War of currents essay sample

In the “ War of Currents” era (sometimes “ War of the Currents” or “ Battle of Currents”) in the late 1880s, George Westinghouse and Thomas Edison became adversaries due to Edison’s promotion of direct current (DC) for electric power distribution over alternating current (AC) advocated by Westinghouse and Nikola Tesla.

Thomas Edison American inventor andbusinessman was known as “ The Wizard of Menlo Park” and pushed for the development of a DC power network.| George Westinghouse American entrepreneur and engineer backed financially the development of a practical AC power network.| Nikola Tesla Serbian-American inventor, physicist, and electro-mechanical engineer was known as “ The Wizard of The West” and was instrumental in developing AC networks.| Introduction:

During the initial years of electricity distribution, Edison’s direct current was the standard for the United States and Edison was not disposed to lose all his patent royalties. Direct current worked well with incandescent lamps that were the principal load of the day and with motors. Direct current systems could be directly used with storage batteries, providing valuable load-leveling and backup power during interruptions of generator operation. Direct current generators could be easily paralleled, allowing economic operation by using smaller machines during periods of light load and improving reliability. At the introduction of Edison’s system, no practical AC motor was available. Edison had invented a meter to allow customers to be billed for energy proportional to consumption.

But this meter only worked with direct current. As of 1882, these were all significant technical advantages to direct current systems. From his work with rotary magnetic fields, Tesla devised a system for generation, transmission, and use of AC power. He partnered with George Westinghouse to commercialize this system. Westinghouse had previously bought the rights to Tesla's polyphase system patents and other patents for AC transformers from Lucien Gaulard and John Dixon Gibbs. Several undercurrents lay beneath this rivalry. Edison was a brute-force experimenter but was no mathematician. AC cannot properly be understood or exploited without a substantial understanding of mathematics and mathematical physics, which Tesla possessed.

When tesla came America he was firstly hired by Thomas Edison. He worked for Edison but was undervalued (for example, when Edison first learned of Tesla's idea of alternating-current power transmission, he dismissed it: " Tesla's ideas are splendid, but they are utterly impractical."). Bad feelings were exacerbated because Tesla had been cheated by Edison. Edison promised Tesla to give $50000 if he could make his dynamos more efficient by keeping them in DC. Tesla worked day and night to finish the job and when he was finally completed. Edison Said: " Tesla you don't understand our American humor."

Thus Tesla left his company and partnered with George Westinghouse who was inspired by his ideas.

THE DIFFERENCE IN OPINION OF THE TWO INVENTORS:

THOMAS EDISON:

“ Anything that wont sell, I don’t want to invent.” (This shows that he was more a businessman then an inventor.)

NIKOLA TESLA:

“ Let the future tell the TRUTH, and evaluate each one according to his work and accomplishments. The present is theirs; the future, for which I have really worked is mine.”

Electric Power Transmission:

The competing systems:

Edison’s DC distribution system consisted of generating plants feeding heavy distribution conductors with customer loads (e. g., lighting and motors) tapped into it. The system operated at the same voltage level throughout. For example, 100-volt lamps at the customer’s location would be connected to a generator supplying 110 volts to allow for some voltage drop in the wires between the generator and load. The voltage level was chosen for convenience in lamp manufacture. High-resistance carbon filament lamps could be constructed to withstand 100 volts and to provide lighting performance economically competitive with gas lighting. At the time, it was felt that 100 volts was not likely to present a severe hazard of electrocution. To save on the cost of copper conductors, a 3-wire distribution system was used. The 3 wires were at +110 volts, 0 volts, and −110 volts relative potential. 100-volt lamps could be operated between either the +110 or −110 volt legs of the system and the 0-volt “ neutral” conductor, which only carried the unbalanced current between the + and − sources. The resulting

3-wire system used less copper wire for a given quantity of electric power transmitted while still maintaining (relatively) low voltages.

However, even with this innovation, the voltage drop due to the resistance of the system conductors was so high that generating plants had to be located within a mile (1–2 km) or so of the load. Higher voltages could not so easily be used with the DC system because there was no efficient low-cost technology that would allow reduction of a high transmission voltage to a low utilization voltage. Westinghouse Early AC System 1887 (U. S. Patent 373, 035)

In the alternating current system, a transformer was used between the (relatively) high voltage distribution system and the customer loads. Lamps and small motors could still be operated at some convenient low voltage. However, the transformer would allow power to be transmitted at much higher voltages (say, 10 times that of the loads). For a given quantity of power transmitted, the wire size would be inversely proportional to the voltage used. Or to put it another way, the allowable length of a circuit — given a wire size and allowable voltage drop — would increase approximately as the square of the distribution voltage. This had the practical significance that fewer, larger, generating plants could serve the load in a given area. Large loads (such as industrial motors or converters for electric railway power) could be served by the same distribution network that fed lighting by using a transformer with a suitable secondary voltage.

Early transmission analysis:

Edison’s response to the limitations of direct current was to generate power close to where it was consumed (today called distributed generation) and install large conductors to handle the growing demand for electricity, but this solution proved to be costly (especially for rural areas which could not afford to build a local station or to pay for massive amounts of very thick copper wire), impractical (including, but not limited to, inefficient voltage conversion) and unmanageable. Edison and his company, though, would have profited extensively from the construction of the multitude of power plants required to make electricity available in many areas. Direct current could not easily be converted to higher or lower voltages. This meant that separate electrical lines had to be installed to supply power to appliances that used different voltages, for example, lighting and electric motors.

This required more wires to lay and maintain, wasting money and introducing unnecessary hazards. A number of deaths in theGreat Blizzard of 1888 were attributed to collapsing overhead power lines in New York City. Alternating current could be transmitted over long distances at high voltages, using lower current, and thus lower energy loss and greater transmission efficiency, and then conveniently stepped down to low voltages for use in homes and factories. When Tesla introduced a system for alternating current generators, transformers, motors, wires and lights in November and December 1887, it became clear that AC was the future of electric power distribution, although DC distribution was used in downtown metropolitan areas for decades thereafter.

Low-frequency (50–60 Hz) alternating currents can be more dangerous than similar levels of DC since the alternating fluctuations can cause the heart to lose coordination, inducingventricular fibrillation, a deadly heart rhythm that must be corrected immediately. However, any practical distribution system will use voltage levels quite sufficient for a dangerous amount of current to flow, whether it uses alternating or direct current. As precautions against electrocution are similar for both AC and DC, the technical and economic advantages of AC power transmission outweighed this theoretical risk, and it was eventually adopted as the standard worldwide.

Tesla’s US390721 Patent for a “ Dynamo Electric Machine”

Transmission loss:

The advantage of AC for distributing power over a distance is due to the ease of changing voltages with a transformer. Power is the product of current × voltage ($P = IV$). For a given amount of power, a low voltage requires a higher current and a higher voltage requires a lower current. Since metal conducting wires have a certain resistance, some power will be wasted as heat in the wires. This power loss is given by $P = I^2R$. Thus if the overall transmitted power is the same — and given the constraints of practical conductor sizes — low-voltage/ high-current transmissions will suffer a much greater power loss than high-voltage/ low-current ones. This holds whether DC or AC is used. However, it was very difficult to transform DC power to a high-voltage/low-current form efficiently.

Whereas with AC, this can be done with a simple and efficient transformer. This was the key to the success of the AC system. Modern transmission grids regularly use AC voltages up to 765, 000 volts. Alternating Current transmission lines do have other losses that are not observed with Direct Current. Due to the “ skin effect”, a conductor will have a higher resistance to alternating current than to direct current. The effect is measurable and of practical significance for large conductors carrying on the order of thousands of amperes. The increased resistance due to the skin effect can be offset by changing the shape of conductors.

Edison’s publicity campaign:

Edison carried out a campaign to discourage the use of alternating current including spreading information on fatal AC accidents, publicly killing animals, and lobbying against the use of AC in state legislatures. He directed his technicians — primarily Arthur Kennelly and Harold P. Brown to preside over several AC-driven executions of animals (primarily stray cats and dogs but also unwanted cattle and horses). Acting on these directives, they were to demonstrate to the press that alternating current was more dangerous than Edison’s system of direct current . Edison’s series of animal executions peaked with the filmed electrocution of Topsy — a Coney Island circus elephant.

Topsy the Elephant was electrocuted by Thomas Edison’s technicians at Coney Island before a crowd of thousands. Photo: Chicago Tribune He also tried to popularize the term for being electrocuted as being “ Westinghoused”. Edison opposed capital punishment. But his desire to disparage the system of alternating current led to the invention of the electric chair. Harold P. Brown who was at this time being secretly paid by Edison constructed the first electric chair for the state of New York in order to promote the idea that alternating current was deadlier than DC . When the chair was first used on August 6, 1890, the technicians on hand misjudged the voltage needed to kill the condemned prisoner William Kemmler. The first jolt of electricity was not enough to kill Kemmler and only left him badly injured. The procedure had to be repeated.

A reporter on hand described it as:

“ an awful spectacle far worse than hanging.”

George Westinghouse commented:

“ They would have done better using an axe.”

Willamette Falls to Niagara Falls:

In 1889, the first long distance transmission of DC electricity in the United States was switched on at Willamette Falls Station, in Oregon City, Oregon. [33] In 1890 a flood destroyed the Willamette Falls DC power station. This unfortunate event paved the way for the first long distance transmission of AC electricity in the world when Willamette Falls Electric company installed experimental AC generators from Westinghouse in 1890. That same year, the Niagara Falls Power Company (NFPC) and its subsidiary Cataract Company formed the International Niagara Commission composed of experts, to analyze proposals to harness Niagara Falls to generate electricity. The commission was led by Lord Kelvin and backed by entrepreneurs such as J. P. Morgan, Lord Rothschild, and John Jacob Astor IV. Among 19 proposals, they even briefly considered compressed air as a power transmission medium, but preferred electricity. But they could not decide which method would be best overall.

International Electro-Technical Exhibition:

The International Electro-Technical Exhibition of 1891 featured the long distance transmission of high-power, three-phase electric current. It was held between 16 May and 19 October on the disused site of the three former " Westbahnhöfe" (Western Railway Stations) in Frankfurt am Main. The exhibition featured the first long distance transmission of high-power, three-phase electric current, which was generated 175 km away at Lauffen am Neckar. It successfully operated motors and lights at the fair.

AC deployment at Niagara:

In 1893, NFPC was finally convinced by George Forbes to award the contract to Westinghouse, and to reject General Electric and Edison's proposal. Work began in 1893 on the Niagara Falls generation project and electric power at the Falls was generated and transmitted as alternating current. Some doubted that the system would generate enough electricity to power industry in Buffalo. Tesla was sure it would work, saying that Niagara Falls could power the entire eastern United States. None of the previous polyphase alternating current transmission demonstration projects were on the scale of power available from Niagara: * The Lauffen-Neckar demonstration in 1891 had the capacity of 225 kW * Westinghouse successfully used AC in the commercial Ames Hydroelectric Generating Plant in 1891 at 75 kW (Single phase)

* The Chicago World's Fair in 1893 exhibited a complete 11, 000 kW polyphase generation and distribution system with multiple generators, installed by Westinghouse. * Almirian Decker designed a three-phase 250 kW AC system at Mill Creek California in 1893. On November 16, 1896, electrical

power was sent from Niagara Falls to industries in Buffalo from the hydroelectric generators at the Edward Dean Adams Station. The hydroelectric generators were built by Westinghouse Electric Corporation using Tesla's AC system patent. The nameplates on the generators bore Tesla's name. To appease the interests of General Electric, the contract to construct the transmission lines to Buffalo using the Tesla patents were given to them.

Tesla's US390721 Patent for a " Dynamo Electric Machine".

Competition outcome:

AC replaced DC for central station power generation and power distribution, enormously extending the range and improving the safety and efficiency of power distribution. Edison's low-voltage distribution system using DC ultimately lost to AC devices proposed by others — primarily Tesla's poly-phase systems and also other contributors such as Charles Proteus Steinmetz (in 1888, he was working in Pittsburgh for Westinghouse).

The successful Niagara Falls system was a turning point in the acceptance of alternating current. Eventually, the General Electric company (formed by a merger between Edison's companies and the AC-based rival Thomson-Houston) began manufacture of AC machines. Centralized power generation became possible when it was recognized that alternating current electric power lines can transport electricity at low costs across great distances by taking advantage of the ability to transform the voltage using power transformers. Today, alternating current power transmission networks provide redundant paths and lines for power routing from any power plant to any load center based on the economics of the transmission path, the cost of power, and the importance of keeping a particular load center powered at all times. Generators (such as hydroelectric sites) could be located far from the loads.

Remnant and existent DC systems:

Some cities continued their DC networks well into the 20th Century. For example, central Helsinki had a DC network until the late 1940s. And Stockholm lost its dwindling DC network in the 1960s. A mercury arc valve rectifier station would convert AC for the downtown DC network. New York City's electric utility company — Consolidated Edison — continued to supply direct current to customers who had adopted it early in the 20th Century, mainly for elevators. The New Yorker Hotel — constructed in 1929 — had a large direct-current power plant and did not convert fully to alternating-current service until well into the 1960s. In January 1998, Consolidated Edison started to eliminate DC service. At that time, there were 4, 600 DC customers. By 2006, there were only 60 customers using DC service. On November 14, 2007, the last direct-current distribution by Con Edison was shut down. Customers still using DC were provided with on-site AC to DC converters. Electric railways that use a third-rail system generally employ DC power between 500 and 750 volts. Railways with overhead catenary lines use a number of power schemes including both high-voltage AC and high-current DC.

High-Voltage Direct Current (HVDC) systems are used for bulk transmission of energy from distant generating stations or for interconnection of separate alternating-current systems. These HVDC systems use solid-state devices that were unavailable during the “ War of Currents” era. Power is still converted to-and-from alternating current at each side of the modern HVDC link. The advantages of HVDC over AC systems for bulk transmission include higher power ratings for a given line (important since installing new lines and even upgrading old ones is extremely expensive) and better control of power flows — especially in transient and emergency conditions that can often lead to blackouts. While DC distribution systems over significant distances are essentially extinct. DC power is still common when distances are small and especially when energy storage or conversion uses batteries or fuel cells. These applications include:

- Vehicle starting, lighting, and ignition systems
- Hybrid and all-electric vehicle propulsion
- Telecommunication plant standby power (wired and cellular mobile)
- Uninterruptible power for computer systems
- Utility-scale battery systems
- “ Off-grid” isolated power installations using wind or solar power In these applications, direct current may be used directly or converted to alternating current using power electronic devices. In the future, this may provide a way to supply energy to a grid from distributed sources. For example, hybrid vehicle owners may rent the capacity of their vehicle’s batteries for load-leveling purposes by the local electrical utility company.