Teacher Background

Inquiry Description

Although electricity generated excitement, and although electrical companies worked hard to gain a domestic market for the power, its use spread slowly, suggesting consumer resistance linked to cost, availability, and alternatives. Electricity first entered homes as batteries for fire and burglar alarms; and potential customers learned that electric lights would neither asphyxiated people nor set the house afire with an exposed flame.

By the early twentieth century, electricity played an ever-increasing and complex role in everyday life in western society as consumers gradually became more dependent on it as a source of energy for light, heat, and power. On the eve of the Second World War nearly 80 percent of the residential dwellings in the United States had electricity as their primary form of illumination. However, more than 20 percent continued to rely on either kerosene or gasoline lighting and almost one percent still used gas lighting. The gap between those using electric lighting in urban and rural America was much wider. According to the 1940 U.S. Census, almost all residents of urban communities and metropolitan districts had electric lighting in their homes and rural-nonfarm dwellings hovered around the national average. However, nearly two-thirds of rural farm dwellings continued to rely on kerosene or gasoline illumination. Indeed, the adoption of new technology is seldom a linear and complete process, but more and more people were accustomed to seeing and using electricity by mid-century. However, In the first decade of the twentieth century, depending on locale, construction, availability, and personal finances, a wide-variety of lighting sources might be found in use, including: candles; kerosene; gasoline; coal or water gas; incandescent coal or water gas with mantles; electric arc light; incandescent electric light; and acetylene gas lighting.

Today, the developed world, and to some degree the developing world, is dependent on electricity for many daily conveniences such as heating homes; brewing morning beverages; refrigerating foodstuffs; powering computers; illuminating residences, offices, recreational spaces, and streets; and operating the traffic lights people sometimes ignore. This dependency is recognized when electric service is disrupted as skyscrapers become dysfunctional, cities come to a near standstill, and urban centers sometimes erupt, resulting in incidents of civil unrest and looting that are broadcast on the evening news. When power is lost people also worry about defrosting refrigerators and maintaining light, heat, air-conditioning, and water service in their homes and businesses.

This unit explores the connections between the invention, commercialization, and adoption of electric lighting as well as alternative forms of artificial illumination in the late nineteenth and early twentieth centuries.

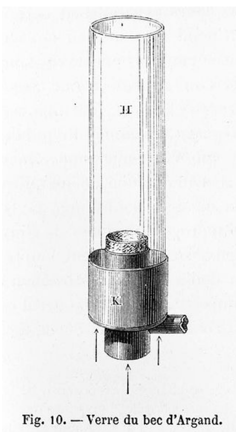
Teachers are encouraged to use the following notes as they prepare for this unit and consult the additional resources listed at the end of this document for more information.

Historical Background

Artificial Illumination

Humans relied on natural light provided by the sun and the moon for millennia. They used torches and, thousands of years ago, they began to use lamps that relied on liquid or semi-solid oil. Sources of fuel for oil lamps included a variety of plants and seeds (almonds, olive, and sesame) and animal fats (fish oil, whale blubber). In time, tallow candles from animal fat, and the less smelly and smoky, but more expensive, bees wax candles also offered a means illumination.

Beginning in 1780, the Argand lamp began replacing other oil lamps and these were replaced around 1850 by kerosene lamps as whale oil supplies diminished. In small towns and rural areas, the kerosene lamp continued in use well into the twentieth century and it remains in common use today in the developing world.



Argand Lamp, https://commons.wikimedia.org/wiki/File:Verre_du_bec_d%27Argand.jpg

An astral lamp (1860), an Argand lamp designed so that the reservoir does not cast a separate shadow. https://commons.wikimedia.org/wiki/File:Astral_Lamp_MET_189873.jpg

PRELUDE TO ELECTRIFICATION

Manufactured Gas

Gas lighting is the production of artificial light from a gaseous rather than a liquid fuel. The gas could occur naturally, or be produced from another carbon-based fuel such as coal. Besides the problems of obtaining and storing a gas rather than a liquid, transport was obviously a challenge. In the 1790s, inventors first started exploring how Gas might be used in a practical way for illumination. Rapid progress followed. The streets of London, England were first illuminated by gas in 1807, by 1860 nearly 250 German cities had gas lighting, and its adoption spread rapidly and widely throughout western and central Europe. In the early nineteenth century, gas companies were also founded in America's larger cities, including Baltimore (1816), New York City (1823), Boston (1828), New Orleans (1832), and Philadelphia (1836). At mid-century many urban centers and small towns had gas manufacturing plants for the production of illuminating gas.

In the United States most manufacturers used bituminous or soft coal to produce gas with an illumination value of fifteen to seventeen candles. This form of artificial lighting became more commonplace in offices, shops, factories, and homes. Until the late 1870s, gas was used almost exclusively for illumination, but then it was adopted for heating and cooking. Society, especially urban dwellers, became increasingly dependent on gas as a source of energy for light, heat, and power. Gas systems provided street, industrial, commercial, and residential lighting either by isolated plant or central station.

ELECTRIFICATION

Electrification – Arc Light

Pioneers and entrepreneurs in London, Baltimore, and Philadelphia invested their fortunes building gas plants, burying pipes, and creating transmission systems that powered streetlights, businesses, and homes. However, just as this booming industry approached maturity, a new practical alternative emerged—the electric light.

The arc lamp, invented as early as 1802 by Humphry Davy in the UK, was able to be introduced commercially around 1880. It produced light by passing an electric current between two electrodes. The arc of current provided a brilliant white light and it eventually illuminated streets, factories, and lighthouses. Electricity, a newly understood power source (Alessandro Volta invented the first practical chemical battery in 1799, and by 1831 Michael Faraday had demonstrated how to generate electricity from mechanical motion) had many potential advantages over gas, the main being that it could be produced anywhere, and easily transported over wires.

At the time of its invention, however, the arc lamp faced several technological barriers to its practical use. The intensity of the electric arc quickly consumed the ends of the electrodes until the gap between them was too distant for the current to jump. In 1870, the Russian inventor, Pavel Nikolayevich Yablochkov, devised one solution, the Jablochkoff Candles, which awed visitors to the Paris World's Fair in 1878. While Yablochkov's two parallel carbon rods solved the original problem, his "candles" needed frequent adjustments to maintain a constant arc, and so they too remained an impractical solution. Cleveland inventor, Charles F. Brush, also tackled the problems with arc lighting. Arc lamps used massive amounts of current and were originally powered by batteries. The limited charge of even the best batteries in the early 19th century meant that a single arc lamp required frequent battery replacement. Brush solved this problem in the 1870s with an improved electric-generating dynamo, which produced a constant and continuous current.

He developed a solution to the arc lamp's second big problem as well – the short life of the electrodes that produce the arc. Brush created an electro-mechanical device that adjusted the distance between the electrodes to match the current that passed through the system. By combining his dynamo and arc lamp improvements, Brush made the arc lighting system a commercially viable alternative to gas lights. In the early 1880s, the Brush Electric Company illuminated the streets of major cities, including Cleveland, New York, Baltimore, Boston, and Montreal.

Electrification – Incandescent Lamp

While Brush worked to improve the life of the arc lamp, other inventors worked on a separate problem with the technology – the intensity of the light. The arc of current produced by the arc lamp, while acceptable for streetlights, was too glaring for comfortable use in homes, offices, and shops. The arcing could also be noisy and occasionally smelly, thus not affording much of an advantage over gas lighting. For engineers at the time, the "holy grail" of commercial success was to find a way to reduce and contain the electric arc.

One such engineer was Thomas Alva Edison. Edison had used the revenue from his early successful inventions such as the stock ticker-tape machine and an improved telegraph to construct a laboratory in Menlo Park, New Jersey (today the town has been renamed Edison!). Many consider this to have been the first modern research and development (R&D) lab. His invention there of the phonograph made him even more financially successful and cemented his reputation as "The Wizard of Menlo Park," the world's greatest inventor. He and his team then turned their attention to the electric lighting problem.

As many had before him, Edison theorized that a conducting filament, connecting the two electrodes, could produce a more comfortable light when heated by the current, a so-called "incandescent lamp." This system can then be enclosed in a glass cover.

Many inventors worked on this problem in the lab, but as with Edison's earlier endeavors, he developed the first practical incandescent lamp, which could be commercialized. In his usual fashion, he had his team experiment with literally hundreds of filaments and lamp designs. They settled on a carbon filament enclosed in an evacuated glass bulb. In 1879, Edison's incandescent lamp became a reality, but this was only the beginning of the Wizard of Menlo Park's quest to electrify America (and, ultimately, the world).

Edison realized that to compete with an entrenched gas system, he needed an entire system of his own. That is, a way to produce electricity, and transport it to the electric lamps. Also, since lamps burned out, they needed to be easily replaced, not hard wired into the system. So, Edison and his team developed generators, wiring, and even the screw connection for electric lamps (as lightbulbs continued to be called for some time).

On 4 September 1882, Edison began operating his first commercial central station, a coal-powered plant located on Pearl Street in New York City at the center of the financial district and newspaper district in lower Manhattan. That same year, a much smaller central station went on line in Appleton, Wisconsin, the hydropowered Vulcan Street plant. Electric central stations quickly spread to urban and manufacturing centers around the country and around the world, as Edison and his team continued to make improvements.

One key member of Edison's team was Lewis Latimer. Lewis' father, George Latimer, was a slave in Virginia who escaped with his wife, Rebecca to Boston in 1842. Their "owner" attempted to recover them through the infamous Fugitive Slave Act and their case became a major icon in the Abolitionist movement. Given the politics of the time, the only way their abolitionist supporters could rescue them was to buy George's freedom.

Lewis was George and Rebecca's fourth child, born in freedom in 1848. He turned out to be a gifted student and artist. After serving in the Union Navy, he got a job as an "office boy" at a patent law firm. He observed and spoke to the draftsmen, and taught himself mechanical drawing. His firm recognized his talent and hired him as a draftsman. One of the first clients assigned to Lewis was Alexander Graham Bell, who was working on the telephone. From there, he was able to get jobs as a patent draftsman at a series of electric companies. In the meanwhile, he set up a lab at his home in Queens, New York, where he became an inventor himself. In 1888, Edison accomplished another one of his coups. He hired Latimer—not as a draftsman, not as an engineer, but as a patent consultant, probably the first in the electric industry. As Edison and his rivals sued one another over infringement, Edison figured that no one in the entire industry new patents better than this African-American son of former slaves.

Lewis Latimer (1848 – 1928).
From Wiki commons, Public Domain

LIGHT THROWN ON A DARK SUBJECT.
(Which is Bad for the Gas Companies.)

Light thrown on a dark subject (Which is Bad for the Gas Companies)," *Puck*, (23 Oct. 1878): 16. Library of Congress, Prints and Photographs Division, Washington, D.C. 20540 USA. AP101.P7 1878 (Case X) [P&P]. No restrictions on publication. https://www.loc.gov/item/2004679729/ (accessed: 10 Feb. 2016)

Thomas Edison, with his newly-invented electric light bulb, throws light on the gas company monopoly, personified by two men with monstrous gas-meter heads. On 27 Jan. 1880, Thomas Edison received a patent for an incandescent light bulb. Edison did not invent the electric light, but he was the first to make the technology commercially viable by reducing its cost and adapting it to safely work at low voltages.
Thomas Edison, with his newly-invented electric light bulb, throws light on the gas company monopoly, personified by two men with monstrous gas-meter heads.

THE EDISON LIGHT.
(AND THE SILLY BIRDS.)

Charles Keene, "The Edison Light (and the silly birds)," *Punch*, 26 Oct. 1878.
"Mr. Edison the great American inventor, had devised a new plan for subdividing the electric light, and thus rendering it available for domestic use in the place of gas. The holders of gas shares were greatly alarmed at the prospect of such a rival as the Edison Electric Light, and alarm which *Mr. Punch*, rightly as the result proved ridiculed as groundless." See **Mr. Punch's Victorian Era: An Illustrated Chronicle of the Reign ..., Volume 3,**

https://books.google.com/books?id=Yso-AAAAYAAJ&pg=PA72&lpg=PA72&dq=punch+cartoon+the+edison+light+and+the+silly+birds&source=bl&ots=8mxwfW9W2d&sig=ACfU3U3oDJD75PIdQrCzMPGLK9kfVkygQ&hl=en&sa=X&ved=2ahUKEwj_rt2AlvnhAhUGT98KHVI0BCkQ6AEwEXoECAQQAQ#v=onepage&q=punch%20cartoon%20the%20edison%20light%20and%20the%20silly%20birds&f=false

"Coming Events Cast Their Shadows Before," *Punch, or the London Charival*, 14 Sept. 1878.

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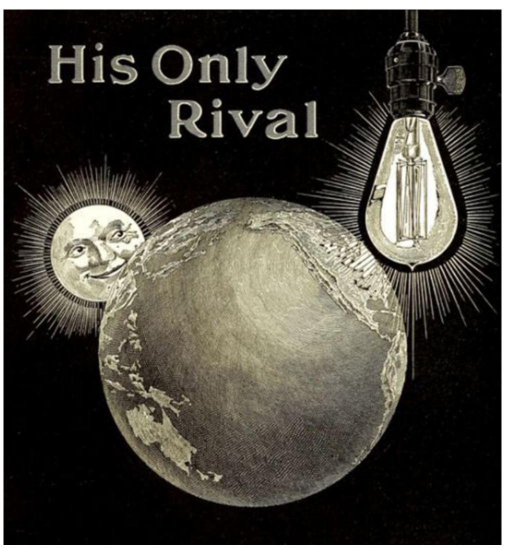


General Electric, Mazda Light Bulb advertisement, 1909.
https://www.collectorsweekly.com/articles/let-there-be-light-bulbs

THE EDISON INCANDESCENT LAMP SCREWED IN SOCKET.

Edison's improved light bulb patent, showing screw connection (During his career, Edison was awarded 1,093 U.S. Patents.) Edison Papers Project (http://edison.rutgers.edu/lamp.htm; retrieved 12 June 2020)

Thomas Edison U.S. Patents by Subject	
Batteries *(147)*	Cement *(49)*
Electric Light & Power *(424)*	Mining & Ore Milling *(53)*
Miscellany *(50)*	Motion Pictures *(9)*
Phonographs & Sound Recording *(199)*	Telegraphy & Telephony *(186)*

“THE CURRENT WARS”

The main limit of Edison’s system was the short distances that his direct current (DC) generators could transmit electric power. Edison experimented with three-line systems (rather than just two lines, hot and ground) to improve the situation. In Europe, engineers were experimenting with alternating current (AC) generators, where the current moved rapidly back and forth between positive and negative. The power could go much farther, and over less-expensive wires, although the current also operated at dangerous levels. In 1886, Nikola Tesla, from what was then the Austro-Hungarian Empire, developed a practical three-phase alternating current generator. He moved to America and briefly worked for Edison, who remained committed to DC. Tesla then tried to form his own electric company, but turned out to be a better inventor than he was a businessman. So, instead, in 1886 he went to work for George Westinghouse, an industrialist who decided that he could use Tesla’s patents to compete with Edison. Thus began the so-called “Current Wars.” Edison tried to emphasize the safety problems with AC. Some of his associates publicly electrocuted animals, and Edison invented an AC electric chair to sour the public on the rival energy source.

In the end, the financial advantages of AC proved to be too strong. In 1895, Westinghouse opened an AC power plant at Niagara Falls, which was able to supply sufficient power all the way to Buffalo, New York. AC is the power now that we all have coming out of sockets in our home. Interestingly, DC power still has certain uses, for example for transportation. Most electric streetcars and subways have used DC power. To this day, the largest system, New York City, takes commercial AC power but converts it to DC to run its lines.

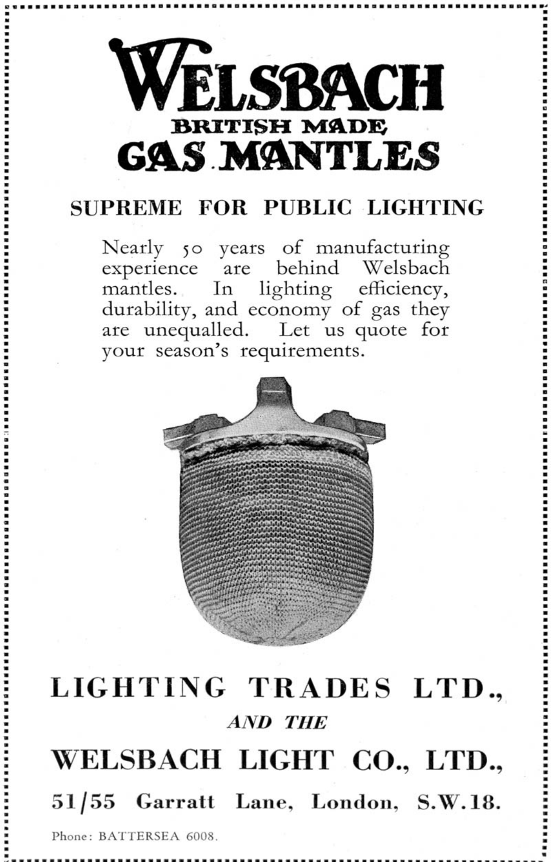
ALTERNATIVES TO ELECTRIC LIGHTING

Besides the competition between AC and DC electricity, electric lighting still faced competition from other energy sources.

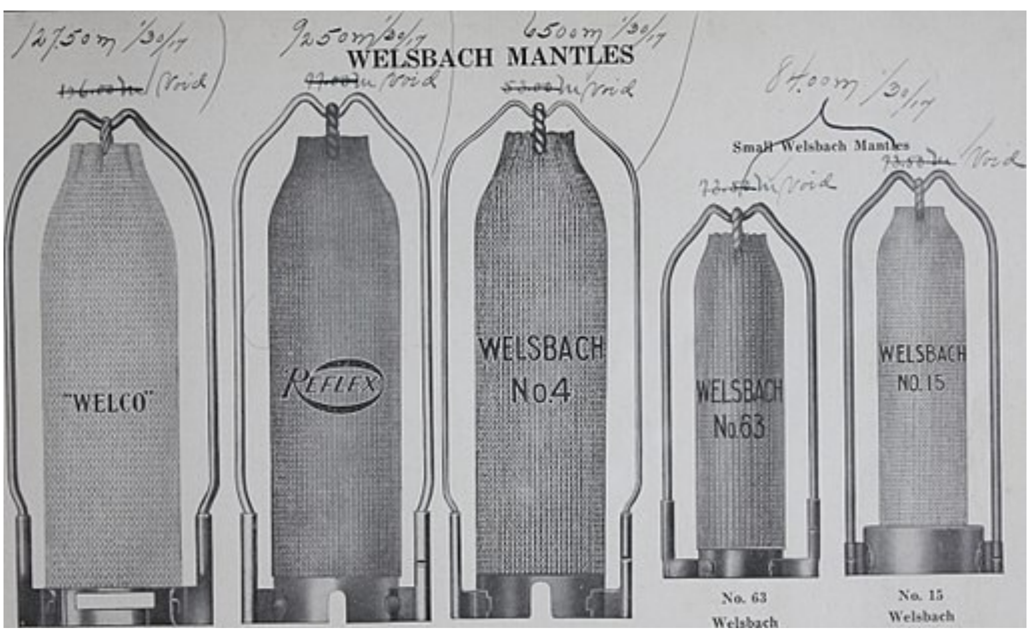
Improved Manufactured Gas Lighting

With the advent of the electric light age, manufactured gas did not capitulate. Inventors and manufactures continued to improve gas quality and production processes, distribution systems, and light fixtures. They also expanded their market to offer improved lighting, domestic appliances, and heating technology.

Carl Auer, Freiherr von Welsbach, Austrian chemist and engineer, invented the gas mantle, which greatly increased output of light by gas lamps. In 1885, Welsbach found that a fabric impregnated with a mixture of thorium nitrate and cerium nitrate could be made into a mantle that glowed brightly when heated by a gas flame. Patented in 1885, the Welsbach mantle greatly improved gas lighting and, although largely supplanted by the incandescent lamp, is still widely used in kerosene and other lanterns. In 1898, Welsbach introduced the first metallic filament for incandescent lamps. Although the osmium he used was too rare for general use, his improvement paved the way for the tungsten filament and the modern light bulb.



Welsbach Street Lighting Company of America. Improved gas lighting with invention and adoption of the Welsbach gas mantle. (Retrieved from http://www.simoncornwell.com/lighting/manufact/lt/archive/c37-1.htm, 12 June 2020)



The Welsbach Mantle of 1890, image retrieved from https://medium.com/@taboca/the-incumbent-arrived-the-competition-strikes-back-feat-the-welsbach-mantle-of-1890-c465f3a17e57 (Accessed: 1 May 2019)

Manufactured gas companies expanded their product line to include light, heat, and power applications and appliances. Harrisburg Gas Co., "The MODERN Kitchen is the GAS Kitchen," *Harrisburg Patriot,* 1912.

The Illuminating Engineering Society, founded in 1906 and headquartered in New York City, held its first annual meeting on 13 February 1906 at the Hotel Astor. L. B. Marks delivered his presidential address outlining "the present state of the science and art of illumination." Marks collected data from U.S.

Acetylene gas, also known as carbide

Ironically, the growing electric industry gave rise to one of its own rivals. In 1836, Edmund Davy, professor of chemistry at the Royal Dublin Society, had discovered a gas that he recognized as "a new carburet of hydrogen." It was an accidental discovery while attempting to isolate potassium metal. By heating potassium carbonate with carbon at very high temperatures, he produced a residue of what is now known as potassium carbide, (K_2C_2), which reacted with water to release the new gas. A similar reaction between calcium carbide and water was subsequently widely used for the manufacture of acetylene.

In 1892, Thomas Willson discovered an economically efficient process for creating calcium carbide in an electric arc furnace from a mixture of lime and coke. The arc furnace provides the high temperature required to drive the reaction. That is, electricity was needed to produce a substance which could in turn produce light to compete with electricity. Manufacture of calcium carbide was an important part of the industrial revolution in chemistry, and was made possible in the US as a result of massive amounts of inexpensive hydroelectric power produced at Niagara Falls before the turn of the twentieth century.[6] In 1895, Willson sold his patent to Union Carbide. Domestic lighting with acetylene gas was introduced circa 1894 and bicycle lamps from 1896. In France, Gustave Trouvé, a Parisian electrical engineer, also made domestic acetylene lamps and gasometers.

Carbide lighting was used in rural and urban areas of the United States that were not served by electrification. Its use began shortly after 1900 and continued into the 1950s. Calcium carbide pellets were placed in a container outside the home, with water piped to the container and allowed to drip on the pellets releasing acetylene. This gas was piped to lighting fixtures inside the house, where it was burned, creating a very bright flame. Carbide lighting was inexpensive, but was prone to gas leaks and explosions. Early models of the automobile, motorbike and bicycle used carbide lamps as headlamps.

Advertisement for home acetylene gas lighting for country homes and farms. This type of gas light was brighter than both kerosene lamps and candles. Source: Union Carbide advertisement. *Country Gentleman*, 7 Oct. 1922. https://commons.wikimedia.org/wiki/File:Gas_Lighting.jpg

Census Reports and information from Union Carbide (Acetylene) and Standard Oil , estimating the consumer costs of lighting for 1905: electric light, $120 million; coal and water gas $40 million; natural gas $1.7 million; acetylene (carbide gas) $2.5 million; and oil $60 million. This totaled about $220 million, and was probably an underestimate. (see Di Laura, David. Illuminating Engineering Society. History https://www.ies.org/about-us/history/)

RURAL AMERICA

The economics of the new electric lighting systems favored cities and mining and manufacturing hubs, but not farms. President Franklin Roosevelt, in his "New Deal" to take America out of the great depression, felt that electrification was the key to eradicating rural poverty. In 1933, the Tennessee Valley Authority was established to produce electricity (among other benefits) to the Tennessee River area that includes much of Tennessee, Alabama, Mississippi, and Kentucky, Georgia, North Carolina, and Virginia. By the end of World War II, it was America's largest single electricity supplier

Just recently, however, in 2018, Richard Hirsh published a revisionist history of rural electrification, perceptively noting that "traditional histories of rural electrification glorify New Deal [REA and TVA] efforts to bring electricity to farmers, enabling them to enjoy modern amenities equal to those of their urban counterparts. Though not disparaging the fruitful work performed by government agencies in the 1930s, [he challenged the] standard narratives by highlighting extensive electrification efforts undertaken earlier by power companies and land–grant universities." Hirsh concluded, "while many urban utility executives viewed the rural power market with disdain, others formed an undercurrent movement that—even in an agricultural recession—led to an almost quadrupling of electrified farms in the years between 1923 and 1931."

Hirsh, Richard. "Shedding New Light on Rural Electrification: The Neglected Story of Successful Efforts to Power Up Farms in the 1920s and 1930s." *Agricultural History*, v. 92, No. 3 (Summer 2018): 296-327.

Lee, Russell, photographer. Daughter of John Whitehead with kerosene lamp. Coleman Fuel Co., Red Bird Mine, Field, Bell County Kentucky, 31 Aug. 1946. Dept. of the Interior. Solid Fuels Administration for War (04/19/1943-06/30/1947), NARA record: 2489414.
https://commons.wikimedia.org/wiki/File:Daughter_of_John_Whitehead_with_kerosene_lamp._Coleman_Fuel_Company,_Red_Bird_Mine,_Field,_Bell_County,_Kentucky._-_NARA_-_541204.jpg

RECENT GLOBAL ELECTRIFICATION TRENDS

Although outside the main scope of this unit, it is worth pointing out that the rise of electricity after World War II was perhaps an unmatched phenomenon in technological history. In addition to the political and transportation developments of the past 75 years, there is no question that the continued growth of electricity contributed mightily to postwar economic boom and to globalization.

Yet, by 1994, approximately 25 percent of the world's population still lacked access to electricity! Their "TVA Moment" was yet to come.

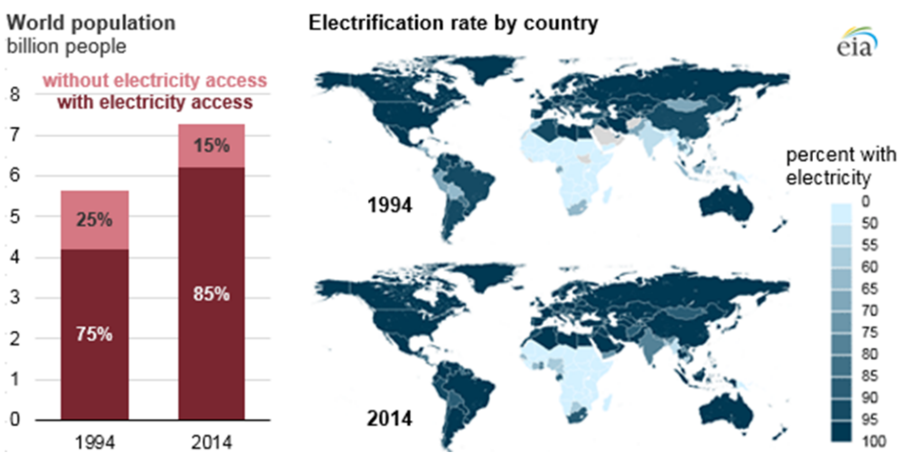
Part of the increased share of access to electricity is attributable to the faster rate of population growth in urban areas; the share of the world's population living in urban areas grew from 44 percent in 1994 to 53 percent in 2014. Urban areas tend to be more electrified, but most of the world's population without access to electricity lived in rural areas. In 2014, 27 percent of the world's rural population did not have electricity access compared with 4 percent of urban populations. Data from the World Bank indicated that 15 percent of the world's population, approximately 1.1 billion people, lacked access to electricity in 2014. (Global Access to Electricity, Global access to electricity has increased over the past two decades. https://data.worldbank.org/indicator/eg.elc.accs.zs;

http://wdi.worldbank.org/table/3.7)

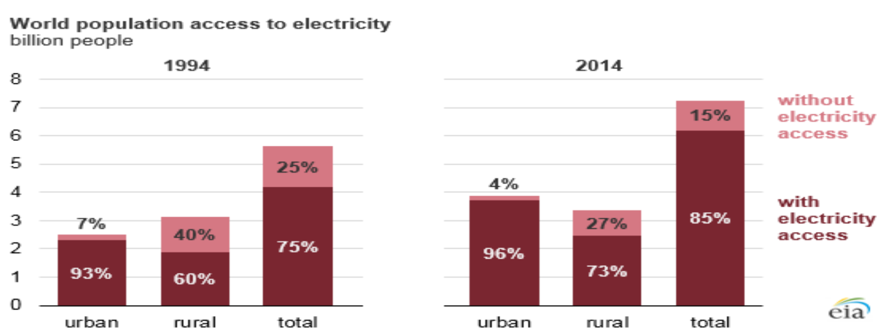
The electrification rate grew the fastest from 1994 to 2014 in Africa, the Middle East, and South and Southeast Asia. Investments to increase electricity access have significant implications for economic development and quality of life as well as the energy consumption and energy-related emissions for each country. In 2014, access to electricity globally climbed to 85.3 percent, up only slightly from 85 percent in 2012, representing a slowdown from previous years. This means that 1.06 billion people – about three times the population of the United States – still lived without access to electricity; despite the fact that 86 million people are newly getting electricity every year. Access to electricity in Africa is not growing as rapidly as its population. But countries like Kenya, Malawi, Sudan, Uganda, and Zambia and Rwanda, in particular, increased their electrification by 2 to 4 percentage points annually in the 2012-2014 period. In 2017, three years later, the World Bank reported 80 percent of the global population without access to electricity live in twenty countries. Most recent data (2019) indicates around 800,000 million are without access to electricity and many people in the developing world do not have access to electricity twenty-four hours per day.

During the past few decades, there has been a regional shift in access to electricity. In 1990, nearly half (45 percent) of people in the world without access lived in South Asia. By 2016, this shifted significantly; the largest share now lives in Sub-Saharan Africa (which is home to nearly two-thirds of the world population without electricity access). High-income countries – or countries defined by the United Nations to be "developed" are assumed to have an electrification rate of 100 percent from the first year the country entered that category. Therefore, the increasing global share has primarily been driven by increased access in low and middle-income economies. In many countries, this trend has been striking. Access in India, increased from 43% to almost 85% and Indonesia is at almost 98%, up from 62% in 1990.

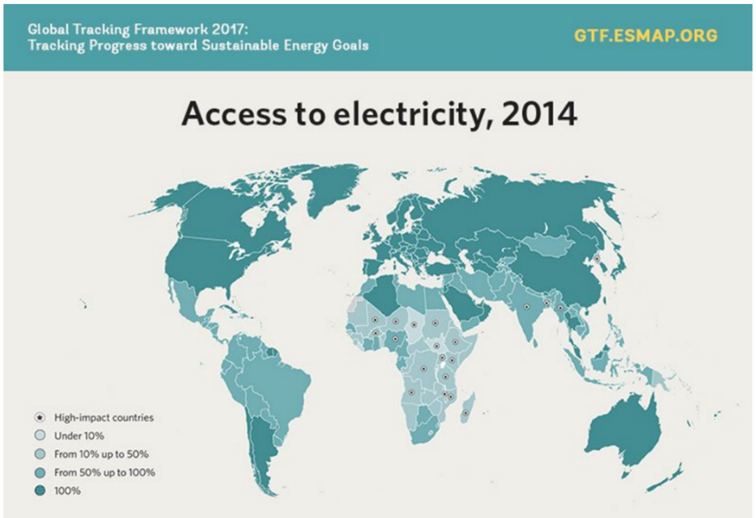
While the trend is upward for most countries, some are still severely lagging. The most underserved region is Sub-Saharan Africa. For example, only 8.8% of Chad's population has electricity access. Access to electricity is typically more dependent on national infrastructure development; the development of effective and inclusive grid or decentralized delivery networks. In some cases, this does not provide an accurate indication of electricity or energy affordability at the individual or household level. Many households may only consume the minimum threshold of electricity usage necessary to be considered 'electrified' as a result of personal finance constraints. If a household consumes only small quantities of electricity (despite having access), it is unlikely to gain the range of social and economic benefits that come with it. In the developed world there is a trend toward efficiency and decreased consumption. Despite this decline in high-income countries, large global inequalities still exist. The average person in the US consumes more than ten times the energy of the average Indian, four to five times that of a Brazilian, and three times more than China. The gulf between these and very low-income nations is even greater- a number of low-income nations consume less than 500 kilograms of oil equivalent per person. (Ritchie, Hannah and Max Roser, "Energy Access," https://ourworldindata.org/energy-access, Sept. 2019.)



Source: U.S. Energy Information Administration, based on the World Bank Population and *Access to Electricity* datasets. Hannah Ritchie and Max Roser (2019) - "Access to Energy". Published online at OurWorldInData.org. Retrieved from: 'https://ourworldindata.org/energy-access' [Online Resource]



Source: U.S. Energy Information Administration, based on the World Bank population and *Access to Electricity* datasets. Hannah Ritchie and Max Roser (2019) - "Access to Energy". Published online at OurWorldInData.org. Retrieved from: 'https://ourworldindata.org/energy-access' [Online Resource]



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Museum Sites

Deutsches Museum, Munich, Germany, https://www.deutsches-museum.de/index.php?L=1

Lewis Latimer House Museum, Flushing, N.Y., https://lewislatimerhouse.org/

National Museum of American History, Smithsonian Institution, Washington, D.C., https://americanhistory.si.edu/

The Henry Ford, Menlo Park in Greenfield Village, Dearborn, Mich. https://www.thehenryford.org/collections-and-research/digital-collections/expert-sets/10254/

Science and Industry Museum, Manchester, UK, https://www.scienceandindustrymuseum.org.uk/

Thomas Edison Center at Menlo Park, Edison, N.J. http://www.menloparkmuseum.org/

Thomas Edison National Historical Park, West Orange, N.J., https://www.nps.gov/edis/index.htm