As is the case for the construction of a new substation, all typical phases of contract execution are involved, such as design, product manufacturing and site activities including civil works, erection and commissioning, for AIS, GIS and MTS technologies. The execution of these tasks is more complex than the typical management of a new substation as multiple constraints apply. One of the most difficult decisions in the lifetime of an electrical substation will be taken when the asset owner faces the necessity of renewal, or the building of another new substation, to cover new requirements of the electrical network. The process required to successfully upgrade or uprate a substation, or any element thereof, requires careful consideration. These factors that should be assessed when embarking on a project of this nature.

- Identification of the requirements
- Evaluation of all options
- Up-rating/upgrading considerations
- Feasibility report
- Project overview
- Evaluation of completed project
- Validation

**Upgrading**

**Increasing rated current**

The thermal effect of the rated current and its collateral consequences, such as mechanical impact on rigid busbars, strain conductors, high voltage insulated cables, connectors and equipment, as well as possible solutions must be evaluated.

**Increasing the short circuit current**

A short circuit has both mechanical and thermal considerations. The impact of increased short circuit current on substation equipment including circuit breakers, disconnectors, ear switches, current transformers, voltage transformers, surge arresters, power transformers, busbars, insulators, supports, gantries, foundations and the earthing system are to be considered.

**Changing voltage level**

The growing demand for electrical energy may make it necessary to rebuild the transmission and distribution network.

At the same time planning constraints introduce crucial restrictions concerning such activities, making it difficult, or even impossible, to build new HV lines and substations. Therefore the need arises to reconstruct the existing lines and substations at higher voltages by either building a new switchyard at a higher voltage than exists at the existing substation location, or replacing an existing switchyard with one of a higher voltage.

The choice of a solution should be done on a case-by-case basis by analysing the site possibilities and the cost of realisation. Insulation coordination, surge arresters, air clearances, short circuit forces, and electrical field exposure also have to be taken into account.

**Upgrading**

**Bus scheme**

The bus scheme arrangement depends on many aspects, including where it is positioned in the network, what kind of processes and services are being supplied by the substation, how the system is being operated, what redundancy is required, etc. Other factors may include land acquisition cost, initial project investment costs, initial size of service and infrastructure required, indoor versus outdoor, and so on. When planning a substation one should consider whether it is necessary to build the final solution from day one or whether it would be acceptable to create an initial supply point but upgrade the substation at a later time. Due to cost considerations, it may be appropriate to only undertake the work necessary to establish a supply point, node in the network, or a connection point for the generator, with a plan to complete the final upgrade over a number of years.

**Seismic reinforcement**

Seismic reinforcement has to be taken into account when planning and upgrading substations within areas of seismic
Three main reasons have been identified as decisive in establishing the need for upgrading a specification:

- Low efficiency in the performance of the asset’s function
- “State of the art” evolution and technology trends
- Compliance with a company’s strategic agenda, such as the normalisation of existing equipment.

Salt/pollution contamination reinforcement

Environmentally-induced pollution of high voltage insulators is a common problem experienced by utilities worldwide. Increases in pollution levels at a substation initially manifests itself through increased corona activity during wet atmospheric conditions. If the unfavorable pollution conditions persist, insulators in the substation may start to flash over under normal voltage operating conditions. Upgrading solutions such as extending the creepage distance of insulators, use of insulators with optimised shape, periodic cleaning, grease coating, RTV coating, use of resistive glaze insulators, and non-ceramic insulators could solve the problem.

Safety

Upgrading of substations generally involves carrying out work in existing installations, which inherently means they are in service, live and so must be carried out with care. Some upgrading can be limited to a single bay and therefore isolation and safety from the system, e.g. HV electrical system, LV electrical system, compressed air ring system, common oil system, etc., can be assured in line with the utility’s normal safety practices. Upgrading of equipment which needs to remain in service must be given special consideration from the project outset.

AIS – MTS

When confronted with the task of uprating or upgrading, one of the most sensible solutions is to take advantage of the newer technologies available – not only for switchgear equipment, but also entire substations. The gas insulated substation or separate elements, such as GIS or MTS, offer advantages in situations where space is limited, and in terms of enhanced reliability and lower maintenance costs.

A set of guidelines has been prepared for engineers planning to uprate and upgrade substations, including case studies and a check list of the main items to consider in an uprating or upgrading process.

Contact Rob Stephen, Eskom, Tel 031 563-0063, rob.stephen@eskom.co.za

### Table 1: Uprating/upgrading main issues.

<table>
<thead>
<tr>
<th>Equipment &amp; function</th>
<th>Basic design engineering</th>
<th>Equipment modification, manufacture and transportation</th>
<th>Site activities civil work, testing, commission and documentation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increasing rated current</td>
<td>Clearances/conductor sags, Thermal limit of conductors, connectors and equipment. Protective device settings.</td>
<td>Busbar, Equipment to adapt or change. Conductors (cable tube), HV insulated cable cooling.</td>
<td>Cable trench for insulated cables. New equipment. Phasing of site activities order to minimise out duration. Test/Exploration evident of equipment withstanding capability.</td>
</tr>
<tr>
<td>Increasing short-circuit current</td>
<td>Mechanical forces on equipment structures and civil works. Clearances. Compatibility of CT and protection.</td>
<td>Additional structures to limit mechanical forces (possibly). Equipment to adapt or change.</td>
<td>Earth grid modification (possibly). Increased loading foundation. Phasing of site activities order to limit outage duration. Test/Exploration evidence of equipment withstanding capability.</td>
</tr>
<tr>
<td>Changing voltage level</td>
<td>Insulation coordination, electrical clearance.</td>
<td>All HV equipment to change. Mechanical stress on equipment structures and civil works. Adaptation of all control systems to the new voltage level control philosophy (probably a new control system).</td>
<td>New foundation adaptation of existing foundations. Demolition. New equipment.</td>
</tr>
<tr>
<td>Seismic reinforcement</td>
<td>Mechanical calculation to manage the whole substation. Mechanical reinforcement of secondary equipment, but no modification of the control system.</td>
<td>Site modification of steel support structures and anchoring. New equipment (Possibly).</td>
<td>Some foundations reinforce or change a seismic calculation (possibly). Site modification. Phasing of site activities order to limit outage duration.</td>
</tr>
<tr>
<td>Salt/pollution contamination reinforcement</td>
<td>Adaptation of the layout and clearances to new equipment. Sensor integration. Control modification link to sensor interaction.</td>
<td>Equipment to adapt or change.</td>
<td>Adaptation of equipment site. New equipment erection.</td>
</tr>
</tbody>
</table>

*Table 1: Uprating/upgrading main issues.*

**Specification improvement**

Improvement of a specification for equipment or function is made when enough technical research is built into the decision-making process. Specification upgrading is undertaken to benefit the substation either by supporting new system requirements or improving reliability, including technical, economical, and environmental aspects.