
Office of Utilities Regulation

**Enquiry into JPS Power System
Shutdown of January 9, 2008**

Preliminary Report



OFFICE OF UTILITIES REGULATION

February 12, 2008

**Preliminary Report of the Panel Established by the
Office of Utilities Regulation
To Enquire into
The All-Island Electricity System Shutdown of 9th January 2008**

Background

At about 6.12 p.m. on Wednesday 9th January 2008 a fault on the Jamaica Public Service Company's (JPS) 138 kV (kilovolt) transmission line between the Tredegar and Duhaney substations resulted in unstable voltage and frequency conditions. This condition in turn precipitated shutdown of all generating units then connected to the system and consequently total system failure in less than a minute after the fault occurrence.

This was the third occasion on which the JPS system experienced a total shutdown in less than eighteen months. The first of these three instances, which occurred in July 2006, had been thoroughly investigated not only by JPS itself but independently by the Office of Utilities Regulation (OUR) and by a group of overseas experts. The findings and recommendations submitted by both independent parties were in substantive agreement, particularly with reference to actions to be taken to minimize the probability of recurrence of another costly system collapse. In July 2007 the system again failed and the circumstances and causes were once more investigated by the OUR, the results reaching conclusions similar to those in the previous instance as to the causes and the appropriate corrective action to be taken.

Following the January 2008 shutdown the OUR decided to establish a panel to enquire into the circumstances salient to the shutdown and to undertake investigations similar to those conducted in the previous instances. The OUR also decided that the panel should be chaired by an individual who is not on its regular staff but has had extensive experience in power system operations. The other members of the panel would comprise OUR staff as well as consultants with specific technical expertise in areas relevant to the issues being studied.

This report presents the initial findings and conclusions of the panel and outlines the actions planned to be undertaken in continuance of the investigation.

The Enquiry Panel

The members of the Enquiry Panel ("the Panel") are:

Winston Hay	Chairman
Raymond Silvera	Deputy Director General (OUR) – ex officio member
Peter Broven	Consultant Electrical Engineer
Courtney Francis	Electrical engineer – OUR
Duane Rowe	Electrical engineer – OUR

Panel Terms of Reference. The Panel's Terms of Reference are to:

- Enquire into the circumstances of the JPS all-island shutdown of 9th January 2008;
- Identify significant events before, during and after the shutdown, including the service restoration exercise;
- Investigate the possible causes of the system collapse and evaluate whether it was avoidable;
- Examine previous shutdown and outage enquiry reports and recommendations, including that prepared by the international consultants following the July 2006 shutdown;
- Indicate conclusions relative to actions or inactions on the side of JPS or any other party having a bearing on the system shutdown;
- Recommend any corrective action which is required to remedy the existing situation and prevent a recurrence of the collapse. The order of priority for implementation of these recommendations is to be indicated.

In addition to establishing the Panel the OUR has engaged the services of a group of local consultants to undertake an audit of JPS' 138 and 69 kV substations, power stations and the system control center to verify the extent to which the utility has complied with OUR Directive of actions to be taken following the July 2006 shutdown as well as implementation of the recommendations made by the group of international consultants which investigated the July 2006 system collapse. The consultants recently hired may also be asked to undertake such verification checks in the field as may be relevant to the enquiry currently underway.

The Outage Event

As indicated in the opening paragraph of this report, on the day in question a fault developed on the Tredegar to Duhaney 138kV wooden pole transmission line. The Tredegar substation is located in the general area of Ensom City and the Duhaney substation is close to the intersection of Washington Boulevard and Nelson Mandela Highway. The information currently available indicates that the important steps in the shutdown process after the initial fault occurred in the following sequence:

- Investigations carried out by JPS immediately after the shutdown revealed that a pole supporting one of the transmission line conductors (wires) and located less than two (2) miles from the Duhaney substation had toppled over, permitting current to flow from the conductor directly to the ground, precipitating an unstable condition since a short-circuit (fault) then developed.
- The protective devices intended to isolate faults on the transmission system operated correctly at Duhaney, cutting off the flow of current from that substation to the fault location.

- At Tredegar the protective relays operated correctly but one of the two circuit breakers that were required to open in response to the relay signals failed to do so and fault current continued to flow from Tredegar to the fault.
- The first line of protection against the stuck circuit breaker condition did not operate, as the DC breaker supplying the relay circuits was switched off.
- The second line of protection comprising back-up relay devices at the Old Harbour and Bellevue substations and on the transformer circuits at Tredegar responded to isolate the fault, but the response was slower than required.
- The sustained fault conditions caused the system voltage to collapse which in turn caused all generators island-wide to shut down and the entire system to go dead within about one minute after the fault had developed.

JPS reports that the pole which toppled over was located in a swamp and the water was about four (4) feet deep at that location (See picture of fallen pole attached). The guy wire supporting the pole had pulled out of the ground and consequently the pole fell over. (A guy wire is a length of wire attached to the upper section of the pole at one end and anchored in the ground at the other end, thereby increasing the stability of the pole). The strength of the guy's anchor in the earth may have been weakened because of the waterlogged condition of the ground. The pole was reinstalled in its original location by JPS crews. The pole was inspected by the Panel after its reinstallation and no evidence was found of rot or other conditions that would render it unsuitable for continued service.

As previously noted one of the two circuit breakers in the Tredegar substation (the breaker designated 9-530) which should have been the first line of protection against the effects of the fault caused by the fallen pole did not operate. Inspection of the circuit breaker after the shutdown showed that the operating coil which would have tripped the circuit breaker and isolated the fault was burnt. A back-up relay is installed to operate in the event that the first line of defense fails, but the breaker providing DC power to that relay was found in the off position, rendering the relay inoperative. Problems were also experienced with other protective relays at the Tredegar and Old Harbour substations in that their operating times were slower than the design values.

Restoration of Service

The first step in service restoration after the total shutdown was to ensure that none of the equipment to be energized in the process presents a hazard to personnel or property. This was done. The next step was to place in service those generating units which can start without an external power source. These include the hydroelectric units, some diesel and some gas turbine units. Steam-driven generators need external power for re-starting. When the all-clear was given for re-energizing the system, a gas turbine at the Hunts Bay station was placed in service at about 6.54 p.m., then another gas turbine at Bogue about two minutes later. A number of breakers were opened to divide the system into four discrete sections, so that, in the event of one sub-system developing a problem the

stability of the other sub-systems would not be jeopardized. As more generating units were restored to service the areas being served expanded and eventually the whole system was re-integrated. Some difficulty was initially experienced in reconnecting the privately owned generating facility at Rockfort due to high system voltage.

Full restoration of power was achieved at 10.35 p.m., 4 hours and 23 minutes after the shutdown. This is a significant improvement on the experiences of the 2006 and 2007 all-island shutdowns, one of which extended over more than 11 hours.

Preliminary Analysis of the Causes of the Shutdown

The Panel is now engaged in the preliminary phases of the investigation, but the evidence at hand indicates that although some technical problems with system stability exist, the most significant contributory factor to the shutdown was inadequate maintenance practices on JPS' part. This conclusion is supported by the following observations:

- Transmission line inspection. The transmission line on which the fault developed had not been inspected at ground level since 2002. At that time the water level at the base of the poles was not as deep as it now is. It should therefore have been expected that the stability of the poles' foundation would have been weakened by the high moisture content of the soil in which they were now fixed and some attention paid to evaluation of the resulting risk. Ground-level inspection would not necessarily have indicated that the security of the poles in general, or of any specific pole, was endangered, but would nevertheless have been a prudent precautionary measure.

Aerial inspections were undertaken in December 2004 and October 2005 but these would have provided information primarily about the top of the poles - the cross arms, insulators and conductors, but not very much about the foundations. However, the pictures taken from the air on that occasion showed the poles standing in a large lake of water and should have raised concern about the security of the foundations.

On 4th January 2008, five days before the all-island shutdown, a fault developed on the same Tredegar - Duhaney line, but on that occasion the protective devices worked properly and service to consumers was not interrupted. Investigations showed that the fault had been caused by vegetation growing up a pole and into the conductors. The pole involved was not the one which later caused the shutdown but nevertheless the incident should have been another signal of the urgent need for line inspection at ground level. There is no report of any such inspection having been undertaken.

- Protective relay and circuit breaker performance. The 138 kV circuit breaker (9-530) at the Tredegar substation operated to clear the fault on 4th January. However when the line was later re-energized on the same day to test the transmission circuit the fault was still on the line and the circuit breaker malfunctioned in opening. The report of that incident prepared by the Protection and Control Department recommended that the integrity of the breaker failure scheme be assessed and that a timing test be carried out on the very breaker (9-530) that later caused the problem.

Admittedly less than four (4) working days elapsed between the two incidents involving that breaker, but the problem was obviously not being treated as urgent.

Operating time tests carried out on a number of circuit breakers indicated that several in the Tredegar substation have significantly longer operating times than their design specifications. The date on which the tests were conducted is not currently known to the Panel, but JPS is currently embarking on a program of replacing the older 138 kV circuit breakers with more modern counterparts and has, in fact, already replaced the malfunctioning 9-530 breaker. No reason has been advanced as to why the DC breaker supplying the breaker-failure scheme in the Tredegar substation was open. There has also been no report to date of any alarm indicating loss of supply to the breaker failure scheme. This would have given early warning of the problem and should have initiated a visit to the substation to identify and correct the source of the problem. The provision of alarms and consequent response will be further investigated by the Panel.

- Remote System Supervision. The report submitted by JPS indicates that in a number of substations the batteries needed to keep the System Control and Data Acquisition (SCADA) system operating without mains power suffered from low capacity during the period of the outage. These batteries must be designed to maintain operating voltage to cover the periods likely to be experienced under emergency contingency conditions. The batteries are therefore either undersized or defective. In either case the problem will not be solved by installation of solar panels as is being proposed, especially since most of the outage hours were during periods of darkness.

Matters for Further Work

- 1) The conclusions recorded in this initial report will be discussed with JPS and the independent power providers to solicit their comments and any other contributions they may wish to make to assist in achieving the objectives of the panel.
- 2) The audit of JPS compliance with past recommendations for a more robust system will be completed.
- 3) System stability and relay coordination studies will be undertaken
- 4) Evaluate possibilities to make generating units better capable of withstanding system upsets without endangering unit reliability. This will include a rigorous analysis of the root causes of generator tripping.
- 5) Evaluate operating strategies to ensure that supply security is maximized.
- 6) Investigate whether appropriate written policies and procedures for the maintenance of transmission lines and substation equipment are available, and if the requisite skills sets exist in the company to carry out the required maintenance work.
- 7) Consider carefully what issues may have been overlooked so far but may be of significance in improving system reliability.

Winston C. Hay
Chairman – Enquiry Panel



Picture showing fallen pole on structure # 18 on JPS Tredegar to Duhaney 138 kV transmission line