Standard Voltages and frequencies.

The type of electricity delivered to homes and businesses was at first direct current (DC) but then changed to AC three phased electricity. In a three-phase system, three circuit conductors carry three [alternating currents](http://en.wikipedia.org/wiki/Alternating_current) (of the same frequency) which reach their instantaneous peak values at one third of a cycle from each other. Taking one current as the reference, the other two currents are delayed in time by one third and two thirds of one cycle of the electric current. This delay between phases has the effect of giving constant power transfer over each cycle of the current and also makes it possible to produce a rotating magnetic field in an [electric motor](http://en.wikipedia.org/wiki/Electric_motor). The standard voltage level started at 110V, went to 240V, back to 110V, and then to 220V. The frequency, which is the number of times the current changes sign in a second, started at 60Hz and then went to 50Hz in most areas. Hence, they vary from country to country throughout the world. Most countries use 50Hz (50 Hertz or 50 cycles per second) as the frequency of their AC. Only a handful use 60Hz. The United States uses 110V and 60Hz AC electricity. Lebanon uses 220V and 50 Hz. Why the frequency is set globally at 50 or 60 Hz and the voltage set at 110 or 220 V? How did they come to these values? And which ones are better?

Between 1886 and 1887 experiments were done using belt driven generators. It was proven that the best frequency to be used for illumination was 133 1/3 Hz. It helped avoiding flickering but it was too high for motors which were developed later. Between 1889 and 1890 direct driven generators started to appear. They were robust and needed lower rotation speeds, therefore lower frequencies were introduced.

Early1890's Westinghouse was involved in bidding electrical equipments for the Niagara Falls power project. When Tesla joined Westinghouse, it was using the frequency 133 1/3 Hz. Later on the Cataract Company (in charge of the Niagara Falls project) selected hydraulic turbines running at 250 rpm(rpm=120f/n where f is the frequency and n is the number of poles.). So if a 16-pole generator was chosen, the frequency would be 33 1/3 Hz and if a 12-pole machine was chosen then the frequency would be 25 Hz. The project consultant projected an 8-pole generator or 16 2/3 Hz. The compromise was 25 Hz. At the time lower frequencies were easier to handle on transmission lines. Another reason is that the Steel industry preferred 25 Hz because of the huge slow speed induction rollers, which had a low power factor for 60 Hz and worked better at 25 Hz. Niagara Falls generated 25 Hz way into the 20th century. By 1910 it looked there would be two frequencies in North America, 25Hz for transmission and heavy industry that needed DC or slow moving heavy machinery and 60 Hz for lighting. There was an effort by GE to introduce 40 Hz as a compromise between 25 Hz and 60 Hz in the 1890's but it was too late to overtake the 60 Hz and 25 Hz infrastructures already in place although there were some 40 Hz installations. Even so most installations in the US were done in 60 Hz after Westinghouse and GE cross licensed their patents. Development of high-speed turbines instead of slow reciprocating machinery, and later developments of the rotary converter that worked well at 60 Hz, made it easy to shift everything to 60 Hz. By 1920 most of the problems associated with 60 Hz transmission were solved so that there was no longer any advantage of transmitting 25 Hz over 60 Hz. This is the reason why the USA uses the 60 Hz frequency rather than the 25 Hz one.

Many theories exist explaining why Tesla insisted on using 60 Hz. Some say that the frequency 133 1/3 Hz was too high for his motor and that 60 Hz is "the fundamental frequency of the universe". Others say that after executing experiments with 8-20 Hz, 20-40 Hz and 40-100 Hz he decided that 60 Hz was the safest frequency and that it's the lowest frequency that would not cause lightening to flicker visibly. Later on, the 50 Hz was employed because it's the rounding off of 60 Hz in the 1 2 5 standard metric scale. The drawbacks of the 50 Hz frequency are that it's not as efficient as the 60 Hz frequency and that it causes more losses. For example, the 50 Hz electrical generators are 20% less effective than 60 Hz generators due to the slower speed.

Tesla preferred the 220 V (AC) voltages to 110 V voltages. It's true that the higher AC voltage provides power to a distance, but the lower voltage is safer. The value 220 V was more utilized since it could be split into two 110 V, in a 2 wired system between neutral and hot wire. Moreover the 110 V, first established by Edison, was already used in different countries.

Originally Europe was using 110 V. In 1889, Berlin Electric Works, owned by AEG, changed from 110 to 220 V to enlarge the capacity of their distribution system since Berlin was already two wired. Since AEG had a virtual monopoly on the region, Europe switched to 220V after World War II. US also wanted to switch to 220 V but it turned out that it was too expensive to change all their electrical appliances. The voltage 220 V delivers more power with less losses and better efficiency in electrical transmission.

To sum up, a voltage of 220 V is more efficient than a 110 V but the 110 V is safer. The 220 V was established because of the previous existence of the 110V and the two wired system. Moreover a frequency of 60 Hz provokes less losses and more power and a 50 Hz frequency. The 60 Hz frequency was utilized because it was the lowest frequency that could be used with motors without unclenching the flickering of lightening. The 50 Hz frequency was set up because it's the closest frequency to 60 Hz which was included in the 1, 2, 5 standard metric scale.

List of references

* <http://www.worldstandards.eu/electricity.htm>
* <http://muller.lbl.gov/teaching/physics10/old%20physics%2010/physics%2010%20notes/electrocution.html>
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