TECHNICAL NEWS

CORTEM GROUP

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The voltage Levels and the energy distribution in the world

1. Introduction

Electricity is the engine of the world, whether it is produced by oil, gas, water flow (waterfalls with dams and related turbines), wind energy, photovoltaics, fossil combustion (coal and fossil coal) or from renewable sources (bio gas or bio masses).

The discovery of energy, clean or less clean, has changed the lives and habits of the populations, in fact distorting the organization of the society in all its aspects, up to generate conflicts between states, such as agreements or embargoes aimed in blocks on the export of oil or coal by strong nations to weak nations or totalitarian regime systems. There are those who invest to encourage renewables and those who are still anchored (by necessity and by economy) to coal, just as there are nations that invest in gas transportation, as an alternative source of production.

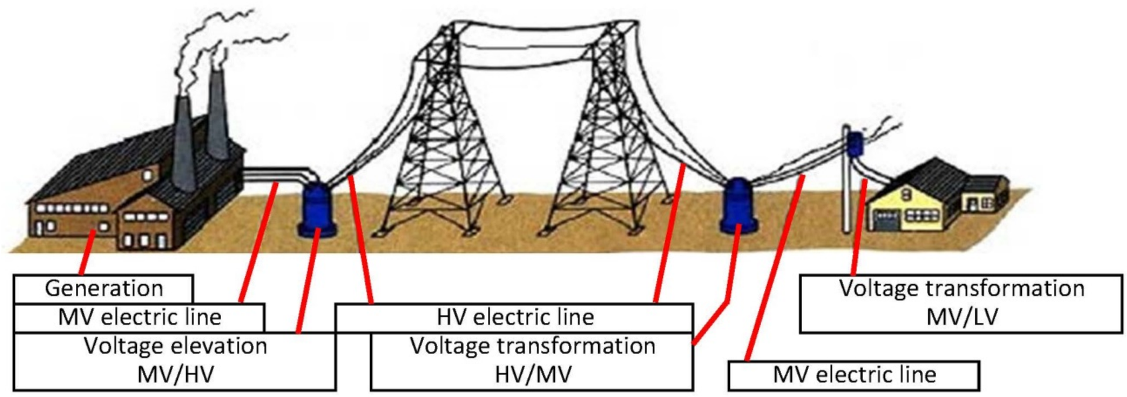
2. The electricity distribution

In the pioneering era of electricity, the production was carried out in direct current and the distribution took place in direct current for the small distances. Only towards the end of 1800, there was a rapid transition to alternating current with the three-phase system, allowing the operation of high-efficiency static transformers and, therefore, the transmission and distribution at a considerable distance.

Electricity distribution is the last phase in the delivery process, after production, transformation and transmission. It is carried out through a network system of the aerial type and the underground type, arriving to the end users.

These network systems include High Voltage power lines (between 36kV and 1000kV), Medium Voltage lines (between 10 and 24kV) and Low Voltage lines (between 0.23kV and 1kV).

These systems include the generations of energy by means of thermal combustion plants (coal or gas or oil power plants), by exploiting the flow of rivers (hydroelectric power plants) or the wind power (wind generators) or the energy latent in the air (photovoltaic generators) or the production of gas from bio masses, using transformation plants HV/MV (primary cabins), MV/LV (secondary cabins).



The choice of voltage levels, therefore of energy transport, over long distances is more efficient by operating at High Voltage. Approaching the end user, instead, the tension needs to be progressively lowered for safety reasons (the risk of electrocution is lowered) and also because the electric loads of industrial users and those of domestic users work respectively at Medium and Low Voltage.

3. The electric standards in the world

At the industrial level, there are complex systems AT/MT and MT/BT, which are used for distribution over large distances and that, in order to optimize the sizing of electrical conductors, are used to limit the voltage drop deriving from the specific resistance of the conductor and from the current that is transported therein.

DV = K x L x I x (R x Cosphì + X_L x Senphì), where:

- DV = voltage drop, expressed in Volt
- K = Fixed coefficient for three-phase systems: 1,73
- L = length of the cable, expressed in Km
- I = intensity of current passing through the cable, expressed in Ampere
- R = resistance for copper or aluminium conductors, expressed in Ohm/Km
- X_L = inductance for copper or aluminium conductors, expressed in Ohm/Km
- Cosphì = variable value from country to country, conventionally it is considered a value of 0.9, with an angle of 25° and 50 '
- Senphì = variable value from country to country, conventionally we consider a value of 0.43, with an angle of 25° and 50 '

Let's take a practical example:

1,73 x 0,16 x 150 x (0,784 x 0,9 + 0,08 x 0,43) = 30,7248 Volt, which, if compared to a nominal voltage of 400V will give:

DV% = (DV x 10^2)/ V, where:

- DV% = voltage drop, expressed in % of rated voltage
- V = rated voltage, expressed in Volt, it is considered a voltage of 400V

DV% = (30,7248 x 10^2)/ 400 = 7,6812%

As can be seen, with the increase of the nominal voltage and with the same current, there will be a decrease in the voltage drop, both in absolute value and in percentage, thus entailing the possibility of decreasing the conductor cross-section.

For this main reason, increasingly large voltage levels are chosen when the underlying load increases. Obviously, this entails an increase in economic terms due to the need to realize such levels with the use of power transformers, power plants, substations and air transport lines that, however, justify this increase with the savings in the dimensioning of electrical conductors.

As can be seen from table 1 below, there are many variables of voltage levels in the world, gradually developed according to criteria that do not have a real logic but only a specific feature dictated by local laws and regulations, whether or not the nation belongs to the pre-colonial or subjugation of other colonizing nations. Little or nothing is the global standardization of causes that go back to the protectionist positions of many national producers protected in a monopolistic sense by their respective governments.

For convenience and simplicity, where there are equalities of voltage levels, we have grouped several nations in a single row.

Legend of the distribution system in use:

- **M**= single phase, **S**=star-delta with neutral, **D**=delta with delta, with a fourth thread in the middle of a winding, **T**= three-phase three-wire with possible two-phase distribution.

Table 1

Nation	Distribution in use	Voltage (V)	Frequency (Hz)
Afghanistan, Albania, Andorra, Angola, Argentina, Armenia, Azerbaijan, Azores, Benin, Belarus, Bosnia Herzegovina, Burkina Faso, Burundi, Cape Verde, Chad, Chile, China, Comoros, Congo-Kinshasa, Egypt, Ethiopia, Gabon, Djibouti , Greenland, Guinea, Guinea Bissau, French Guiana, Hong Kong, Faroe Islands, Kazakhstan, Kyrgyzstan, Lesotho, Macao, Macedonia, Mali, Martinique, Moldova, Mozambique, Niger, New Caledonia, Central African Republic, Reunion, Russia, Serbia and Montenegro , Syria, Tajikistan, Thailand, Turkmenistan, Ukraine, Uzbekistan, Zimbabwe	S	220	50
Algeria, Austria, Bahrain, Belgium, Bhutan, Botswana, Bulgaria, Cameroon, Vatican City, Congo-Brazzaville, Ivory Coast, Croatia, Denmark, Dominica, United Arab Emirates, Eritrea, Estonia, Finland, France, Gambia, Gaza (Gaza Strip), Germany, Ghana, Greece, Grenada, India, Indonesia, Iran, Iraq, Ireland, Northern Ireland (United Kingdom), Iceland, Channel Islands, Israel, Italy, Laos, Libya, Liechtenstein, Lithuania, Luxembourg, Malawi, Maldives, Malaysia, Mauritius, Monaco, Mongolia, Namibia, Norway, New Zealand, Holland, Pakistan, Poland, Portugal, Czech Republic, Romania, Rwanda, Saint Vincent and the Grenadines (Winward Is.), Samoa, Sierra Leone , Singapore, Slovakia, Slovenia, Spain, Sri Lanka, Sudan, South Africa, Sweden, Switzerland, Swaziland, Tanzania, Tunisia, Turkey, Hungary, Yemen, Zambia	S	230/400	50
Netherlands Antilles, Cameroon, France, Indonesia, Canary Islands (Spain), Balearic Islands, Italy, Libia, Madagascar, Morocco, Principality of Monaco, Senegal, Spain, Tunisia, Vietnam.	S	127/220	50
Australia, Brunei, Cyprus, Fiji, Gibraltar, Isle of Man, Cook Islands, Channel Islands, Falkland Islands, Kenya, Kuwait, Malaysia, Malta, Nauru, Nigeria, Oman, Papua New Guinea, Qatar, United Kingdom, Saint Lucia, Tonga, Uganda	S	240/415	50
Bangladesh	S	220/400	50
Barbados	S	115/200	50
Netherlands Antilles, Bolivia, Cambodia, Cameroon, United Arab Emirates, Balearic Islands, France, Jordan, Guadalupe, India, Canary Islands, Lebanon, Madagascar, Madeira (Portugal), Morocco, Namibia, Paraguay, Somalia, South Africa, Togo, Vietnam	S	220/380	50
North Korea, Jamaica, Togo	D	110/220	50
Cambodia	S	120/208	50
Barbados	D	115/230	50
Equatorial Guinea, Latvia, Mauritania, Myanmar Burma, Timor-est, Uruguay	M	220	50
Kiribati	-	240	50
Lebanon	S	110/190	50
United Kingdom	D	240/480	50
Nepal	S	230/460	50
Madeira (Portugal), Somalia	D	220/440	50
Somalia, Panama, Perù	D	110/220	50
India	D	250/500	50
Seychelles	T	240	50
Japan	D	100/200	50/60

Follows Table 1

Nation	Distribution in use	Voltage (V)	Frequency (Hz)
Liberia,	D	120/240	50/60
Colombia, Liberia,	S	120/208	50/60
Antigua, Montserrat (Leeward Is.), Saint Kitts and Nevis, Trinidad and Tobago,	S	230/400	60
Anguilla (United Kingdom)	-	110	60
Saudi Arabia, Aruba, Brazil, Ecuador, Mexico, Suriname, Tahiti,	S	127/220	60
Saudi Arabia, Brazil, South Korea,	S	220/380	60
Bahamas, Bermuda, Equador, Guam, United States,	S	120/208	60
Bahamas, Bermuda, Canada, Costa Rica, Ecuador, Guatemala, Guyana, Cayman Islands, Virgin Islands, Nicaragua, Okinawa (Japan), Puerto Rico, American Samoa, United States,	D	120/240	60
Belize, Brazil, Colombia, South Korea, Cuba, Philippines, Guam, Haiti, Honduras, Taiwan,	D	110/220	60
Belize	D	220/440	60
Canada	T	575	60
Colombia,	S	150/240	60
Equador	S	121/210	60
El Salvador, Philippines, Trinidad and Tobago,	D	115/230	60
Micronesia	-	120	60
Okinawa (Japan)	D	100/200	60
Perù	T	220	60
Dominican Republic,	D	110/220	60
American Samoa	D	240/480	60
United States,	T	460	60
Venezuela	S	120/240	60

In table 1 above, only the tensions of the lower level are highlighted, ie Low Voltage (LV), for the obvious reason that higher levels are the prerogative of complex systems such as the national electricity distribution network, the need to produce and increase the voltage according to the load involved and not least, the saving deriving from the limited use of copper or aluminium for the electricity transport.

4. Distribution criteria in industrial plants

So far, we have talked about the levels of tension in the world and now we will briefly talk about the concepts of electricity distribution in industrial plants.

When the designer examines the system, as a whole, he first analyses the list of electrical loads and, depending on the power involved, decides how many and what levels of voltage will be considered in the phases of engineering development.

Another fundamental parameter is the analysis of the system plan, in order to correctly define the positioning of the electric cabins, if and where possible, trying, as much as possible, to place them in a barycentric position to the users to be fed, maximizing the distances and, consequently, containing voltage drops as much as possible.

For large installed power values, over 20 MW, HV/MV substations is generally chosen, with Medium Voltage distribution, usually with values of 20kV, up to the secondary distribution booths, where further MV / MV transformations will be carried out in case of need to start motors with powers equal to or higher than 1 MW (1000kW) and MV/LV for the power supply of all the low voltage users, both of the three-phase and single-phase type.

With this concept, the secondary distribution criteria are defined for the various electrical panels to supply Power users (motors up to 250 kW), auxiliary utilities such as switchboards for auxiliary services, to supply motorized valves, for power supply to FM and Light sockets. for feeding to the local sub-panels of lighting circuits etc. etc.

The main distribution systems can be defined in:

- Radial system: the power is directed to the underlying user
- Double radial system: the power supply on the subtended user has a reserve equal to 100% thanks to a double power supply
- Ring system: underlying user is powered by two lines closed in ring and which, in the event of disruption of one of the two lines, can be powered by opening the ring and feeding it from the ring part still in use.

Always with the same perspective, the designer analyses all the needs aimed at the safety of the plant management, preparing suitable safety circuits, such as local panels for emergency lighting power supply, for powering ESD (Emergency Shut Down) and PSD safety systems (Process Shut Down) that will have to guarantee the personnel to safely evacuate the system in case of emergency.

These systems were previously managed by systems powered directly by direct current from specific local batteries that, in addition to powering the emergency lighting circuits, also supplied power for all the functional logics of the power, command and control panels.

Today, with the advent of the "UPS" systems (Uninterruptible Power Supply), these systems are powered by alternating current, through dedicated DC/AC converters that supply them even in case of primary energy disservice, thus guaranteeing the continuity of the electricity supply, until the UPS batteries have run out of capacity.

5. Conclusions

With this very short exposition, we only wanted to highlight the differences in tension at the world level, hoping that what described can be of help to readers and does not want to be a guideline, as the designer has to analyse. in all the multiple situations, which levels of tension adopted in the design phases and taking into due account the regulations and laws in force in each specific country of destination.