City Power Johannesburg has an internal 88 kV transmission network which is now roughly 65 years old. The condition of this transmission network has become unreliable and based on the age should actually be replaced. Due to financial constraints this is not an option and other solutions had to be considered. Based on all the options available, it was agreed that the most technically and financially viable solution would be to reconductor the existing lines with high temperature conductor under live-line conditions.

Increased electricity demand within the City Power supply area had caused many of these old transmission lines to become overloaded. The design capacity of the existing transmission lines varied from 60 to 100 MVA. The old lattice tower designs, from the 1930s and constructed in 1950s could only handle a maximum of 100 MVA with conventional sized conductor. Current servitudes could also not cater for any new transmission lines and it was not possible to increase the current servitude sizes. The master plan identified key network upgrade projects that had to be undertaken to avoid serious network overloading. Increased power had to be made available at substations deep within the network and this meant that transmission lines capacities had to be increased.

The highest priority project was the four Kelvin power station to Cydna substation 88 kV transmission lines that had to be refurbished and upgraded from 100 to 200 MVA while reducing thermal sag. These transmission lines supply power to the Alexandra, Cydna and Rosebank substations areas. It was also agreed in the future to standardise on 200 MVA capacity lines for all other existing lines to ensure adequately capacity throughout City Power's transmission network as the demand increases throughout the area of supply.

The four double-circuit 88 kV transmission lines had to be refurbished and upgraded under live line (energised) conditions while retaining the existing towers. City Power Johannesburg contracted Edison Jehamo Power (EJP) with their United States-based Quanta Services/Allteck partner to get this first in Africa project done. MacDonald (Merz and McLellan) McLellan) consultants were appointed by EJP to conduct line survey, conductor assessments, tower load calculations, refurbishment fittings requirements, and live-line approach distance.

Live line working entails contact by linemen with energised conductors. Various techniques have been used, including the use of helicopters, aerial platforms, ladders and other methods to insulate the linemen from earth. Development of a robotic arm which can hold conductors while work is being done has considerably simplified the process and improved safety.
on utility networks around the world. Energised work is in most cases safer than de-energised work as there is no induction on de-energised lines to consider and the condition of the line is known. In the case of city power live line replacement was the only option as there were no spare circuits available and the lines could not be taken out of service for any extended period of time.

Energised work methods

Types of energised work methods and associated equipment:
- Bare-hand
- Hot sticks
- Rubber glove
- Robotics
- Spray washing - dry
- Aerial platforms
- Helicopter
- Combination of all

Energised work - bare hand

Bare-hand live work is performed whereby the lineman physically makes contact with the energised part. Access to the line energised parts can be obtained via:
- Aerial platforms – insulated bucket trucks, scaffolding
- Helicopter – underslung method, skid method
- Rope hoist method – 45 degree, vertical
- Horizontal ladder – mostly strain type towers
- Vertical ladder – mostly suspension type towers

Energised work - criteria

Determining factors to perform energised work

Safe working clearances – phase to earth, phase to phase must be determined for the voltage and configuration of the line. Approved work methods / procedures applicable for the job must be selected and adhered to. Personal protective clothing must be selected and applied for each specific job, and approved tools and equipment for the job must be used. The access method used will depend on the technique used and the line configuration. Weather plays an important role and the work can be influenced by thunderstorms and lightning. Protective equipment such as auto re-closures on circuits need to be taken into account. Tests, inspections and audits must be carried out regularly on equipment and staff. Finally each job must be documented and a "tailboard" briefing held prior to commencement where details of the work to be done are discussed.

Working clearances

Primary insulating medium is air and the scientific safe working clearances are derived and influenced by:
- Electrical parameters of network
- Geographical conditions - altitude etc.
- Ergonomic conditions
- Type of insulation
- Configuration of towers
- Tools in air gap

Technology – linemaster

Quanta has developed a robotic arm which enables securely holding energised lines/equipment intact while upgrades are occurring. The system allows maintenance, repairs, reconductoring of and rebuilding of lines under live conditions. The system is fitted with station class type insulation and offers improved safety compared with other techniques, as well as increased personnel safety distance to live lines.

The system makes use of a hydraulic actuator that attaches to conventional line trucks and cranes, and consists of an adaptor, robotic arm and insulated fiberglass segment.

To facilitate positioning with line apparatus All robotic arms can rotate 120°, and the 3400 kg (7500 lbs) arm can rotate 170°. Robotic arms can extend/retract depending on the structure type and arm model. The arm is controlled by ground-based operator and safety watcher, keeping the operator away from live apparatus.

Safety

The system has a very good energised safety record, with more than 4500 000 energised work man-hours of experience.

Quanta conducts demanding extensive training program:
- Linemen undergo extensive apprenticeship program
- Screen and select all linemen for bare hand work
- 120+ hours of training per candidate, including theory and practical use of tools by working on energised circuits
- Over 400 quanta lineman have been energized work certified

“Proven-safe” energised work procedures

All work methods are approved before being implemented and revised if need be. All linemen are trained in all methods statements.

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