Decoding the Journey of Electricity

Center for Study of Science, Technology and Policy
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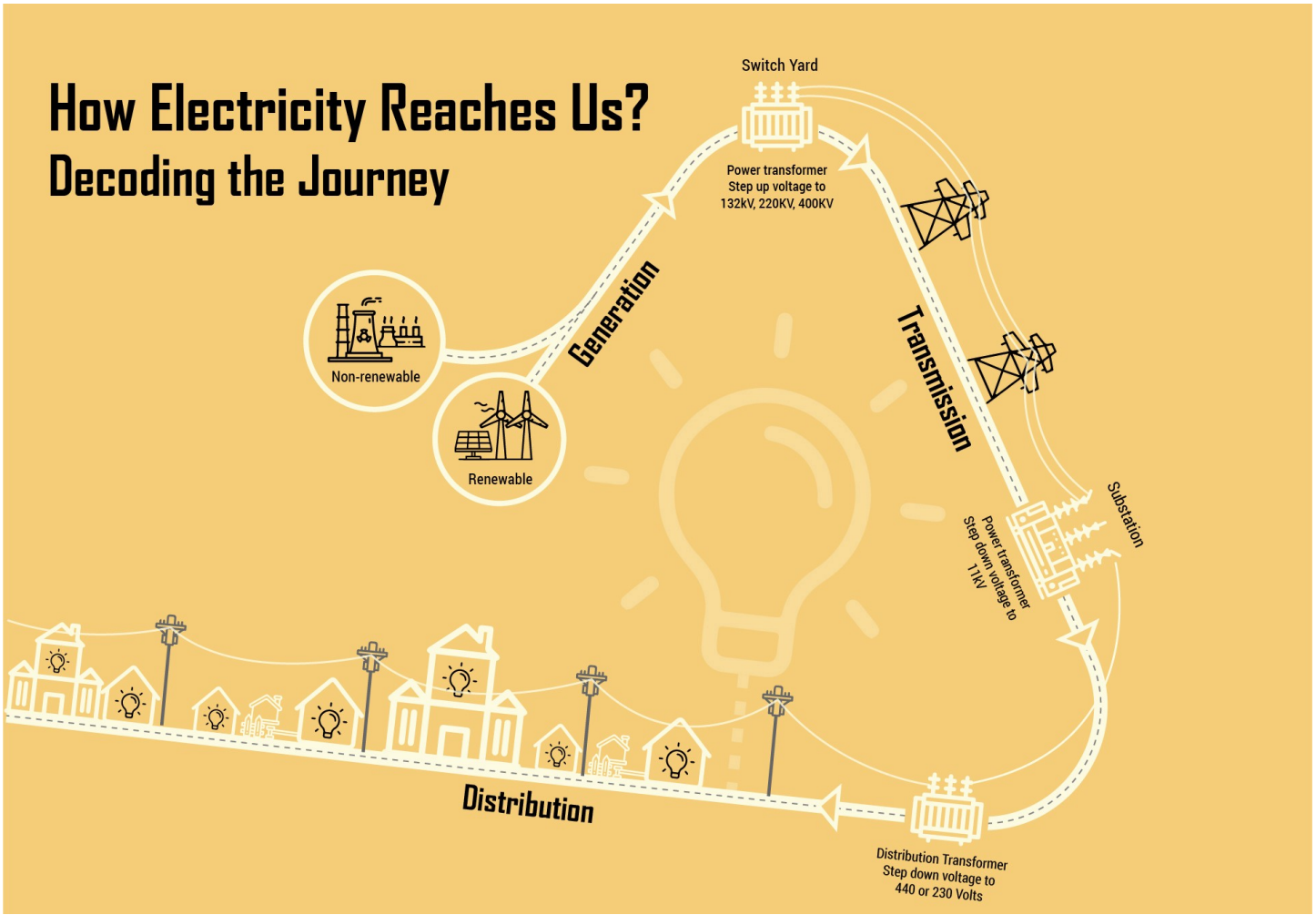
This article is first in the #Empower series of blogs by CSTEP, which aims to inform and interest the public in technical and policy issues that affect us on a day-to-day basis. In this and the next few articles, we will break down the journey of electricity from generation to consumption and elaborate on how every step of this journey has implications for you, the consumer. Read on.

Electricity occupies a vital place in our lives today, so much so that we cannot imagine a world without it. We find its use — for lighting and cooling, and powering the many essential devices (like refrigerators, televisions, computers, and smartphones) — everywhere in our daily lives.

At the national level, electricity plays a pivotal role in the key sectors of the economy, such as agriculture, industries, transport, etc. Also, in determining a country's standard of living, the per-capita consumption of electricity is considered, along with other social indicators.

Electricity makes an interesting journey from the generation station to the end consumers. It traverses complex stages and undergoes several voltage conversions, before consumers receive power seamlessly. The stages can be broadly categorised into

generation, transmission, and distribution. Let's take a close look at how electricity is delivered to our homes.



Every step of the electricity journey has implications for the consumer. Image by CSTEP

Generation

Electricity is generated at power plants located far away from consumer load centres. Power plants are classified on the basis of the type of fuel source they use — non-renewable or renewable. Non-renewable sources include fossil fuels like coal, petroleum, and natural gas, which cannot be readily replaced by natural means at a

quick enough pace to match consumption. Thermal plants use sources like coal and natural gas to generate electricity by combustion. Nuclear plants utilise the heat energy generated during the fission of nuclear materials such as uranium.

Renewable energy sources are those that replenish naturally within a human's lifespan, like solar and wind energy. Sunlight is used directly to produce electricity through solar photovoltaic panels or concentrated solar thermal plants; while wind plants capture the energy to generate electricity by rotating the wings of turbines. Hydro plants generate electricity by using the water stored in the reservoirs or dams to rotate the turbines. The other sources of energy are geothermal, biomass, and tidal energy, etc.

Transmission

Transmission can be considered as a bulk power transfer from generation to distribution substations. Consumers can identify the transmission lines by the tall reinforced steel towers carrying conductors. During transmission of electricity, energy is lost in the form of heat due to the resistance of conductors. This loss of energy reduces as the voltage level increases. Therefore, to transmit power over a long distance, the voltage level has to be stepped up. The voltage level is decided on the basis of transmission distance, similar to the way we decide our commute — taking flights for longer distances, and trains/cars for medium distances. The voltage level of electricity generated at power plants is between 6.6 kV (6,600 volts) and 33 kV, depending on the power output of the generator. The step-up transformer in the switch yard near the power plant, steps up the voltage to different levels like 132 kV, 220 kV, 400 kV, and 765 kV, etc., based on the distance it has to be transmitted. The high-voltage electricity is then transmitted via transmission lines to the substation near the consumer end.

Distribution

The high-voltage electricity received at the substation cannot be supplied in the same form to the end consumers. It needs to be converted to a lower voltage level suitable for the consumers. A step-down power transformer is used to transform the voltage to 11 kV. The lines emanating from the substation are called 'Distribution Feeders' or primary lines that carry electricity across load centres. Since the appliances at our homes operate at a lower voltage level of 440 or 230 volts, electricity has to be transformed to suit this level. This voltage conversion is done by the 'distribution transformers' situated near the consumer premises, which transform the voltage to an optimal level for delivery to consumers. The secondary lines carry electricity from the distribution transformers to the consumer end, through electric poles.

A service line is drawn from the pole to the house, either through overhead service wires or through underground cables to the meter box. The electrostatic meter placed within our home premises records the consumption. The breaker box in our homes is fed through this meter, and acts as a safety mechanism or control. The internal wiring delivers the electricity required to operate the appliances at the plug points, and for lighting up our homes.

In the End:

Electricity is always there when we flip a switch or plug in a cord, but it has to travel a long way to reach us. To create (generation), carry (transmission), and deliver (distribution) electricity to end users, many people work across different levels. Since a glitch at any level can hamper the flow of electricity, due care has to be taken to ensure that processes at all levels are well aligned. Effective monitoring and maintenance of network assets at the different levels can help ensure a reliable power supply, and enhance consumer experience.

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