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SUNGAI PERAK ENERGY MANAGEMENT SYSTEM: IMPROVEMENT OF EFFICIENCY AND RELIABILITY OF SUNGAI PERAK HYDRO POWER PLANT THROUGH MODERNIZATION OF SCADA SYSTEM

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ABSTRACT

The Supervisory Control and Data Acquisition (SCADA) System for the Bersia Group Control Centre (BGCC) is an essential tool in the operation of Sungai Perak Power Stations (SGPS) hydroelectric power plants. It control and monitors remotely the daily operations of all hydroelectric power plants in the SGPS scheme which consist of seven generating facilities with a combined generating capacity of 1,248 Megawatts (MW), being among the major assets to Tenaga Nasional Berhad (TNB) Generation. All the hydro plants in the SGPS scheme are remotely operated with minimal interruption to its SCADA functions. The existing SCADA system in operation since 1998 has enable SGPS personnel to manage and operate the remote hydro plants efficiently, productively and safely. However, it has come to the end of its electronic life span. Thus, the modernization of SCADA System for SGPS been proposed and will be executed in 2016.

Keywords: SCADA, hydro power plants, remote terminal unit, tenaga nasional berhad.

INTRODUCTION

Sungai Perak Power Station (SGPS) cascading hydro power plant was built in 1970 with a total generating capacity of 1,248 MW. These power plants are built either as a peaking or base load. SGPS consists of 22 units where four units of Hitachi for GF1, three units of Hydroarts each for GF2 and GF3, four units of Voest-Alpine for GF4, two units of BHEL each for GF5 and GF6 and four units of Kvearner Boving hydro turbines.
The unit's data tabulated as follows:

Table-1. Installed capacity.

Generating Facilities	Turbine	Control System	No. of Units	Unit MW
GF 1	Hitachi	SCADA	4	87
GF 2	Hydroart	SCADA	3	24
GF 3	Hydroart	SCADA	3	40
GF 4	Voest-Apline	DCS	4	18
GF 5	BHEL	SCADA	2	7.5
GF 6	BHEL	SCADA	2	27.5
GF 7	Kvaener Boving	DCS	4	150
		Total	22	1,248

Since SGPS generating facilities are located across within 200 km square, therefore a Bersia Group Control Center (BGCC) was built to monitor and control all generating facilities by using Supervisory Control and Data Acquisition (SCADA).
The first SCADA System was installed since 1998 and been upgraded several times to ensure it compatible with the fast growing technology requirement. As such, it has reached a point where it exceeded electronic life span and need to be totally replaced. Apart from improving plant reliability and availability, the new SCADA System is hoped to ensure safe plant operation, lower the costs of generation, improve plants efficiency, reduce environmental effects and increase plant profitability.

Characteristic of Sungai Perak power station

Sungai Perak Power Station consists of seven Generating Facilities (GF) with 22 numbers of machines/generators. The GF1, GF2, GF3 and GF4 were designed for Cascading System using the same river source. While for GF5 and GF6 were designed to be operated via Run-by-River and GF7 was designed with reservoir. All the plant signals were connected to centralized control room namely Bersia Group Control Centre located strategically with SCADA System.
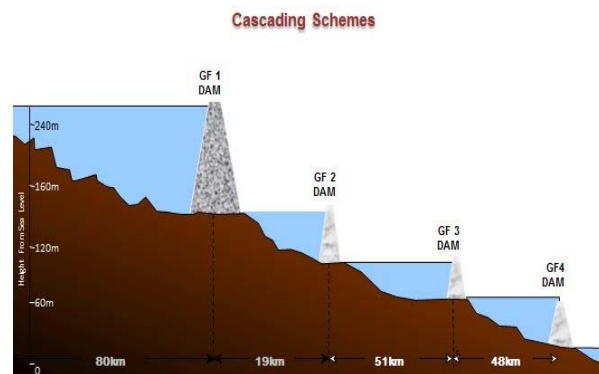

Figure-1. Cascade schemes of GF1- GF4.

Process flow diagram of hydro power plant

Hydroelectric power is generated using the force of water pressure. Water is held behind the dam forming an artificial lake or reservoir. When electricity is needed, the water in the reservoir is released through water intake

in the dam. Gravity causes the water fall through a pipe inside the dam called a Penstock. The water pressure (Water Head) spins a Turbine, a type of water wheel that converts the water energy into mechanical power which is located at the end of Penstock. When the turbine spins, it turn the metal single shaft which go up to an electrical generator. As the shaft turns, it causes the generator to rotate, and electricity is generated. The electricity then been connected to the Grid System thru Switchyard and Tower Line for Peninsular Malaysia usage. After flowing thru the Penstock and across the turbine, the water continues into the river on the other side of the dam via a Tailrace.
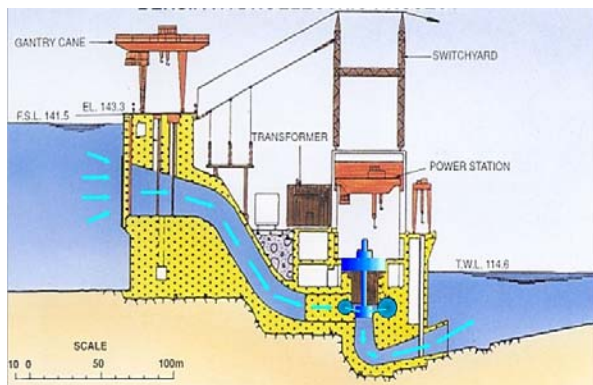

Figure-2. Operating mode of hydroelectric

SCADA components and reliability

SCADA monitors, controls and set alarms at the generating facilities operating system from a centralized location namely as Bersia Group Control Centre (BGCC). BGCC is connected to the generating machines in SGPS. Moreover, it includes the communication of information between a SCADA central host computer and several Remote Terminal Units (RTU). The system consists of the following elements:

- SCADA Master Units: The repository of the real-time data collected from the Remote Terminal Unit (RTU) connected to it. It serves as central processor for the SCADA System. Master units provide a human interface to the system and automatically regulate the manage system in response to the sensor inputs.
- Human-Machine Interface: The parameters that have been stored in the host computers are presented to the human operator using HMIs. The parameters can be in form of trending, diagnostic or management information and detailed schematics representing the current states of the generating facilities under its control.
- Remote Terminal Units (RTUs): Serve as local collection points for gathering reports from sensor and delivering commands to control relays. Normally a transducer or sensor which allows the electrical circuitry to interface with the process instrumentation and control equipment.

- Communication Network: The conveying of data from RTU to the master station and commands from the local host to the RTU need to be done over a communication system. SCADA data is encoded in standard protocol format.

As for SGPS's SCADA System philosophy, all the data that been collected from the each of generating facilities are processed by the Master Units located at BGCC. Upon receiving demand of electrical energy to be generated from the Grid Operator, the human operator then will give commands via HMI to run the machines accordingly as requested to produce the Megawatt (MW) required.
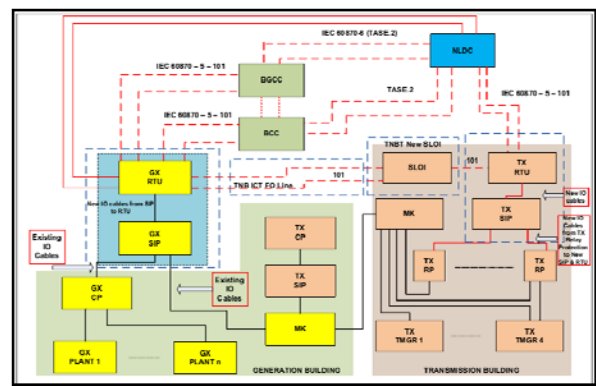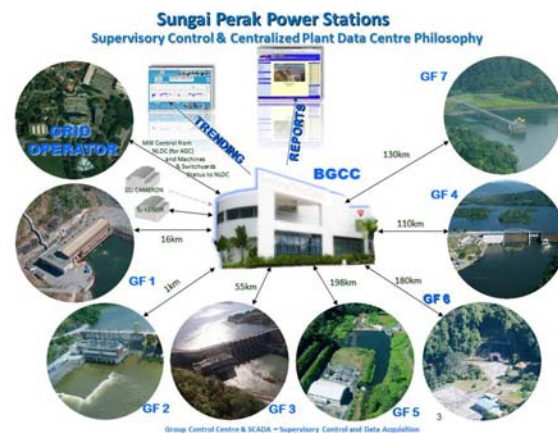

Figure-3. Simple SCADA system.

Figure-4. SGPS SCADA philosophy.

DESIGN CONCEPT

SCADA system configuration

Figure-5 shows the schematic diagram of the existing SCADA system configuration. Dedicated redundant Local Area Network (LAN) was used as a communication link between HMI and the Master Servers. Monitoring, trending, engineering and diagnostic are done from the HMI connected to the server. The communication links use 100Mb/s Industrial Ethernet for communication.

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The existing SCADA been designed with Primary and Secondary LAN. It is highly dependent on Primary server for SCADA System operation and data replication only between main servers. The Secondary server is not fully utilized.

Figure-6 shows the new conceptual schematic diagram for the modernization SCADA System to be installed. The main difference is the layer of redundancy of the network. The main difference for new SCADA System, is it three layer of redundancy namely Management Level, Interface Level and Data Acquisition Level. If any case one of the Main Server failed, any of the server or workstation will override and become the main server. This is possible due to all the data were replicated simultaneously to the entire server database.
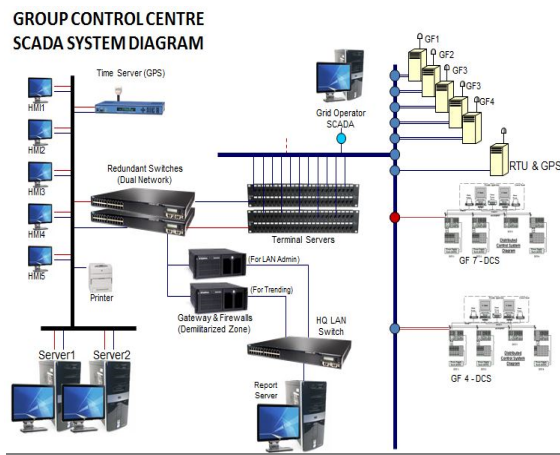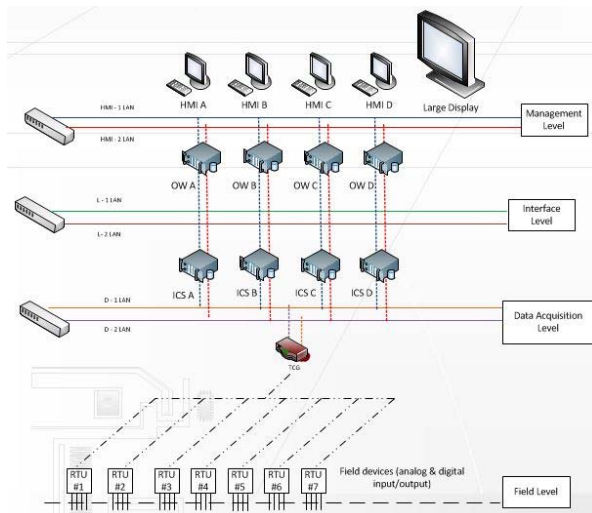

Figure-5. BGCC SCADA diagram (Existing).

Figure-6. Conceptual SCADA diagram (New).

RELIABILITY BEFORE AND AFTER MODERNIZATION

The existing SCADA System already has been in service for 17 years and exceeds its electronic life span. The probability for it to fail is high as there are no more

spare parts available in the market for parts replacement. The Condition Monitoring (COMO) could not be executed due to the limitation of signal numbers and signal tag database capacity. As for the software, it was unable to update with the latest firmware which make it vulnerable for Cyber Threats and does not comply with Information Security Management System spearheaded by TNB.

With modernization of new SCADA System, it is designed to cater for increase number of signals, have better compatibility to connect with other system, allow spare parts pooling with other divisions, increase staff competencies via in house training Simulator, have ability to perform Condition Monitoring of valuable assets, increase plant control ability, more details of plant alarms, have less frequent routine maintenance and breakdown, increase historian capacity, data analysis, integrity, strategically establishment of Disaster Recovery Centre and compliance to ISO27001:2013 to mitigate Cyber Threats.

RESULTS AND DISCUSSIONS

With the experienced gained over the years of maintaining the existing system, the new modern SCADA System has been designed to enhance the operational and maintenance requirements.

Several aspects were considered such as technical supports availability, Cyber Threats, spare parts availability, product life time, standardize protocol among any other system for compatibility of communication, spare signals for future expansion and on top of that, investment cost for the project.

Table-2. Comparison table.

| SCADA System | Support | Specification | | | | Cost |
		Operating System	RTU	Protocol	No. of Signals	
Existing	Oversea	UNIX	Obsolete	DNP 3	8,800	High
New	Local (Malaysia)	SUSE LINUX	New, Available in the market, 10 years supports	IEC 60870-5-101/104, IEC 60870 -6 (TASE.2)	16,000	Low

CONCLUSIONS

In this project, we designed the SCADA System for SGPS with the latest proven technology available in the market. Several benchmark visits and inputs from the interested parties related to the operation of SGPS either directly or indirectly were carefully considered.

All the engineering challenges must be overcome to ensure the modernization of SCADA System at SGPK fully functions and improve the efficiency and the reliability of all the generating facilities.

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