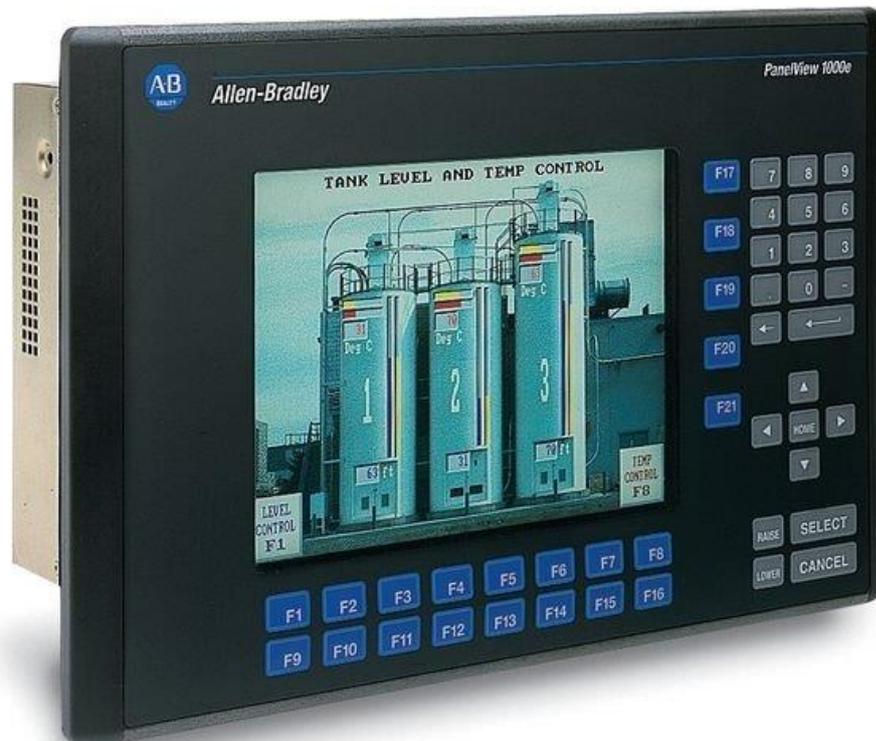


CHAPTER 3: IMPLEMENTATION OF A REAL-TIME ENERGY MANAGEMENT SYSTEM ON A NATIONAL WATER PUMPING SYSTEM



Allen-Bradley HMI (Human Machine Interface)

3 Implementation of a real time energy management system on a national water pumping scheme

3.1 Preamble

By examining the DSM project at hand, it is advisable that the entire system be automated. This is to ensure that the project accomplishes its intended purpose and that no human errors alter the way in which the system has been set-up. This will become more evident in the sections discussed in this chapter.

A system is fully automated by implementing certain equipment in the system. These are: a SCADA system, PLCs, HMI equipment and REMS, as was discussed in the previous chapter. Communications between the pumping stations are also of vital importance to the system, as it allows for all of the equipment to interact.

This chapter will be focusing on the system constraints associated with the intervention. The reader will also be familiarised with the communications within the system as well as the implementation of an energy management system.

3.2 System constraints

Before an automated energy management system can be implemented, the system constraints and parameters have to be determined. Elements that need to be determined prior to the implementation of the REMS include:

- The number of pumps at each pumping station, as well as their availability;
- The installed capacity of each pump in the system;
- The flow rate of each column when different amounts of pumps are running simultaneously;
- The maximum number of pumps which may be operational simultaneously at each pump station at any given time;
- The available water storage capacities in the system;
- Maximum and minimum dam levels.

Most of these details have been discussed in Chapter 2, however, some important minor details have not yet been presented. The following table lists all the above constraints and components; repeated details serve to refresh the reader thereof.

Table 8: Details of pumping stations

Pump station	Grootdraai(GD) & Tutuka(TK)	Grootfontein	Rietfontein
No. pumps	4(GD) + 4 (TK) = 8	5	4
Max no. pumps allowed to operate simultaneously	4	4	3
Flow rate of an individual pump [l/s]	GD – 1 900 TK – 1 400	2 100	1 055
Max delivered flow rate for pumping station [l/s]	GD – 4 130 TK – 3 240	4 900	3 600
Pump installed capacity [kW]	GD – 1 650 TK – 1 725	2 150	3 050
Head [m]	GD - 70 TK - 165.5	85	100

The reader will notice that the maximum delivered flow rate for each pumping station is less than the combined flow rate of all the pumps on that specific station. This is due to the friction losses in the main pumping column exceeding the force of the water-flow through the pipe.

The relative upstream and downstream dams for these pump stations with their physical properties and constraints can be viewed in Table 2.

3.3 Communication systems

To this point, this dissertation has been investigating the SCADA system and all its sub devices. Using a direct connection, like a copper wire, as wiring technique to connect two devices by means of a PLC, seems particularly simple. This is however not that uncomplicated when those devices are separated across large distances such as the Usutu-Vaal project. At the outset, the ability to maintain it is much more complicated than a Global System for Mobile communication (GSM) and it is a lot more costly.

A system of this nature will have to communicate between the pump stations by means of wireless communication. This is made possible by GSM which eliminates all of the physical wiring between the pumping stations, thus eliminating cable theft etc.

Established in 1982, GSM was introduced to the public domain, to create a common European mobile telephone standard for digital cellular communication. GSM operates on frequencies in the range of 850MHz to 1.9GHz and is capable of data transmission speeds of up to 9.5 kilobits per second [48]. One of the distinctive features of GSM is the use of a Subscriber Identity Module (SIM) card.

Figure 39 illustrates a typical layout of a GSM system and how the communications between the sites occur. Data received by the SCADA system on site is transferred, by means of network cabling, to a GSM modem containing a SIM card. From here the data is communicated wirelessly to a GSM tower located nearby. The data is now transferred via the Base station controller (BSC) to a GSM tower located near the recipient of the data. This data is then received by the GSM modem or cell phone on site and communicated to the receiving SCADA.

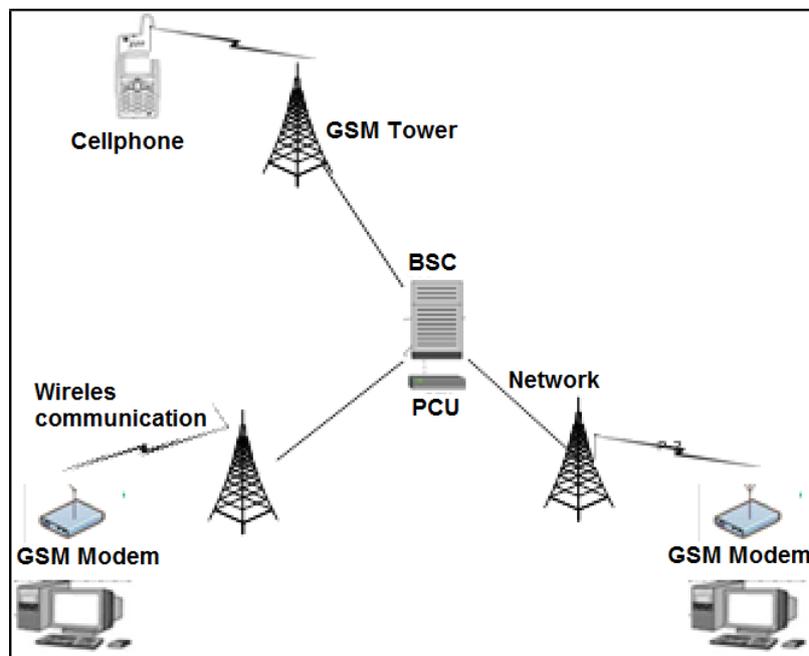


Figure 39: Typical GSM network

3.4 Implementation and problems encountered

3.4.1 Implementation

The subsequent step in the project was the implementation phase of the Usutu-Vaal project. All the pumps in the pumping stations were automated and connected to the necessary hardware, such as PLCs, in order for the SCADA to communicate with the pumps. Three individual SCADAs, one for each pump station, were set up with the necessary GSM and fibre optic communications for successful transmission amongst them. The following figures illustrate upgrades carried out in the pumping stations.

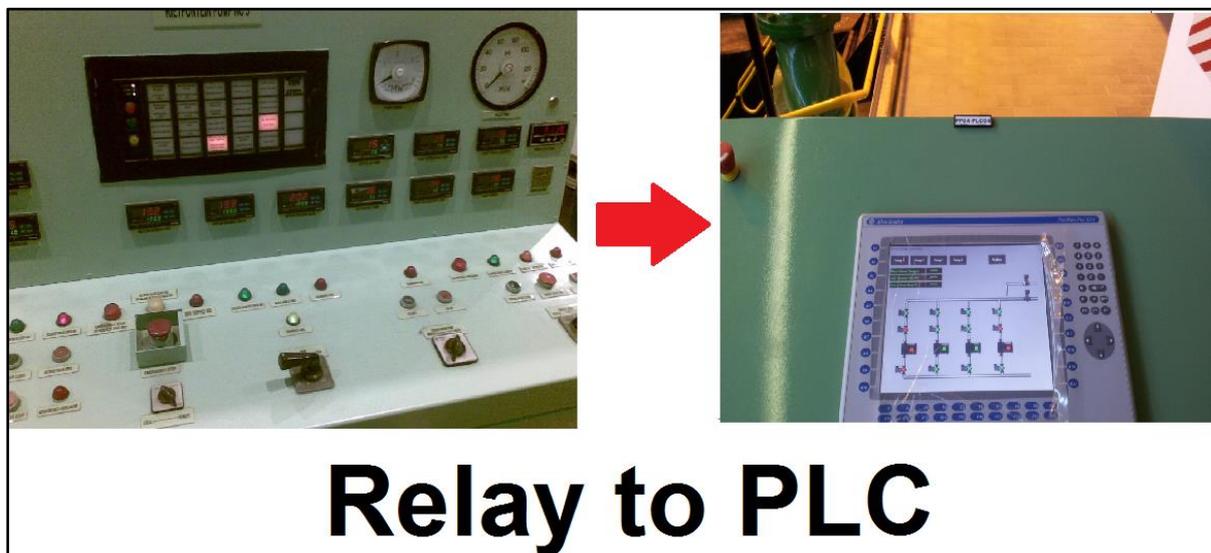


Figure 40: Upgrades relay logic to PLC with HMI Panel



Figure 41: GSM Router installed at Rietfontein pump station

With the SCADA system successfully set-up and capable of fully controlling the system, it was now possible to implement REMS by making use of RSLinx. RSLinx is a computer based software package developed by Rockwell software to interface to all of the A-B industrial control and automation hardware, thus allowing REMS to control the system. REMS will however only be capable of controlling the system if the SCADA allows REMS to operate the pumps. The SCADA consequently had to be hard programmed, ensuring that if it was, for example, detected that a pump was not ready to be operated, it would not allow REMS to control that pump. The SCADA will only allow the REMS to control the pump when it becomes ready and available to be operated.

A REMS was installed for the entire system, as well as for each individual pump station. This had to be done to ensure that the system was still in operation if, for example, a communication problem was encountered with the GSM network.

These real-time energy management systems each had to be inter-connected to prevent the different systems from working against each other, but to rather to function

together to form a combined system. Each REMS was thus programmed to control the site where it was located, as well as to communicate to the other sites so that specific changes in the system could be identified. Figure 42 depicts an image of the REMS and SCADA system located on the Grootfontein pumping station.

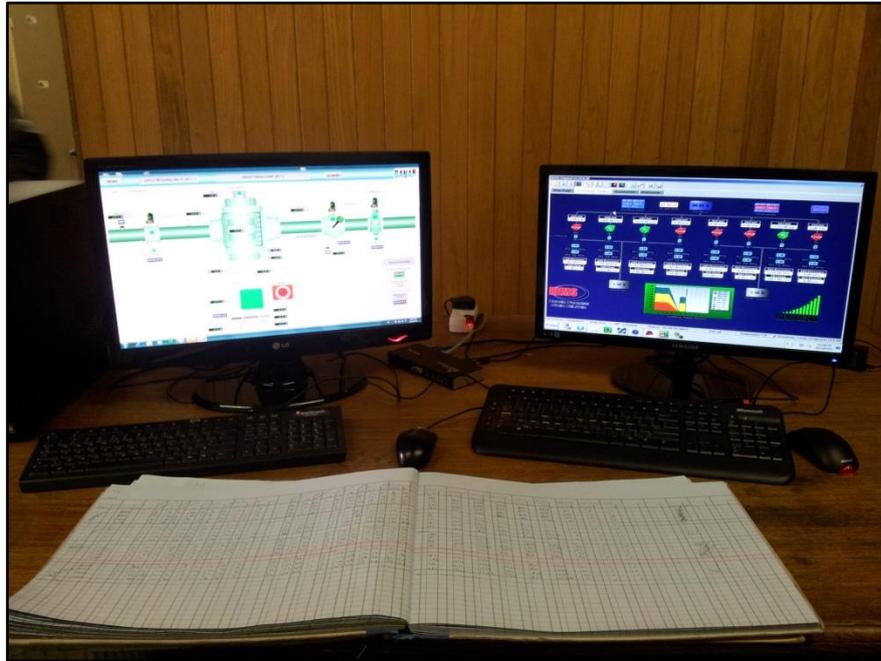


Figure 42: REMS and SCADA located at Grootfontein pumping station

Two servers with UPS's were installed on each site as backup for the system. One of these servers is setup as the master and the other as a slave. These servers also needed to be programmed in such a way that if one fails, the other will control the system according to the way it was set-up.

3.4.2 Problems encountered

While implementing the system on the Rietfontein pump station a minor problem was encountered with the start-up of the pumps. As mentioned previously, three pumps at Rietfontein pump station have to run simultaneously if the system is to supply water to Matla power station. If only one or two pumps were to be in operation at the same time, the power drawn by the pump-motors will exceed their maximum allowable limit, damaging the motor. To eliminate this, the pump-control-valves are opened to only

10% when less than three pumps are running simultaneously. As soon as three pumps are running, the control valves are fully opened and water is supplied to Matla.

This condition thus had to be programmed into the system. The service PLC needed to identify whether three pumps were running or not and accordingly identify which control valves needed to be opened or closed to 10%.

Another issue of concern was the water delay between Grootdraai and Grootfontein pump stations. As discussed earlier, Grootdraai supplies water to the Grootfontein pump station. This water takes approximately 11 hours to reach the Grootfontein pump station situated approximately 35 km away. This needed to be taken into consideration when switching the pumps off in Grootfontein pump station during 18H00 and 20H00, if not the canal would overflow at Grootfontein.

A solution was to switch the pumps off for two hours, eleven hours before 18H00 at the Grootdraai pump station. This meant that the pumps at Grootdraai pump station were switched off between 07H00 and 09H00, as well as 18H00 to 20H00 during weekdays.

Switching off the pumps during 07H00 and 09H00 meant that load was now shifted out of Eskom morning- and evening peak periods at Grootdraai, realising more savings for the intervention.

3.5 Conclusion

In this chapter the system constraints for the project were discussed. The reader was reminded of the number of pumps on each pump station as well as the different dams and canals in the system.

The reader was exposed to the implementation of the intervention and the problems associated with this.