

CASE STUDY: PROTECTION SETTINGS MANAGEMENT AT CITY POWER



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ABSTRACT

A case study on the implementation of an integrated protection settings management system (psms) at City Power is presented. This psms manages and stores all protective relays settings and parameters and allows for workflow management within the protection environment. The new system implemented at City Power allows for communication with manufacturer specific settings software. It also keeps an historical trace and audit trail of all protection settings.

1. INTRODUCTION

Modern numerical relays increasingly have more functions and thus, more protection settings. This combined with ever expanding electrical networks necessitates utilities to reconsider their approach to protection settings management. [1] [2] Historically, utilities have typically stored their protection settings in a combination of different systems with little to no security. [1] [2] This paper looks at how a utility, City Power, identified the need for a centralised protection settings management system (psms) that provides a secure environment to store settings of complex numerical relays which can manage the workflow of protection settings. [3]

2. EXISTING SETTINGS MANAGEMENT

2.1 Background

Correct protection settings of relays are pivotal for the integrity of any power system. Power system engineers are tasked with ensuring the correct settings are applied to relays. These

tasks include calculating settings, ensuring settings are applied correctly on the relay and ensuring accurate record is kept of existing and past settings. Storage of past and present settings is pivotal to ensure quick replacement of a relay with correct settings in event of a relay failure. [1] Furthermore, present settings are required for testing of relays and to aid relay coordination studies in power system analysis tools. [1] [2] This requires utilities to store the power system protection settings in a centralised environment which can be access controlled.

The earliest forms of storage of protection settings was through a hard copy paper file system. This later evolved to storage on computer systems through means of spread sheets or databases. Most of these systems had poor security and had a distinct lack of managing workflow sequence. [1]

2.2 City Power Case

City Power, like other utilities, has traditionally stored protections settings in a simplified format on different platforms. However, they consolidated all their settings to one central excel spreadsheet. This spreadsheet kept a record of all the substations in the network and the settings for each bay relay. Basic parameters were captured, for example, overcurrent plug setting and overcurrent time multiplier. This spreadsheet was stored on a central network drive which could be accessed by all protection users.

This system sufficed for as long as the majority of protection relays used in the system was electro-mechanical. The storage of settings in an excel spreadsheet became troublesome with advanced numerical relays and IEDs

replacing the older electro-mechanical relays. Furthermore, security of settings was a concern since anyone could access the spreadsheet and change the settings as they saw fit. This undermined the integrity and validity of the settings in the spreadsheet.

If a setting was changed, there was no way to know who changed it, when they changed it and why they changed it. Users of the spreadsheet would typically download it to their computers, make changes but then fail to reconcile the data into the centralised spreadsheet. This eventually led to a situation where there were several versions of this spreadsheet, all with different settings.

The spreadsheet system also caused communication breakdown in terms of work flow sequence. Typically, the system engineers will issue settings to be applied to relays to the field teams who will do the application of settings. The spreadsheet system could not handle this workflow process of handing over settings and confirming it was applied internally. This process was handled through engineers and field teams directly communicating with each other by means of email, phone or in person. This process was flawed as it required trust from both parties.

3. NEW SYSTEM SCOPE

City Power resolved to replace their existing hap-hazard settings management system with a new psms that is holistic and has the following features:

- Storage of protection settings of all fault clearing related devices (CTs, VTs, relays etc) on one central system
- Settings lifecycle management to ensure the settings workflow sequence is maintained. The lifecycle should also indicate "Who did what, when and why". The psms must keep an audit trail of settings record changes and store historical data
- Communication integration through an internal email system when changing the lifecycle state of settings. The psms should enforce compulsory emails to next responsible person
- The psms should be easy to navigate. It should be flexible in nature to allow for customization to suit City Power's needs and way of working

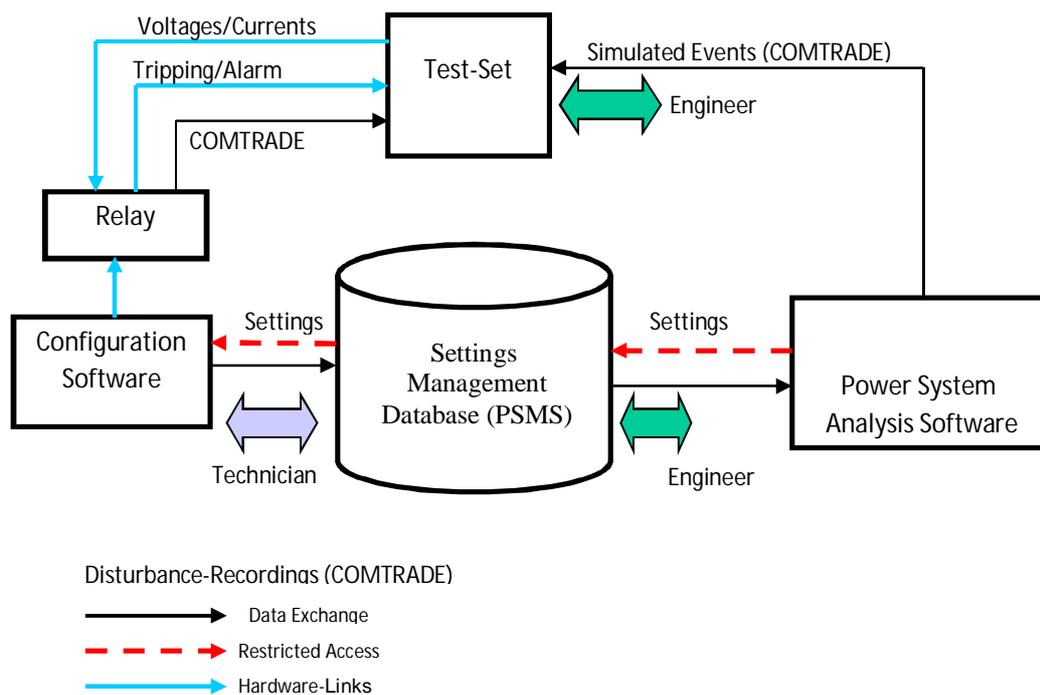


Figure 1 - Protection Settings Environment [4]

- Import and Export of settings from the psms to and from the power system analysis tool, DlgSILENT Powerfactory as well as Import and Export of relay configuration software files to and from the psms
- Flexible user rights management to ensure security of the data stored on the psms
- Full document management to ensure all data related to a settings record is stored centrally as well as easy report printing and data search

This psms will form part of the protection settings environment as shown in Figure 1.

4. THE NEW PSMS AT CITY POWER

4.1 User Interface

The new psms has an easy to use web-based interface. Minimal training was required for users at City Power to use their new psms. Navigation is made easier by defining a system hierarchy structure.

4.2 System Structure

The psms stores settings of protection devices such as relays, CTs, VTs etc. These protection devices are physically located in bays in the network. In turn, these bays form part of substations which in turn could be part of a broader supply or geographic area. [4] The psms used at City Power is DlgSILENT StationWare. The system uses a location hierarchy structure. This hierarchy structure is used find data quickly and easily.

A four layer structure was implemented at City Power. These layers are:

- Area (geographical)
 - Substation
 - Bay
 - Device

The network was divided into geographical areas. Substations were stored per geographical area. All bays with its protection devices were stored per substation. Bays were

created per the equipment type it protects, for example: FeederBay (Feeder), ShuntBay (Shunt Capacitors), TransformerBay (Transformers) etc. Additionally, voltage levels were added to bays to ensure identification of the correct bay is easy. An example of this structure is shown in Figure 2.

4.3 Settings Lifecycle

The settings workflow sequence is managed by the new psms. This is commonly referred to as a 'Lifecycle'. The main aim of this Lifecycle is to manage the process through which settings are initiated, planned, calculated, issued, applied and verified. [1] [2] [3] The Lifecycle of the psms was customised to match City Power's internal processes and workflow sequence. City Power's internal work flow process for protection settings is shown in Figure 3. Figure 4 illustrates how this is implemented in the new psms.



Figure 2 - City Power Location Structure [3]

The Lifecycle shows that responsibility rests with the Settings Engineer (SE) from inception until the settings record is placed in the 'Outstanding' state. The Head of Settings (HoS) then assumes responsibility to review the settings. After review, the HoS can change the settings record state to 'Authorised' or 'Returned'. If the state was changed to

'Returned', then the settings will return to the responsible SE for revision or adjustment as required. Once 'Authorised', the setting will be issued to the Field Teams (FT) who then assumes responsibility. The FT can return settings back to the SE for review or correction by changing the lifecycle state to 'Rejected'. The FT can change the lifecycle state to 'Applied and accepted' after settings were applied successfully and verified.

4.4 Audit Trail

The psms keeps an audit trail of all actions on the psms, in particular when a settings record is moved from one lifecycle phase to another phase. The name of the user who changed the lifecycle phase and a time stamp of when it was changed are stored every time the lifecycle phase of a setting is changed. This ensures a full audit can be conducted on protection settings.

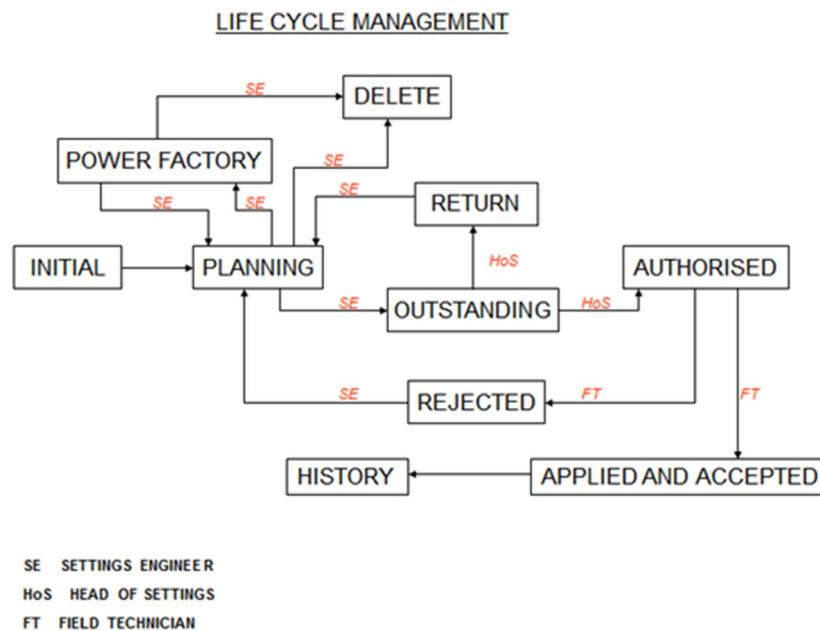


Figure 3 - City Power Lifecycle Management [3]

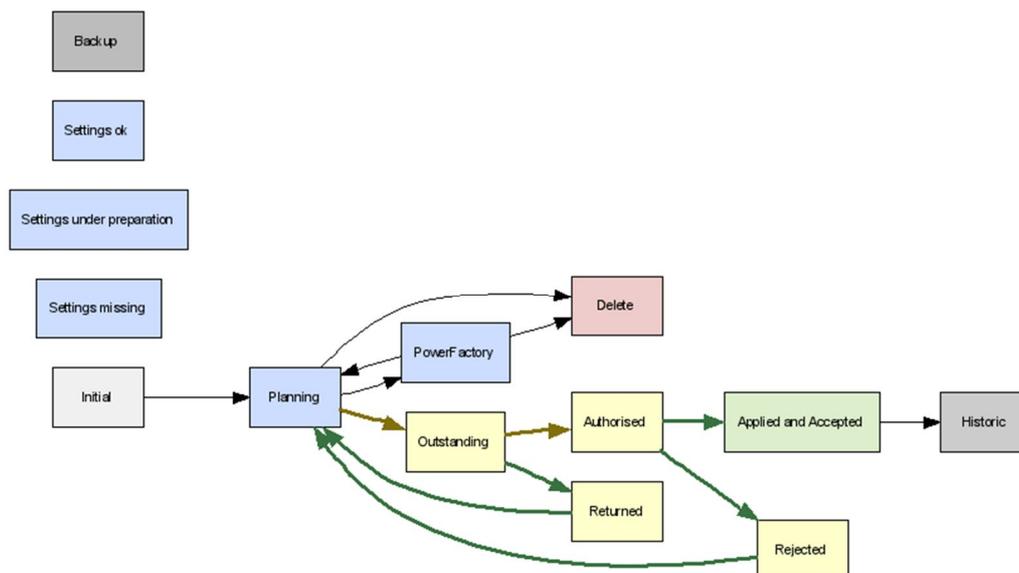


Figure 4 - City Power Lifecycle in PSMS [3]

4.5 Email Communication

The new psms has an email notification system built in to ensure when a lifecycle state is changed, the next responsible person is notified immediately through email. These email notifications were made compulsory where the status change of the settings record leads to responsibility handover. For example, a SE will not be able to change the state from 'Planning' to 'Outstanding' without sending an email to the HoS. This ensures there is no communication breakdown and the process remains streamlined. Furthermore, the system is hard coded to send a carbon copy email to City Power's protection department head. This was implemented to ensure transparency and ensure users accept responsibility when receiving notifications.

5. USER MANAGEMENT

Access to the psms is controlled through assigning users to User Groups. User groups are assigned data access and functional rights according to their duties. The groups are divided into areas of responsibility. Through this it becomes easy to manage which users are allowed to affect changes to the psms or parts thereof and which users can only view the psms but not make any changes to the system. Each user has a unique username and password. The users email address is also associated with their user account to assist with the email notification. [3]

Five groups were created:

- Administrators; super users with super rights. Responsible for system administration.
- Settings Engineers; can create locations, devices and settings. Can change lifecycle state from 'Planning' to 'PowerFactory', 'Delete' and 'Outstanding'.
- Head of Settings; super user like Administrator. Custodian of the system. Responsible for changing lifecycle state from 'Outstanding' to 'Returned' and 'Authorised'.
- Field Technicians; viewing rights for locations, devices and settings.

Cannot change settings though. Users can change lifecycle state from 'Authorised' to 'Rejected' or 'Applied and Accepted'.

- Viewers only; viewing rights for locations, devices and settings. Cannot change settings or lifecycle state.

6. SETTINGS MIGRATION

City Power stored most of their existing network protection settings in a spreadsheet. These settings were migrated from the spreadsheet to the new psms system using an import converter. [4]

The migration of the existing settings into the new psms had to be automated due to the large number of settings. The automation was conducted with a scripting program.

6.1 Migration Converter

Automation through scripting in a programming language becomes easier when sample data is uniform. The existing spreadsheet with these settings was analysed and it was found that whilst the data was uniform mostly, it had some anomalies. To facilitate automation of migration the existing spreadsheet had to be revised into new uniform spreadsheets. [3] A small scripting 'converter' application, written in the C# language, was written with the following outcomes:

- Create all the geographic Areas, with the substations that belong to these Areas. Additionally, create all the bays that belong to substations.
- Assign names as per the original spreadsheet to Areas, Substations and Bays.
- Create devices in bays and migrate settings from spreadsheet to the devices.

The process for migration of settings is illustrated in Figure 5.



Figure 5 - Settings Migration Process

6.2 Generic Devices

'Generic' devices were created in the psms system due to the large amount of data that had to be migrated. The flexible psms allows the user to create devices with any parameters as needed on a XML format. The main settings spreadsheet captured parameters for relays and current transformers (CTs). Thus, the migration converter created 2 devices per bay, a relay and a CT. The parameters captured in these generic devices are as shown in Table 1.

All of these settings were captured through automation with the migration converter.

Table 1 - Parameters captured in generic Relay device

Device Types	Parameter	Description
Relay	O/C ps	Overcurrent plug setting
	O/C tm	Overcurrent time multiplier
	E/F ps	Earth fault plug setting
	E/F tm	Earth fault time multiplier
CT	CT Ratio	CT Ratio
	CT Class	CT Class
	Ratio Used	Ratio Used
	Load setting in Amps	Load setting in Amps

6.3 Detailed Numerical Relays

The new psms installed at City Power can import and export detailed relay configuration files. The file formats supported for import and export are:

- Files formatted according to IEC 61850. [1] [4] [5]
- Manufacturer specific configuration settings files in ASCII or XML formats. [4]

City Power obtained relay manufacturer specific configuration settings files of Schweitzer Engineering Laboratories (SEL) relays and Reyrolle relays in their network. These files were imported directly into the new psms using the built-in import function on the psms. This ensured all the settings from these relays were captured accurately as it was downloaded directly from the relays through the manufacturer relay configuration software.

The 'generic' relays were deleted and replaced with the detailed relay import where possible. In future, over time, all the temporary 'generic' relays should be replaced by the detailed relay models.

The calculation relevant protection settings for the detailed relays (SEL and Reyrolle) can be imported and exported to the power system analysis tool, DlgSILENT PowerFactory. [1] [4] This allows for accurate simulation of power system protection system co-ordination and assists greatly with optimising relay settings. [1] [4]

7. DOCUMENT MANAGEMENT

7.1 Additional Documents

The psms has a document management system which allows users to upload any files relating to protection settings for a protection device. [4] This allows for centralisation of all the necessary documentation pertaining to a particular setting record. Examples of files that are stored are incident reports, test results, settings calculation sheets, technical manuals etc. These files can be in any format and are attached to the setting, relay or bay as an

'Additional Document' which can be downloaded by users.

7.2 Reports

Reports can be generated from the new psms in pdf or html formats. These reports can be viewed with 3rd party programs such as pdf readers.

8. CONCLUSION

City Power previously stored their protection settings on a centralised spreadsheet without being able to manage the settings environment. The spreadsheet system was replaced with a modern integrated protection settings management system.

This new psms has a user friendly web interface that requires minimal training to use. The system has an easy to follow internal structure which allows for quick data access.

Workflow sequence issues are now resolved through a central settings database with a settings record lifecycle. This lifecycle ensures there is no communication breakdown and provides an audit trail for all protection settings.

Data access for the psms is now controlled through user groups with specific access rights as per work duties as set up by City Power.

Existing settings were moved from the spreadsheet platform into the new psms through an import converter. Temporary 'generic' devices with settings as per the original spreadsheet were used to capture all the settings in the spreadsheet. The creation of protection devices with settings and locations like substations and bays was automated.

Detailed numerical relay or IED settings were captured where the downloaded relay configuration file was available. This replaced the temporary 'generic' devices and the replacement of the temporary devices with detailed devices is an on-going process. The psms can import and export relay settings configuration files depending on the file format.

Detailed relay settings can be imported and exported to a power system analysis tool.

Automated reports can be generated from the new psms and all City Power documents relating to protection settings are managed through the system.

9. LITERATURE

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