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B5 – PS3-3.05: What are your expected benefits of using digital substation concepts and how to measure if the benefits can be realized?

The Digital Substation can be used to offer the asset owner a huge increase in productivity in all the phases of the Substation Automation System lifecycle, engineering, commissioning, re-engineering, maintenance and finally device replacement. In all these use cases, digital substation concepts can be used to achieve the same output but with significantly less input of the user's time. Thus, the measuring stick to be applied is labour hours saved and this measurement is both uniform for all use cases and universal between users.

In terms of engineering, the application of IEC61850 allows for a mixed engineering process which is top down but also makes maximum use of bay standardisation. If the user has already standardised the primary switchgear, then ICD templates can be created which already include the datasets and control blocks for all the messages that this device would need to publish. Doing this work once per bay and device type and then reusing it in many substations' triples productivity. Moreover, when combined with smart device management and command line configuration tools this whole process of creating device configuration files can be automated. Users will not need to become expert users with the software tools of each manufacturer, but rather those tools can interface directly with a smart device management system to import the SSD and ICD files, automatically assign the IP addresses, create the IED names and make the subscription of GOOSE messages and assignment of Reports. Not only can the SCD be created in this automatic manner, but the CID can also be created by a command line IED configuration tool which can import the SCD, and Settings file and export the finished device configuration. In this case the benefit is measured from the time differential between manual configuration creation and the automated device configuration creation which happens in a matter of minutes and only requires the manual input of single line diagram and bay types along with the final fault level dependent protection settings. Command line configuration tools don't just exist for the creation of the SCD file, but also for Device configuration too. For example, in real projects, the complete configuration of the Substation HMI can be automated based on a SCD file (wherein the substation section contains bay coordinates and bay type references) along with a signal list and a template library binary file and realised in a matter of minutes.

The top-down engineering process employed for each substation project already guarantees the compatibility between the client and server devices. If a shared and single origin of data has been used, then it might well be possible to guarantee the compatibility with the Remote-Control Centres SCADA system too. This compatibility greatly reduces the potential for errors and need for point-to-point testing in the commissioning process. In fact, the use of the SCD file also means that system integrators, whether they be switchgear manufacturers or cabinet or device suppliers, can conduct full system tests. This means that the very efficient Factory Acceptance Tests can be optimised and correspondingly the geographically displaced Site Acceptance tests can be reduced in scope. The principal digital substation concept is that the engineering work is human and machine-readable information. Each configuration tool, both SCT and ICTs are making validity checks on the imported files which will also help weed out errors before they make the final configuration.

Existing and already commissioned Substations are increasingly likely to have to incorporate new feeder bays, to connect distributed generators or new customers. Ordinarily using a field bus protocol this might entail the complex and ad hoc reengineering of the client devices. However, the streamline creation of a top down SCD file can be very simply, and even automatically, created and this SCD file will be used to reconfigure the Substation Gateway, HMI and any existing IEDs which have subscribed to any Goose Messages from the new IED. Put simply, the digitalisation of the substation using IEC61850 increases the capabilities of the Users so that they can quickly and easily reconfigure their SAS system after any changes to the engineering.

The principal maintenance activity of protection and control devices is the corrective replacement of failed devices. Ordinarily this is carried out by specialist and centralised protection and control engineers. The application of utility specific flexible product naming and a standardisation of inputs and outputs means that IEC61850 could be used to provide us with not just interoperability between devices of different manufacturers but interchangeability. This means that those carrying out corrective replacements of devices do not need access to a comprehensive stock of spare IEDs and this of course means it may well be possible to upskill local more generalist staff to carry out corrective maintenance. Given that they are a much shorter distance to the substation, the application of this interchangeable corrective maintenance could save significant amount of time with every failed IED replacement. In this case, the benefit is found in the much shorter travelling time taken to the substation by the local generalist staff rather than centralised Protection and Control specialists.

Of course, IEDs don’t just need device replacement, they also require firmware upgrades, and this is set to increase in the future due to cyber security concerns. Ordinarily this would necessitate the displacement of engineers to the substation to carry out the image upload and subsequent testing in-situ. Digitalisation opens the possibility of remote firmware uploads; standardisation makes it possible to a priori validate that firmware image and smart device management allows for the careful and automated monitoring of the upload process. This is a paradigm changer; it means that large utilities can tackle new vulnerabilities as soon as they have validated the firmware image. It achieves the same output, devices running with up to date and secure firmware, but with a much smaller input as measured in time. In this case, the benefit is measured from the much shorter time taken to remotely update the firmware rather than send engineers to site to make the upload in-situ.

This same approach, remote batch processing, can also be applied to the configuration changes or corrections to the protection setting values. Device passwords can also be remotely and automatically changed after every use. In these cases, the benefit is found in the time saving from making these changes remotely and automatically.

Switchgear expected useful life contrasts sharply with that of the IED devices and the replacement of IEDs for example embedded in Metal Clad Switchgear can take two complete days per device. However, the use of a Process Interface Unit (PIU) which contains not just the measured values but also encapsulates all the digital inputs and outputs, means that the end-of-life device replacement becomes almost plug and play. In this phase, the benefit is found in the time differential between replacing an IED with PIU, in which case very little cabling needs to be realised and replacing an IED directly cabled to the switchgear which takes a significant amount of time.

Digitalisation is always about process improvement and the same is true for the digital substation where big productivity gains can be realised especially in engineering and commissioning but also in maintenance and device replacement. These gains come from doing once what was previously carried out for each substation project, from applying optimised configuration tools, from doing remotely what was previously carried out on site, and from maintaining the cabling during device replacement. The savings realised by users who apply will these digital substation concepts will greatly exceed the original cost of device purchase and installation.