Manufacturing workers usually work in large automotive assembly plants. These plants are usually quite noisy because they are filled with robotic devices, powerful machines, and hydraulic lifts. Safety conditions in assembly plants have improved considerably over the past several decades. However, manufacturing workers might use machinery or chemicals that require special handling.

Job duties

Electrical and electronic equipment assemblers build products such as electric motors, computers, electronic control devices, and sensing equipment. Some of these components may be too small or fragile for human assembly, so they are assembled by automated systems. Electrical and electronic equipment assemblers fit together the parts of larger components or controlling automated systems that are used for smaller pieces.

Electromechanical equipment assemblers use a variety of tools to build and assemble electromechanical components used in electric vehicles, such as gasoline engines, electric motors, and generators. This occupation is similar to electrical and electronic equipment assemblers. However, these workers focus more on the mechanical components, as opposed to electronics.

Engine and other machine assemblers construct and assemble engines used in automobiles. They put together the gasoline-powered engines that are present in hybrid cars and may be responsible for other components as well.

Team assemblers work on a variety of manufacturing tasks. They may work on a traditional assembly line or in a so-called "lean" manufacturing system, in which they may rotate between several different types of assembly work. These workers are usually on a team that completes the final assembly of a vehicle. They may also assemble vehicle components that are not electrical or mechanical in nature, such as interiors or the body and frame of the vehicle.

Computer-controlled machine tool operators use machines to fabricate metal and plastic components of vehicles. To set up the machine for certain operations, they download a program and fix the appropriate tools into the machine. After positioning the piece that is being worked on, computer-controlled machine tool operators start the machine. They may also be responsible for some routine maintenance of the machines or for troubleshooting if a problem occurs.

Machinists use machine tools, such as lathes, milling machines, and grinders, to produce precision metal parts. Producing large quantities of a single part may be partially or fully automated, and machinists are responsible for monitoring the machines and the quality of the output. Machinists are also responsible for producing small batches or making one-of-a-kind parts for prototypes or testing. If many more pieces are needed, they are often mass-produced using computer-controlled machines.

Industrial production managers plan, direct, and coordinate the production activities required to manufacture vehicles and vehicle components. They make sure that goals for output and quality are met while still remaining within budget. They are responsible

Automobile assembly

for monitoring the production run to make sure that it stays on schedule and for correcting any problems that may arise. Depending on the size of a manufacturing plant, industrial production managers may oversee the entire plant or just one area of it.

Credentials

Manufacturing workers have a variety of skill levels. Most assembly positions require short-term on-the-job training to familiarize workers with production processes and with any equipment they use. Experienced assemblers may be promoted to supervisory positions after several years of working on the assembly line. Computer-controlled machine tool operators are usually trained on the job. Machinists require more training, and they often learn their trade through an apprenticeship that lasts 3 to 5 years.

Industrial production managers usually have at least a bachelor's degree, typically in an engineering discipline, such as mechanical or industrial engineering, and several years of experience working in the automobile manufacturing industry.

Wages

BLS does not currently have wage data specific to the electric vehicle industry. The table shows wages for selected manufacturing occupations in the transportation equipment manufacturing industry group for May 2010. The wages shown are median annual wages for the United States as a whole; wages vary by employer and location.

Selected manufacturing occupations in transportation equipment manufacturing	Median annual wages, 2010[1]
Electrical and electronic equipment assemblers	$29,470
Electromechanical equipment assemblers	32,430
Engine and other machine assemblers	47,440
Team assemblers	32,500
Computer-controlled machine tool operators, metal and plastic	35,580
Machinists	40,810
Industrial production managers	91,460

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

Automotive service technician

Occupations in electric vehicle maintenance

As with any vehicle, electric vehicles need to be occasionally maintained and repaired. Much of the routine maintenance and repair work can be done by normal repair workers, but the electrical systems and drivetrain will often need skilled workers familiar with electric vehicles.[7] Repairing or installing electric vehicle batteries requires workers who are trained to work with specific types of batteries. Batteries need to be replaced every few years depending on usage and type of battery.

Job duties

Automotive service technicians and mechanics inspect, maintain, and repair automobiles that run on gasoline, electricity, or a combination of the two. They plan and perform basic car maintenance and vehicle repairs. The job of automotive service technicians and mechanics has evolved from simple mechanical repairs to high-level technology-related work. Integrated electronic systems and complex computers regulate vehicles and their performance on the road. Fixing problems with these systems requires workers to use computerized shop equipment and work with electronic components as well as traditional hand tools.

Credentials

Automotive service technicians and mechanics are increasingly required to have formal training because of the rapidly growing sophistication of automotive technology. Training typically begins in high school or a postsecondary vocational school or community college. Certification from the National Institute for Automotive Service Excellence (ASE) is usually required to work for larger repair shops or at dealerships. Formal education programs can last from a few weeks of on-the-job

training to a 2-year associate's degree. On-the-job training is necessary before a worker can begin to work independently. It typically takes 2 to 5 years of experience to become a fully qualified automotive service technician through ASE.

Automotive service technicians and mechanics need special skills and knowledge to work on electric vehicles. Electric vehicles use new and unique technologies, so technicians generally are trained to work on a particular type of vehicle and often specialize in vehicles made by a single manufacturer. Auto manufacturers typically provide this specialized training to technicians and mechanics. Workers are usually sent by their employers to formal training courses to gain certification on a particular vehicle type.

Programs, such as the National Alternative Fuels Training Consortium (NAFTC), have been developed to train workers on a wide variety of skills needed to work on electric or alternative fuel vehicles.[8] NAFTC provides curricula and training to secondary and postsecondary students studying automotive technology as well as automotive technicians who are already working in the field.

Wages

BLS does not currently have wage data specific to the electric vehicle industry. The median annual wage for automotive service technicians and mechanics in the automotive repair and maintenance industry group was $33,010 for May 2010. The wage is for the United States as a whole; wages vary by employer and location.

Occupations in infrastructure development

As the number of plug-in hybrids and battery-electric vehicles on the road increases, there will be a growing need for charging stations to charge them. Electric vehicles require special charging stations and increased capacity of electric grids. Most of these chargers will be in the homes of electric vehicle owners or in public charging stations. Public charging stations are needed to recharge vehicles for people away from their home chargers.

Building charging stations will require changes to existing infrastructure. Many large utilities companies—and some large cities—are already developing plans to handle growing numbers of electric vehicles. Urban and regional planners will be involved in planning the infrastructure upgrades, while electrical power-line installers and repairers will lay the wires that carry this extra electricity. Electricians will install the charging stations.

According to a study by the Center for Entrepreneurship and Technology at the University of California, Berkeley, the largest source of job creation related to alternative fuel vehicles is expected to come from the construction of a nationwide charging infrastructure.[9] NAFTC also provides training for electrical infrastructure engineers and installers.

Job duties

Urban and regional planners plan and implement infrastructure upgrades to support electric vehicles. Several cities and local governments are taking an active role in promoting and increasing electric vehicle usage. To facilitate adoption of these vehicles, city and local government officials are introducing improvements that must be made to municipal electric systems so that public charging stations are available to electric vehicle owners. Urban and regional planners determine how many charging stations are necessary to support a given number of vehicles, as well as where to situate them to reach the greatest number of citizens.

Electrical power-line installers and repairers install and maintain the power grid—the network of power lines that move electricity from generating plants to customers. Many electric vehicles require special power stations to charge their batteries, and owners of these vehicles require more electricity than ordinary consumers. Electrical power-line installers install new lines that are capable of handling this increased load. In addition, many local governments are adding public charging stations that must be fed by new power lines. These installers place the new lines and connect them to the grid.

Electricians install charging stations and any other equipment needed for electric vehicles. They attach the charging stations to lines that have been installed by electrical power-line installers and ensure that the chargers are working properly. When there is a problem with the charger, electricians are called to make necessary repairs.

Electric vehicle charging station

Credentials

Urban and regional planners typically work for local or state governments and enter the field with a

master's degree in urban or regional planning or a related field. Some urban and regional planners may be certified by the American Institute of Certified Planners if they have the appropriate combination of education and professional experience, and pass an examination.

Electrical power-line installers and repairers must have a high school diploma or equivalent and have basic math and reading skills. Technical knowledge of electricity is helpful but not required for entry into this field. Installers and repairers receive 1 to 5 years of on-the-job training from their employer. Safety is constantly emphasized during training because working with high voltage electricity can be dangerous.

Electricians should have a high school diploma or equivalent and must go through an apprenticeship that lasts at least 3 years. During an apprenticeship, an electrician receives formal classroom training as well as on-the-job training from an experienced electrician to gain the skills necessary to work independently. In addition, most states and localities require an electrician to be licensed, which usually involves passing an examination that covers knowledge of building codes, the National Electric Code, and electrical theory. Before electricians are certified to install a particular type of charging station, they are required to go through specialized training by the manufacturer.

Wages

BLS does not currently have wage data specific to the electric vehicle industry. The table shows wages for selected infrastructure occupations for May 2010. The wages shown are median annual wages for the United States as a whole; wages vary by employer and location.

Selected infrastructure occupations	Median annual wages, 2010[1]
Urban and regional planners	$63,040
Electrical power-line installers and repairers	58,030
Electricians	48,250

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

Occupations in sales and support

Buying a vehicle is an expensive and complicated process for many customers, and these transactions require the work of sales and support staff to ensure that customers' needs are met. Sales personnel assist customers with the purchase of vehicles, and customer service representatives assist owners after they purchase a vehicle.

Automobile salesperson

Job duties

Retail salespersons sell vehicles to potential customers. In addition to sales, they conduct financial transactions to complete the sale of a vehicle. The retail salesperson helps a customer identify the vehicle that best meets his or her needs and desires. The salesperson also explains the features of various models and the specifications, options, and types of financing available. Salespeople may work long hours and keep irregular schedules and often earn at least part of their salary through commission.

Customer service representatives provide a valuable link between the customer and the companies that produce the products or services that the customer uses. They are responsible for responding to customer inquiries and resolving problems that customers experience. They may do their work in call centers by telephone, or they may interact face-to-face in a service center or office. Often, customer service representatives will act as a liaison between customers and manufacturers or automotive service technicians. They help determine a customer's needs and relay this information to technicians who perform the work.

Credentials

Sales representatives and customer service representatives do not require specialized education beyond a high school diploma. Most of these workers are trained on the job and will be given more responsibility and promotions as they gain experience. All of these occupa-

tions require individuals with good communication and problem-solving skills. Employers seek out people who are friendly and possess a professional manner.

Wages

BLS does not currently have wage data specific to the electric vehicle industry. The table shows wages for selected sales and support occupations in the automobile dealers industry group for May 2010. The wages shown are median annual wages for the United States as a whole; wages vary by employer and location.

Selected sales and support occupations in the automobile dealers industry group	Median annual wages, 2010[1]
Retail salespersons[2]	$36,470
Customer service representatives	31,400

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

Conclusion

Electric vehicles are an important component of the growing green economy because they can reduce pollutants and dependence on fossil fuels. Jobs in the electric vehicles industry show great potential for new employment opportunities, and employment is expected to grow in all of the major sectors of the industry. In addition, jobs will be created as the electric infrastructure is expanded to support these vehicles. These new jobs will cover a wide variety of occupations.

The growth of the electric vehicles industry is evident by the increasing number of electric vehicles purchased over the past decade, as well as new models being introduced by several manufacturers this year in the United States. As more electric vehicles are purchased, employment opportunities in the industry are expected to continue to grow.

Notes

[1] Electric vehicles are a subset of alternative fuel vehicles. Other alternative fuel vehicles—not covered in this report—include vehicles that run on natural gas, propane, or biofuels, such as biodiesel and ethanol.

[2] "One Million Electric Vehicles by 2015, February 2011 Status Report," p.9, (U.S. Department of Energy, 2011), **http://www1.eere.energy.gov/vehiclesandfuels/pdfs/1_million_electric_vehicles_rpt.pdf**.

[3] For more information on the BLS green jobs plans and initiatives, please see **www.bls.gov/green**.

[4] Electric Vehicles in the United States" (Center for Entrepreneurship and Technology, University of California, Berkeley, 2009), p. 21, **http://cet.berkeley.edu/dl/CET_Technical%20Brief_EconomicModel2030_f.pdf**.

[5] Megan M. Barker, "Manufacturing Employment Hard Hit during the 2007-09 Recession," *Monthly Labor Review* (U.S. Bureau of Labor Statistics, April 2011), pp. 28–33, **https://www.bls.gov/opub/mlr/2011/04/art5full.pdf**.

[6] "Vehicle Technologies Program; Graduate Automotive Technology Education (GATE)," (U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, 2010), **http://www1.eere.energy.gov/vehiclesandfuels/deployment/education/fcvt_gate.html**.

[7] "Service Hybrid Electric Vehicles–Safely!," *Alternative Fuel Technology* (National Institute for Automotive Service Excellence, 2005) **http://www.cdxetextbook.com/asearticles/servicehybelecvehicle.html**.

[8] For more information see the National Alternative Fuels Training Consortium at **http://www.naftc.wvu.edu**.

[9] "Electric Vehicles in the United States" (Center for Entrepreneurship and Technology, University of California, Berkeley, 2009), p. 21, **http://cet.berkeley.edu/dl/CET_Technical%20Brief_EconomicModel2030_f.pdf**.