1. Load-shedding functionality overview

The Power Management System (PMS) is essential to ensuring safe, efficient and reliable industrial power system operation at <name of the plant/customer>. The PMS includes load-shedding function in the proposal. The objective of the load-shedding functionality is to respond to electrical disturbances and loss of generation capacity by cutting off loads in a fast, accurate and determined manner. It acts in accordance to a pre-defined load priority order and ensures the least possible interruption to the plant process.

2. Load-shedding system

The offered load-shedding system must ensure a quick load relief and stable power supply for critical process loads after a system contingency (loss of power source or a situation causing a power shortfall in a power network).

The load-shedding system must support the following modes:

- Fast acting load-shedding on loss of power resources
- Load-shedding based on overload of power sources or demand violation
- Manual load shed based on power and priority definitions
- Load shedding on frequency drop

The load-shedding system must be based on a dedicated load-shedding IED and protection and control IEDs distributed in each bay/feeder. All IEDs must be interconnected over a native IEC 61850 network utilizing analog and digital GOOSE and MMS communication profiles. It must also be possible to integrate non-IEC 61850 IEDs to the load-shedding system using suitable interface devices.

The load-shedding system must ensure an overall performance of within 60 milliseconds, that is, the time from the detection of the system contingency to the activation of circuit breaker commands in the load feeder IEDs.

3. Load-shedding inputs and outputs

The load-shedding system must be based on IEC 61850 substation communication standard and its GOOSE and MMS communication profiles.

All load-shedding operational and control information must be exchanged over IEC 61850 GOOSE and MMS. The station HMI should also be able to integrate with the upper level system over the IEC 104, DNP3.0, Modbus or OPC protocol.

The GOOSE communication profile must be deployed for several advantages.

1. Minimal or no hardwiring between panels where it is possible to use substation LAN as the transmission medium of binary and analog process data between IEDs
2. Less I/O hardware in IEDs
3. Lesser maintenance costs due to lesser wiring diagrams, terminal blocks and connections
4. Better predictability in the system or functionality verification
5. Fast and reliable station bus for data transfer offered by Ethernet LAN technology with a much faster binary signal transfer between IEDs than with conventional hardwiring
6. Supervision of signals being transferred over GOOSE for data integrity (based on, for example, quality and communication status)

4. Load-shedding operator interface

The load-shedding IED must support basic HMI functions for setting, monitoring and manual control of the load-shedding system. The station HMI, based on an industrial grade PC, must also include a comprehensive set of load-shedding displays and be integrated into the load-shedding system based on IEC 61850. All equipment in the load-shedding system must be able to withstand substation environment.

Dedicated load-shedding displays, included in the station HMI, must contain information for every power network (island) such as:

- Busbar configuration
- Power balance values (critical data)
- Load power values
- Load shedding status information
- Adjacent power network area available spinning reserve values
- Load-shedding mode, power network active status
- Accumulated load table
- Manual load shed control, reset of load shedding
- Key single line diagram showing power source and bus coupler/tie circuit breaker status.

This information must also be available on the load-shedding IED HMI, in order to ensure that operations are possible even when the station HMI is not available.

Furthermore, it must be possible to create additional displays in the station HMI for the following:

- Overall single line diagram display of all load feeders, power source feeders and network circuit breaker status as processed by the load-shedding application
- Display of power information as processed by the load-shedding application
- Display of load-shedding priorities for load feeders
5. Feeder information for load-shedding

The generator power source IED must be configured to send the active power, circuit breaker status, circuit breaker service position and protection trip information. If the generator power source needs to be configured also for slow (overload) load-shedding, the 3-phase currents need to be configured too.

The grid transformer or tie feeder IED must also be configured to send the three-phase currents (direct connection from CTs to the load-shedding IED), active power, circuit breaker status, circuit breaker service position and protection trip information.

A tie-feeder or a bus coupler circuit breaker IED must be configured to send the active power, circuit breaker status, circuit breaker service position and protection trip information.

The load feeder IEDs must be configured to send the active power, circuit breaker status and circuit breaker service position information.

All the above information must be sent by the respective IEDs to the load-shedding IED using IEC 61850 GOOSE communication.

In case of load feeders without IEDs supporting IEC 61850, modular IOs with GOOSE profile must be used as bay-level gateways.

6. Load-shedding functions

The load-shedding system or IED must support the following functions:

1. Fast load-shedding

A network power deficiency may occur when a power source such as a generator or a grid transformer trips. A power shortage may occur when a network gets isolated due to trip of a bus coupler or a bus tie breaker. The fast load-shedding function protects the power network during a power deficiency.

The fast load-shedding function takes corrective action before the system frequency drops and therefore provides faster and accurate load-shedding action based on the power balance calculations and defined priorities. Thus, the function also contributes towards faster improvement of the frequency profile of the system.

2. Slow (overload or maximum demand violation-based) load-shedding

The slow load-shedding function prevents the tripping of a power source during an overload condition. The slow (overload) load-shedding function triggers the load-shedding and resets the overload condition by acting faster than the dedicated overload protection function for the power sources. The overload situation can arise due to the overcurrent detection in a generator or grid transformer, or a maximum demand violation at the power grid incomer for a specified period of time. Based on the amount of the overload, the slow load-shedding function determines the required load to be shed and uses the power balance calculations or absolute power relief
required to arrive at the load-shedding priority decision and initiate load-shedding action.

3. Manual load-shedding

Using the manual load-shedding function, the load-shedding of multiple load feeders is possible to be initiated based on priorities or the required total power relief.

4. Underfrequency load-shedding

The underfrequency-based load-shedding function detects frequency decay and activates the load-shedding according to load-shedding priorities, defined for the above functions.

7. Integration into switchgear

The IEDs can be directly mounted in a medium-voltage metal-clad switchgear.

Additionally, the station HMI must be based on the ruggedized mechanics with no moving parts subject to wear and tear. The visualization display unit associated with the HMI must be based on a COTF industrial-grade touch panel.

It is therefore possible to realize the entire load-shedding system in the medium-voltage switchgear. This ensures that the load-shedding uses the same infrastructure as the medium-voltage switchgear and protection and control system.
8. Annex-I

8.1) Typical configuration for greenfield (IEC 61850-based) substation
8.2) Typical configuration for brownfield (non-IEC 61850 based) substation
8.3) Typical arrangement (GA) for control panel-based arrangement