In the process of supplying electricity to consumers, technical losses occur naturally and consist mainly of power dissipation in electricity system components such as transmission and distribution (T&D) lines, transformers, and measurement systems. T & D losses have I²R losses as a major component, and if one can reduce the resistance, the losses can be reduced. So, while resistance depends upon metal area and its resistivity, there is a need to improve both without changing the physical area of the conductor. This is besides improving compaction % i.e. Metal area/Physical area. Also, normal compacted conductors have a compaction of 87-91% causing a limit on metal area that can be fitted inside the physical area. These issues have been sorted by a unique design using 2 layers of trapezoidal wires.

Pranav Vasani
The electricity sector in India had an installed capacity of 205.34 Gigawatt (GW) as of June 2012, the world’s fifth largest. Captive power plants generate an additional 31.5 GW. Thermal power plants constitute 66% of the installed capacity, hydroelectric about 19% and rest being a combination of wind, small hydro, biomass, waste-to-electricity, and nuclear. India generated 855 BU (855 000 MU i.e. 855 TWh) electricity during 2011-12

In terms of fuel, coal-fired plants account for 56% of India’s installed electricity capacity, compared to South Africa’s 92%; China’s 77%; and Australia’s 76%. After coal, renewal hydropower accounts for 19%, renewable energy for 12% and natural gas for about 9%. In December 2011, over 300 million Indian citizens had no access to electricity. Over one third of India’s rural population lacked electricity, as did 6% of the urban population. Of those who did have access to electricity in India, the supply was intermittent and unreliable. In 2010, blackouts and power shedding interrupted irrigation and manufacturing across the country. The per capita average annual domestic electricity consumption in India in 2009 was 96 kWh in rural areas and 288 kWh in urban areas for those with access to electricity, in contrast to the worldwide per capita average of 2600 kWh and 6200 kWh in the European Union. India’s total domestic, agricultural and industrial per capita energy consumption estimates vary depending on the source. Two sources place it between 400 to 700 kWh in 2008–2009. As of January 2012, one report stated that the per capita total consumption in India to be 778 kWh.

Demand trends
As in previous years, during the year 2010–11, the demand for electricity in India far outstripped availability, both in terms of base load energy and peak availability. Base load requirement was 861.591 (MU) against availability of 788,355 MU, a 8.5% deficit. During peak loads, the demand was for 122 GW against availability of 110 GW, a 9.8% shortfall. In a May 2011 report, India’s Central Electricity Authority anticipated, for 2011–12 year, a base load energy deficit and peaking shortage to be 10.3% and 12.9% respectively. The peaking shortage would prevail in all regions of the country, varying from 5.9% in the North- Eastern region to 14.5% in the Southern Region. India also expects all regions to face energy shortage varying from 0.3% in the North-Eastern region to 11.0% in the Western region. India’s Central Electricity Authority expects a surplus output in some of the states of Northern India, those with predominantly hydropower capacity, but only during the monsoon months. In these states, shortage conditions would prevail during winter season.

According to this report, the five states with largest power demand and availability, as of May 2011, were Maharashtra, Andhra Pradesh, Tamil Nadu, Uttar Pradesh and Gujarat.

Further, the 17th electric power survey of India report claims: Over 2010–11, India’s industrial demand accounted for 35% of electrical power requirement, domestic household use accounted for 28%, agriculture 21%, commercial 9%, public lighting and other miscellaneous applications accounted for the rest.

The electrical energy demand for 2016–17 is expected to be at least 1392 Tera Watt Hours, with a peak electric demand of 218 GW. The electrical energy demand for 2021–22 is expected to be at least 1915 Tera Watt Hours, with a peak electric demand of 298 GW. Also, if the current average transmission and distribution average losses is around 32% then India needs to add about 135 GW of power generation.
capacity, before 2017, to satisfy the projected demand after losses.

Electricity sector capacity and availability in India (excludes effect of blackouts / powershedding)

<table>
<thead>
<tr>
<th>Item</th>
<th>Value</th>
<th>Date Reported</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Installed Capacity (GW)</td>
<td>201.64</td>
<td>April 2012</td>
</tr>
<tr>
<td>Available base load supply (MU)</td>
<td>837374</td>
<td>May 2011</td>
</tr>
<tr>
<td>Available base load supply (GW)</td>
<td>118.7</td>
<td>May 2011</td>
</tr>
<tr>
<td>Demand base load (MU)</td>
<td>933741</td>
<td>May 2011</td>
</tr>
<tr>
<td>Demand base load (GW)</td>
<td>136.2</td>
<td>May 2011</td>
</tr>
</tbody>
</table>

McKinsey claims that India’s demand for electricity may cross 300 GW, earlier than most estimates. To explain their estimates, they point to four reasons:

India’s manufacturing sector is likely to grow faster than in the past Domestic demand will increase more rapidly as the quality of life for more Indians improve

About 125,000 villages are likely to get connected to India’s electricity grid Currently blackouts and load shedding artificially suppresses demand; this demand will be sought as revenue potential by power distribution companies A demand of 300GW will require about 400 GW of installed capacity, McKinsey notes. The extra capacity is necessary to account for plant availability, infrastructure maintenance, spinning reserve and losses.

The Cause for losses

India currently suffers from a major shortage of electricity generation capacity, even though it is the world’s fourth largest energy consumer after United States, China and Russia. The International Energy Agency estimates India needs an investment of at least $135 billion to provide universal access of electricity to its population. The International Energy Agency estimates India will add between 600 GW to 1200 GW of additional new power generation capacity before 2050. This added new capacity is equivalent to the 740 GW of total power generation capacity of European Union (EU-27) in 2005. The technologies and fuel sources India adopts, as it adds this electricity generation capacity, may make significant impact to global resource usage and environmental issues.

India’s network losses exceeded 32% in 2010 including non-technical losses, compared to world average of less than 15%. Both technical and non-technical factors contribute to these losses, but quantifying their proportions is difficult. Some experts estimate that technical losses are about 15% to 20%, a high proportion of non-technical losses are caused by illegal tapping of lines, but faulty electric meters that underestimate actual consumption also contribute to decrease in payment collection. A case study in Kerala estimated that replacing faulty meters could reduce distribution losses from 34% to 29%.

In 2010, electricity losses in India during transmission and distribution were about 24%, while losses because of consumer theft or billing deficiencies added another 10–15%. Power cuts are common throughout India and the consequent failure to satisfy the demand for electricity has adversely effected India’s economic growth.

Sustainable optimal reduction of technical losses

Optimization of technical losses in electricity transmission and distribution grids is an engineering issue, involving classic tools of power systems planning and modeling. The driving criterion is minimization of the net present value (sum of costs over the economic life of the system discount data representative rate of return for the business) of the total investment cost of the transmission and distribution system coupled with the total cost of technical losses. Technical losses are valued at generation costs. Technical losses represent an economic loss for the country, and its optimization should be performed from a country’s perspective, regardless of the institutional organization of the sector and ownership of operating electricity utilities.

Losses - Resistive

Transmitting electricity at high voltage reduces the fraction of energy lost to resistance, which averages around 7%. For a given amount of power, a higher voltage reduces the current and thus the resistive losses in the conductor. For example, raising the voltage by a factor of 10 reduces the current by a corresponding factor of 10 and therefore the I²R losses by a factor of 100, provided the same sized conductors are used in both cases. Even if the conductor size (cross-sectional area) is reduced 10-fold to match the lower current the I²R losses are still reduced 10-fold. Long distance transmission is typically done with overhead lines at voltages of 115 to 1,200 kV.

Sterlite’s solution

Sterlite ULTRAEFF low loss MV Power Cables consist of conductor made from very compactly packed trapezoidal cross-section aluminium strands which are prepared from specially treated aluminium having improved conductivity, high performance XLPE insulated,
armoured and unarmoured power cables as per IS-7098-II and equivalent standards.

**methods to reduce resistance**

As resistance of a conductor is dependent on resistivity, length and area, we can improve the resistance by following: Improving the conductivity of aluminium by annealing and heat treatment. The metal is heat treated for a preset amount of time at a preset temperature improving the conductivity to 62.5 %.

1) Putting more metal area in the same physical area by improving the compaction of the conductor.
2) A stranded circular compacted conductor is made of wires, stranded and compacted to a form of conductor. Two methods of conductor making are prevalent: die compaction with a maximum possible compaction of 90-91 %, Roller compaction for sizes of 240 sq.mm and above with a max possible compaction of 92-93%. This leads to presence of air gaps and limits the amount of metal area that can be put in the same physical area.

If trapezoidal wires are used in place of circular wires, this compaction can be increased to 97 % increasing the metal area and thus effectively reducing the resistance and hence the losses.

Sterlite with its background in metallurgy and conductor making adapted this concept for overhead conductors as well as underground cables.

With enhanced conductivity and higher compaction, 300 sq.mm conductor with trapezoidal wires was produced to have a conductor resistance of 87% value of that specified by IS 8130.

**Result**

Lower I2R losses for the transmission/distribution network for the same transmitted current. Higher current rating for conductor temperature of 900C. Higher short circuit rating because of higher metal area in the conductor.

**CONCLUSION**

With the extensive use of electricity, and the wide geographical distribution of users, an effective transmission and distribution system is essential. The history of electricity transmission can be dated back to 1883, when Thomas Edison first introduced an economically viable model for generating and distributing electric power. Edison’s greatest achievement was perhaps not the invention of the light bulb or any other single application, but the universally applicable electricity transmission system which has lit up the whole world. Modern electrical transmission and distribution systems are the result of conscientious efforts and design skills of engineers to ensure high energy efficiency and safety. Thus, high energy efficiency means the loss of power through transmission is minimized.

**EXPERT OPINION**