Cabinet Appointed Expert Committee to Investigate the Causes of the Islandwide Power Outage on Wednesday 16th February, 2022

Report

April 2022

CABINET APPOINTED COMMITTEE

CHAIRMAN:

- PROFESSOR CHANDRABHAN SHARMA (BSC, MSC, PHD, FAPETT, SMIEEE, MIAENG, RENG)

  RETIRED PROFESSOR OF ELECTRICAL AND COMPUTER ENGINEERING

MEMBERS:

- MR. KEITH SIRJU (BSC, MSC)

  FORMER CHAIRMAN OF T&TEC

- AG. SUPERINTENDENT ALLISTER GUEVARRO (MBA)

  TRINIDAD AND TOBAGO POLICE SERVICE

Scan for Appendices

TABLE OF CONTENTS

ACKNOWLEDGEMENTS

The Committee acknowledges the cooperation and efforts of the key participants who facilitated the successful completion of this exercise. These are:

- The General Manager of T&TEC and relevant departments of the commission
- The General Manager of PowerGen
- The General Manager of Trinidad Generation Unlimited
- The General Manager of Contour-Global Trinity Power
- The Chief of Defence Staff
- The Commissioner of Police
- The Chief Executive Officer of WASA
- The Chief Executive Officer of TSTT
- The Chief Executive Officer of Digicel
- The Chief Executive Officer of the ODPM
- The Director of the Strategic Services Agency
- The Director of the Meteorological Services of Trinidad and Tobago
- The Forestry Division of the Ministry of Agriculture, Land and Marine Resources
- The President General and Executive of the OWTU
- The Physical Security Unit of the Special Branch
- Ms. Andail Hackett – Secretariat to the Committee
- The Department of Electrical and Computer Engineering, The UWI

All requests for information, relevant data and site visits were handled in a prompt and efficient manner.

List of Abbreviations

APETT	Association of Professional Engineers of Trinidad and Tobago
CAPA	Crime and Problem Analysis
CCTV	Closed Circuit Television
CDM	Comprehensive Disaster Management
CGTP	Contour Global Trinity Power
CWP	Country Work Programme
DCP	Deputy Commissioner of Police
EAS	Emergency Alert System
ESSI	Energy Sector Security Initiative
FC	Fault Clearance
FS	Fault Initiation
FSNL	Full Speed No Load
GAS	Group Alert System
GEB	Guard and Emergency Branch
HQ	Headquarters
Hz	Hertz
IATF	Inter-Agency Task Force
IEEE	Institute of Electrical and Electronic Engineers
IMGD	Imperial Million Gallons per Day
IPPs	Independent Power Providers
JAP	Joint Army Patrol
kV	Kilovolt
m	Metre
MACP	Military Aid to Civil Power
MEEI	Ministry of Energy and Energy Industries
MET	Meteorological
MVA	Mega Volt Amp
MW	Mega Watt
NAS	National Alert System
NESC	National Electrical Safety Code
NGC	National Gas Company
NOC	National Operations Centre
NOFC	National Operations Fusion Centre
NSFC	National Security Fusion Centre
OCC	Operations Command Centre
ODPM	Office of Disaster Preparedness and Management
OWTU	Oilfields Workers' Trade Union
PAS	Popular Alert System
PBX	Private Branch Exchange
PDC	Pacific Disaster Centre

PoS	Port of Spain
PowerGen	Power Generation Company of Trinidad and Tobago
PPA	Power Purchase Agreement
PR	Public Relations
PRU	Preparedness and Response Unit
QRF	Quick Response Force
RAU	Research and Analytical Unit
RIC	Regulated Industries Commission
ROTT	Republic of Trinidad and Tobago
RRU	Rapid Response Unit
s	Second
SCADA	Supervisory Control and Data Acquisition
SOPs	Standard Operating Procedures
SSA	Strategic Services Agency
SW	South West
T&TEC	Trinidad and Tobago Electricity Commission
TEMA	Tobago Emergency Management Agency
TGU	Trinidad Generation Unlimited
TPL	Trinity Power Limited
TSTT	Telecommunications Services of Trinidad and Tobago Limited
TTAG	Trinidad and Tobago Air Guard
TTCG	Trinidad and Tobago Coast Guard
TTDF	Trinidad and Tobago Defense Force
TTFS	Trinidad and Tobago Fire Service
TTMS	Trinidad and Tobago Meteorological Services
TTPS	Trinidad and Tobago Police Service
TTR	Trinidad and Tobago Regiment
U-G	Union to Gandhi
UNDRR	United Nations Office for Disaster Risk Reduction
USA	United States of America
UWI	University of the West Indies
WASA	Water and Sewerage Authority
WTP	Water Treatment Plants

LIST OF FIGURES

GLOSSARY OF TECHNICAL TERMS

The definition for most of these terms have been extracted from the The Authoritative Dictionary of IEEE Standards Terms 7th Edition (IEEE 2000).

AC	A periodic current the average value of which over a period is zero. (Unless distinctly specified otherwise, the term refers to a current which reverses at regularly recurring intervals of time and which has alternately positive and negative values.)
DC	A unidirectional current in which the changes in value (polarity) are either zero or so small that they may be neglected. (As ordinarily used, the term designates a practically non-pulsating current.)
Generator	A machine that converts mechanical power into electric power.
Inrush current	The maximum root-mean-square or average current value, determined for a specified interval, resulting from the excitation of the transformer with no connected load, and with essentially zero source impedance, and using the minimum primary turns tap available and its rated voltage.
Load shedding	The process of deliberately removing preselected loads from a power system in response to an abnormal condition in order to maintain the integrity of the system.
Oscillation	The periodic variation of a function between limits above or below a mean value, for example, the periodic increase and decrease of position, speed, power output, temperature, rate of fuel input, etcetera within finite limits.
Overload	Output of current power, or torque, by a device, in excess of the rated output of the device on a specified rating basis.
Overspeed protection	The effect of a device operative whenever the speed rises above a preset value to cause and maintain an interruption of power to the protected equipment or a reduction of its speed.
Power system resilience[1]	The ability of this system to withstand disasters (low-frequency high-impact incidents) efficiently while ensuring the least possible interruption in the supply of electricity, sustain critical social services, and enabling a quick recovery and restoration to the normal operation state.
Risk assessment	The process and procedures of identifying, characterizing, quantifying, and evaluating risks and their significance.
Relay	An electric device designed to respond to input conditions in a prescribed manner and, after specified conditions are met, to cause contact operation or similar abrupt change in associated electric control circuits.
Sag	The distance measured vertically from a conductor to the straight line joining its two points of support. Unless otherwise stated in the rule, the sag referred to is the sag at the midpoint of the span.
Spinning reserve	The reserve generating capacity connected to the bus and ready to take load.
Substation	An area or group of equipment containing switches, circuit breakers, buses, and transformers for switching power circuits and to transform power from one voltage to another or from one system to another.

[1] (Raoufi 2020)

EXECUTIVE SUMMARY

On Wednesday 16th February 2022, at 12.52 pm, electricity supply to all customers in Trinidad was lost. Industries, businesses and households were all affected. Only facilities with installed functioning standby generator(s) were able to operate, in some cases limited by the capacity of their respective standby generator(s). The first localised return of supply occurred at 3.03 pm. The areas supplied at that time were associated with the sub-stations at Guapo, Point Fortin and Santa Flora. This was however short-lived as these areas again went out at 3.11 pm. Partial restoration re-started in the Syne Village area at 6.56 pm some six hours after the system collapsed, progressing thereafter to most of the island returning to supply at 1.34 am on Thursday 17th February 2022, some twelve and a half hours later.

On Tuesday 22nd February 2022, a three-member committee was established by the Government of Trinidad and Tobago to investigate, among other matters, the circumstances which gave rise to the failure of the electricity supply system, the process for restoring power supply and the status of physical security of T&TEC's facilities. Specific terms of reference have been given and these are appended herein as Appendix 1 – Terms of Reference.

THE CAUSE

On Wednesday 16th February 2022, a 21.64 m tall fungal affected Palmiste tree fell in the vicinity of Grants Trace Extension Road and the NGC private road in Rousillac. A weather (high wind) yellow alert had been issued by the MET office for that day. (Appendix 4 – National Security Documentation) The fallen tree came into contact with T&TEC's 12 kV Line, (the "*underbuilt*" structure) that supplies the local area. The main 220 kV transmission line which transmits power generated by TGU to the sub-station at Gandhi Village crosses above the "*underbuilt*" 12 kV line referred to earlier, orthogonally, in the vicinity of the fallen tree. The vertical gap between these two (2) lines was over four metres, a distance more than two times the minimum stipulated by international standards. The branches (palm leaves) of the falling tree brushed the lower 12 kV line, setting it in a "*whipping*" motion that resulted in an upward reversal of the natural sag. The resulting whipping of the line caused it to come into contact sequentially with the B phases of both circuits of the 220 kV transmission line above. This caused the line protection relays to trip both lines sequentially thereby isolating the TGU plant from the grid.

At the time of the system failure, the overhead 220 kV line was transmitting 537 MW of power from TGU to the electricity grid. The sudden loss of the line immediately put the generators at TGU into protection mode and they automatically shut down on overspeed. The 537 MW of power represented 40% of the

power in the entire T&TEC system. This abrupt and sudden loss of power then resulted in a cascading effect that shut down the other power plants as the output capacities including the spinning reserves of the generators operating at the time were incapable of bridging the instantaneous power shortfall. The underfrequency protection for these machines operated, thereby causing an entire shut down of the plants at Point Lisas, Penal, (PowerGen) and Brechin Castle (Trinity). As a consequence, the entire system in Trinidad collapsed. Tobago was left unaffected as the protection system immediately (<1 s) isolated the Tobago system from the Trinidad system.

THE RESPONSE

The electricity grid, operated by T&TEC, is a complex network of transmission and distribution lines interconnected through substations which manage supply to customers at desired voltages throughout the country. Electric power injected into this network is produced by independently run power plants. There are four power plants in Trinidad viz, at La Brea, operated by TGU, at Penal and Point Lisas, operated by PowerGen and at Brechin Castle, operated by Trinity Power. Of necessity therefore, coordination of each of these IPP operators is critical, and more so in times of crisis such as the failure on Wednesday 16th February 2022. T&TEC, as the operator of the network is responsible for this coordination and the power producers are required to respond, in accordance with their contractual obligations, to instructions given by T&TEC.

Under normal operating conditions it is not unusual to experience system disturbances which can, at times, cause a generator to trip. Depending on the output of the failed machine, customers may experience no change as the spinning reserves of other machines would dynamically increase their outputs to bridge the short fall. If more than one generator is lost simultaneously, thereby creating a more severe situation where the spinning reserve is now inadequate to cope with the loss, T&TEC sheds load from predetermined circuits, rendering discrete locations to be without supply until the requisite power is restored. Operators of the system are therefore well acquainted with such disturbances and well capable of managing such situations. Documentations on the process to manage such minor occurrences exist at T&TEC, see Appendix 2 – Technical Documentation.

The restoration of supply to the electricity grid from a state of zero power is a rather more complex operation. There are many considerations which can impact the procedure to be adopted and whilst comprehensive guidelines are highly desirable and ought to be put in place, variations in the circumstances

at any given time requires in-depth understanding of how the power system operates. Such considerations may include but not limited to:

- The cause of the failure including its root cause and remediation.
- The generators available at each power plant as some may be out of service for maintenance or other reasons.
- The state of readiness for restart of each power plant including its black start capability.
- The philosophy for start of restoration having regard to the issues above.
- Clear understanding of the system circuitry
- Clear understanding of the power demand for each circuit as it is closed to restore supply.
- Charging inrush current values that are inherent in the re-energisation of an AC power grid.

Examination of the roles, functions and responses of each of the participants in the restoration process has been undertaken by the Committee and the analyses of the outcomes are detailed in this report. The occurrence of an entire power system collapse is rare, and in Trinidad, could occur if one of the major power plants (Point Lisas or TGU) goes out of service or if the T&TEC grid develops a major fault that inhibits the injection of power to meet customers' demands as occurred on Wednesday 16th February 2022. However total failure could be mitigated if foresighting is done and procedures implemented to prevent total system shutdown. The last occasion on which the system collapsed was in 2013 due to an incident at Phoenix Park Gas Processors Limited that disrupted gas supply to the power plants.

Trinidad and Tobago's electricity network is a robust one with reasonable redundancy and generally well operated. It must be noted however that no electricity grid is without risk or immune to failure. The issues to be addressed are whether a clear process exists for all participants in the restoration of full power to the electricity grid when total failure has occurred and what ought to be the optimal time to restore the service.

It is the Committee's view that restoration of the grid from a state of zero power to full demand capacity ought to be completed in a period of four (4) to five (5) hours measured from the time of fault determination and remediation, all things being equal. For this occurrence, the "all clear" to start energising the system was given by T&TEC at 2:45 pm, one (1) hour and fifty-three minutes after the blackout. The first attempt to put a machine (TGU 12) onto the grid was at 2:48 pm. This unit went offline at 3:11 pm. Restoration began at 6:50 pm (PEN 8) and was completed at 1:24 am the next day.

1 BACKGROUND

T&TEC was established in 1945 and is the utility responsible for the twin island's electrical transmission and distribution networks. T&TEC is state owned and regulated. Legally, it is the sole retailer of electrical power in Trinidad and Tobago. T&TEC now has over 400,000 customers and both islands are connected via a submarine link to form a single interconnected grid. Prior to the incident on Wednesday 16th February 2022, the generation output from the Tobago Stations (Cove plus Scarborough) was 46.5 MW. In Trinidad there are four power generation stations. The outputs onto the grid from each station prior to the fault were:

- PowerGen - Point Lisas at 472 MW, Penal at 50 MW
- TGU, La Brea at 537 MW
- TPL, Point Lisas at 71 MW

At 12:51:57.59 pm on Wednesday 16th February 2022 there was single line to ground fault on the blue phase of the Union to Gandhi #2 220 kV circuit. This was immediately followed at 12:51:58.02 pm by a similar fault on the blue phase of the Union to Gandhi #1 220 kV circuit. Both transmission circuits originate from the Union 220 kV substation which receives all the power from the TGU generating facility. The power system transmission line protection activated and disconnected these circuits, in effect disconnecting TGU. This led to rapid cascading tripping of all the generators in Trinidad with the last generator (Trinity) tripping at 12:52.01 pm. Tobago was automatically isolated from the Trinidad failure, with the underground cable being switched off at 12:51:59.08 pm. Trinidad was now under an Islandwide outage with all power stations down. At the time of the fault, TGU was supplying 46.7% of the load in Trinidad. The whole event from initiation of the fault to total blackout lasted less than 4 s.

The Tobago power system, which was automatically isolated from Trinidad, was unaffected. Restoration of the electricity to all customers was achieved by 1:30 am on Thursday 17th February 2022, some twelve and a half hours later.

This investigative report shall make observations, discuss findings and provide conclusions where possible of this recent Islandwide outage. Recommendations are made to mitigate a recurrence of a nationwide power outage in the future.

2 Scope of Works

The Terms of Reference from Cabinet can be located in Appendix 1 – Terms of Reference.

The Committee appointed is required to investigate, make site visits, review documents and interview witnesses, stakeholders and interested parties, regarding the following:

1. *Investigation of the incident that occurred on Wednesday 16th February 2022, that led to an islandwide electrical power outage in Trinidad, including, inter alia, the following:-*
    a. *Investigation of the circumstances that caused fault(s) to develop on T&TEC's lines at Gandhi Village/Union Estate and any other location;*
    b. *Investigation of how these fault(s) resulted/contribution to a loss of generating capacity at the Trinidad Generating Unlimited (TGU) power plant and knock-on effect at the other Independent Power Producer (IPP) power plants;*
    c. *Determination of what, if any measures could have been taken to mitigate the impact of these fault(s) on TGU's generating capacity;*
    d. *Determination of what, if any measures could have been taken to mitigate the loss of TGU's generating capacity and the loss of generating capacity at the other's IPP's; and*
    e. *Examination of the methodology and approach utilized by TGU and all other IPP's in re-establishing electrical power supply on the island following the complete loss of generating capacity.*
2. *Investigation of the current design/configuration/installation of T&TEC's electrical transmission and distribution system to determine whether there are systemic design/installation features which make it vulnerable to a repeat of a similar event, whether by accident, natural or man-made causes.*
3. *Examination of the effectiveness and appropriateness of the communication by T&TEC, ODPM and any other state agency responsible for communication in the situation, on the nature of the problem and on the progress being made to restore electrical power to the national population.*
4. *Examination of the national security response to the event of Wednesday 16th February 2022 to determine the following:-*
    a. *The country's state of preparedness in response to the incident that occurred; and*
    b. *The country's vulnerability to a repeat occurrence, given the current design/configuration/installation of T&TEC's electrical transmission and distribution system and the current capability of the IPP's to respond quickly and efficiently in a similar situation in the future.*
    c. *The nature of the response by the protective services, national security agencies and other relevant agencies, such as the Office for Disaster Preparedness and Management, to the power outage.*

Having completed (1) to (4) above, the Committee is to make observations, findings and conclusions, as well as recommendations to avoid a recurrence of a nationwide power outage.

All documentation provided for review can be located in Appendix 2 – Technical Documentation.

3 Investigation of the Events on Wednesday 16th February 2022

1. *Investigation of the incident that occurred on Wednesday 16th February 2022, that led to an islandwide electrical power outage in Trinidad, including, inter alia, the following:-*
    a. *Investigation of the circumstances that caused fault(s) to develop on T&TEC's lines at Gandhi Village/Union Estate and any other location;*
    b. *Investigation of how these fault(s) resulted/contribution to a loss of generating capacity at the Trinidad Generating Unlimited (TGU) power plant and knock-on effect at the other Independent Power Producer (IPP) power plants;*
    c. *Determination of what, if any measures could have been taken to mitigate the impact of these fault(s) on TGU's generating capacity;*
    d. *Determination of what, if any measures could have been taken to mitigate the loss of TGU's generating capacity and the loss of generating capacity at the other's IPP's; and*
    e. *Examination of the methodology and approach utilized by TGU and all other IPP's in re-establishing electrical power supply on the island following the complete loss of generating capacity.*

3.1 Review & Findings

a. *Investigation of the circumstances that caused fault(s) to develop on T&TEC's lines at Gandhi Village/Union Estate and any other location;*

3.1.1 The Anatomy of the Union to Gandhi Fault

The triggering event for the incident was the impact of a fallen Palmiste tree on a single phase 12 kV distribution line. This is captured in Figure 1 and Figure 2. It should be noted that at the time of the fault, the country was under a Yellow Alert issued by the MET Office *(see Appendix 4. ii)*. The said distribution line was crossing orthogonally under the 220 kV line circuit Union to Gandhi (U-G) between towers #53 and #54. The U-G 220 kV twin circuit is responsible for exporting most of the power from the TGU generating facility. A small quantity (70 MVA max) goes through the 66 kV bus to Brighton. This 66 kV circuit is colloquially termed the "back door". The 220 kV U-G corridor is composed of two circuits, one on either side of each tower. The result was a ground fault developed on both circuits. The protective devices operated and isolated both circuits, clearing the fault.

Figure 1: Photograph of fallen Palmiste tree

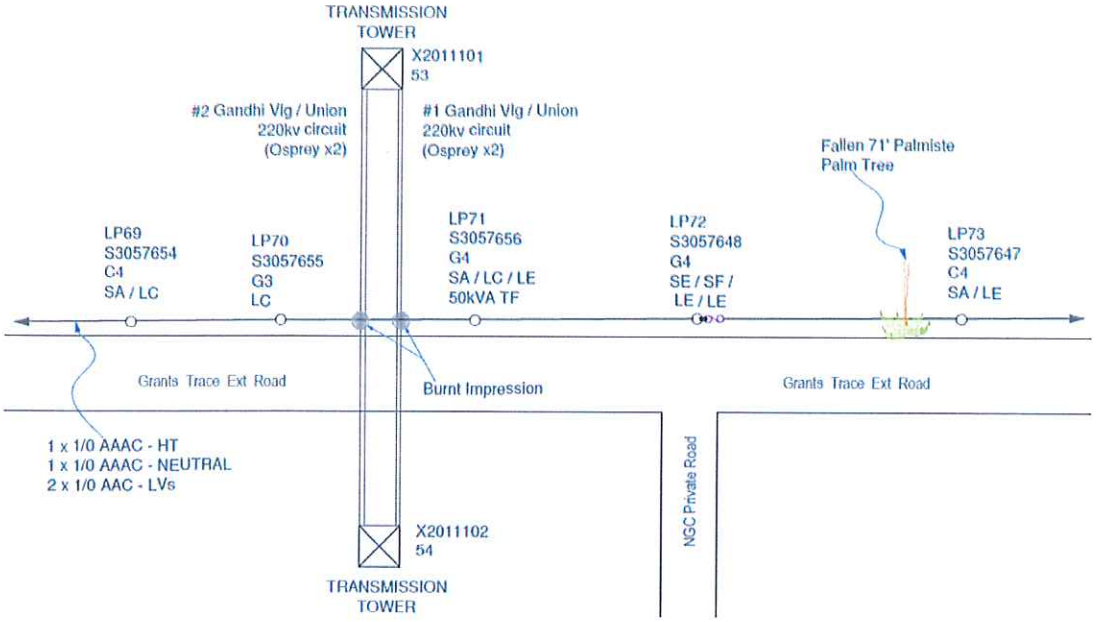


Figure 2: Diagram of affected circuit from the fallen Palmiste tree

An investigation of the affected lines after the incident showed evidence of severe scorching (see Figure 3) where the 12 kV line came into contact first (at 12:51:57.59 pm) with the blue phase of the 220 kV Circuit #2 and then shortly after (12:51:58.02 pm) with the blue phase of the 220 kV Circuit #1 of the U-G 220 kV lines. Using a drone, similar scorching marks were seen on the blue phases of the 220 kV lines above it.

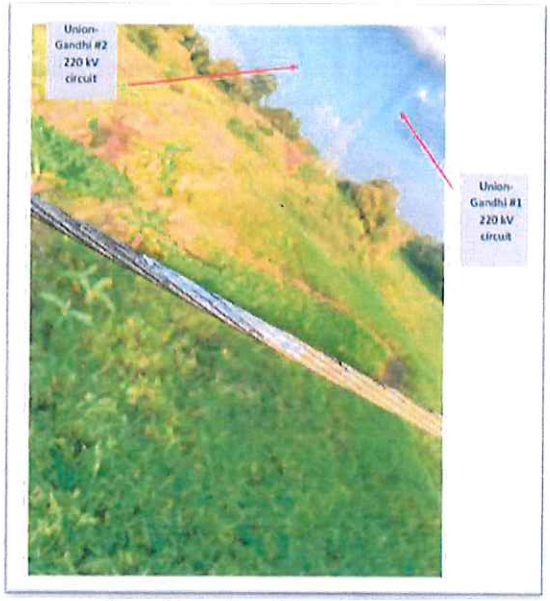


Figure 3: Scorching of the 12 kV conductor

A review of the fallen tree, by the Forestry Division, Ministry of Agriculture Land and Fisheries *(see Appendix 4. iii)* indicated that the windy condition at that time, with the fungal infection and heavy rotting at the base of the tree, caused the tree to fall. Hence this incident was due to natural causes. The team spent some time determining what could have caused the 12 kV line to come into contact with the 220 kV circuit. It was found that the clearance between the two lines were well above the recommended NESC standard (Rule 233) of 1.74 m. The #1 220 kV blue phase was the closest and it was 3.7 m above the 12 kV line.

Figure 4: Top of pole 72

A recreation of the incident on the day indicated that the Palmiste tree first struck the 12 kV line between poles 72 and 73, pulling this line into rigid tension. The line was connected to pole 72 using a dead-end porcelain insulator as shown in Figure 4. This caused the top of pole 72 to bend in tension towards the fallen tree.

The tree then slipped from the 12 kV conductor, fell and rested on the lower TSTT communication cable. This in effect caused the 12 kV freed line to oscillate like a plucked guitar string albeit heavily damped after the first half wave. The first oscillation caused a whipping of the conductor to produce a wave whose initial amplitude was equal to the sag on the line. This caused the conductor to come into contact with the #2 circuit first and then the #1 circuit as shown in Figure 5.

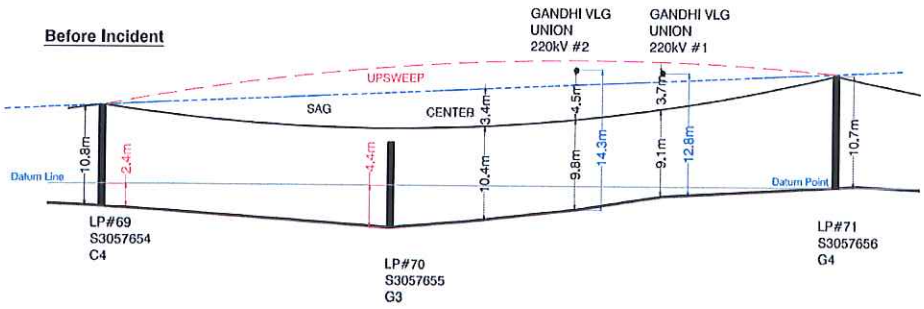


Figure 5: Standing Wave

In Figure 5, the black line represents the line position before the tree fell. The blue line represents the taut line whilst the tree was on the 12 kV conductor and the red line represents the first oscillation of the line. As can be seen from the upswing of this line it will, due to the normal sag, contact the 220 kV circuits. This initiated the collapse of the electricity grid on Wednesday 16th February 2022.

On learning of this T&TEC modified the 12 kV line structure by replacing pole 70 with a 10 m pole as shown in Figure 6 as an interim measure.

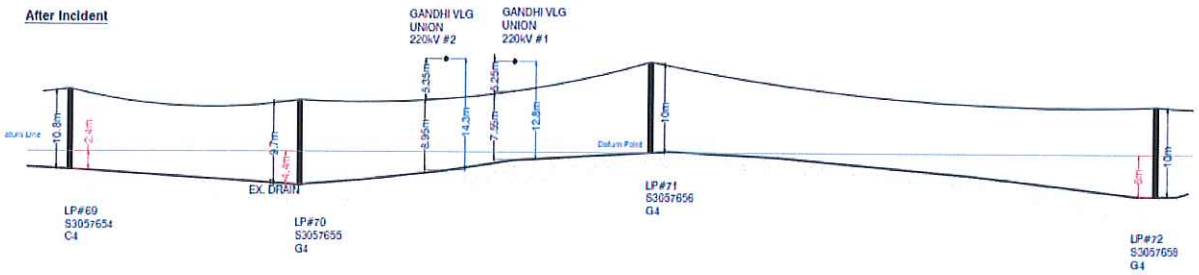


Figure 6: New pole structure

On the Thursday 17th March 2022, the 12 kV line between poles 70 and 71 (which are below the 220 kV lines) was replaced by an underground cable as shown in Figure 7, ensuring that this event will not recur.

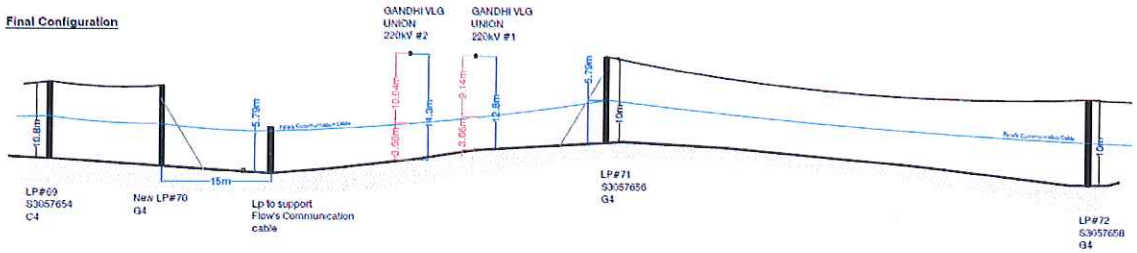


Figure 7: Final configuration employing an underground cable

b. *Investigation of how these fault(s) resulted/contribution to a loss of generating capacity at the TGU power plant and knock-on effect at the other IPP power plants;*

At the time when the U-G lines tripped, the Union 220 kV substation was still connected to TGU by the three lines from the power plant. The clearing of these two Union Gandhi Village lines however, left TGU's 557 MW (20 MW feeds internal load at the plant) of online generation, trying to continue to supply the island through the 70 MVA transformer to Point Fortin (the "*backdoor*"). Within milliseconds of the fault, this line then saw a sudden increase in power flow to 141.5 MW as the plant tried to divert the lost 537 MW that it was delivering via the U-G circuits through this 66 kV corridor to the rest of the power system (See Figure 8). This caused the 220/66 kV 70 MVA transformer at Union substation to immediately trip on overload.

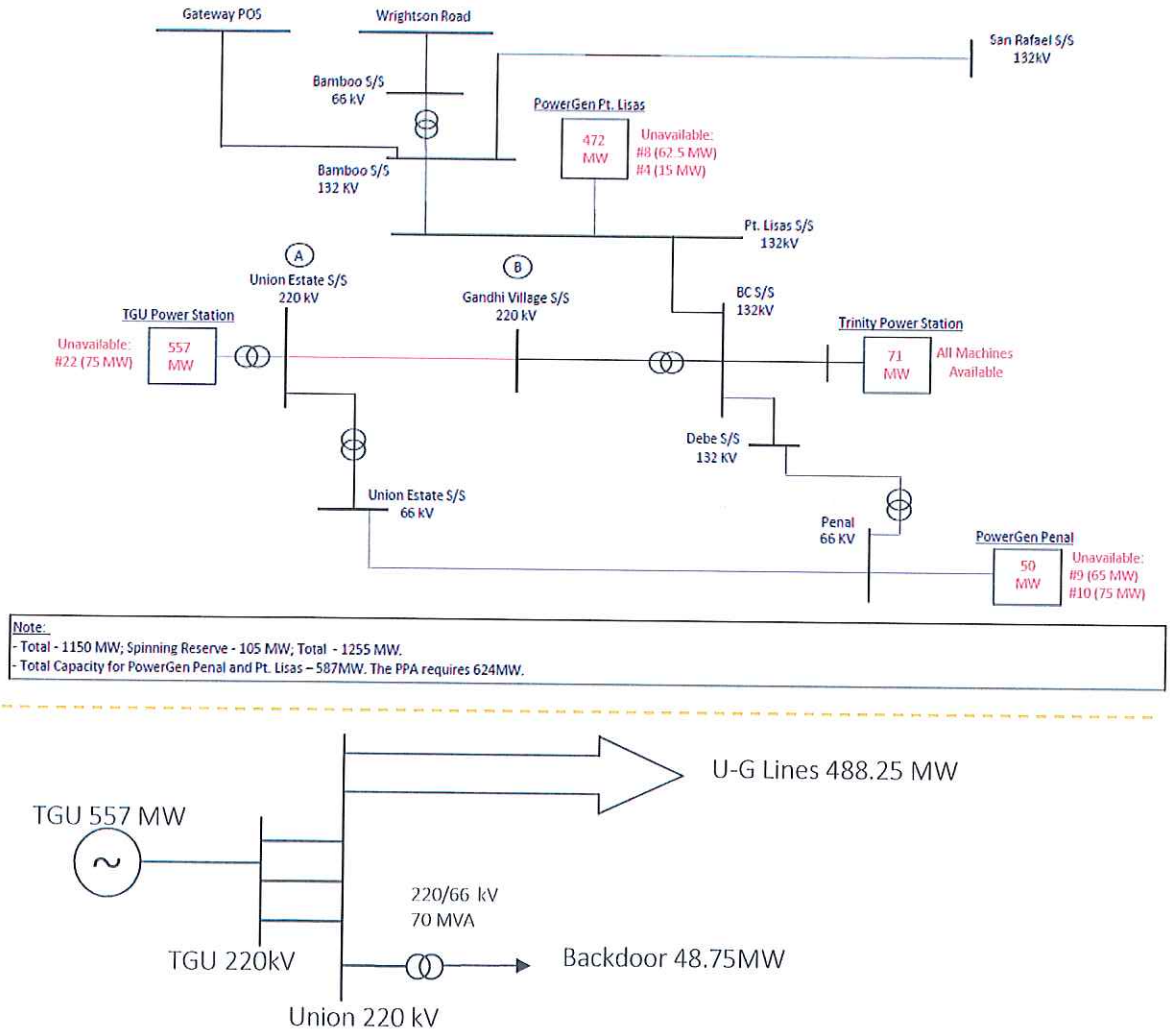
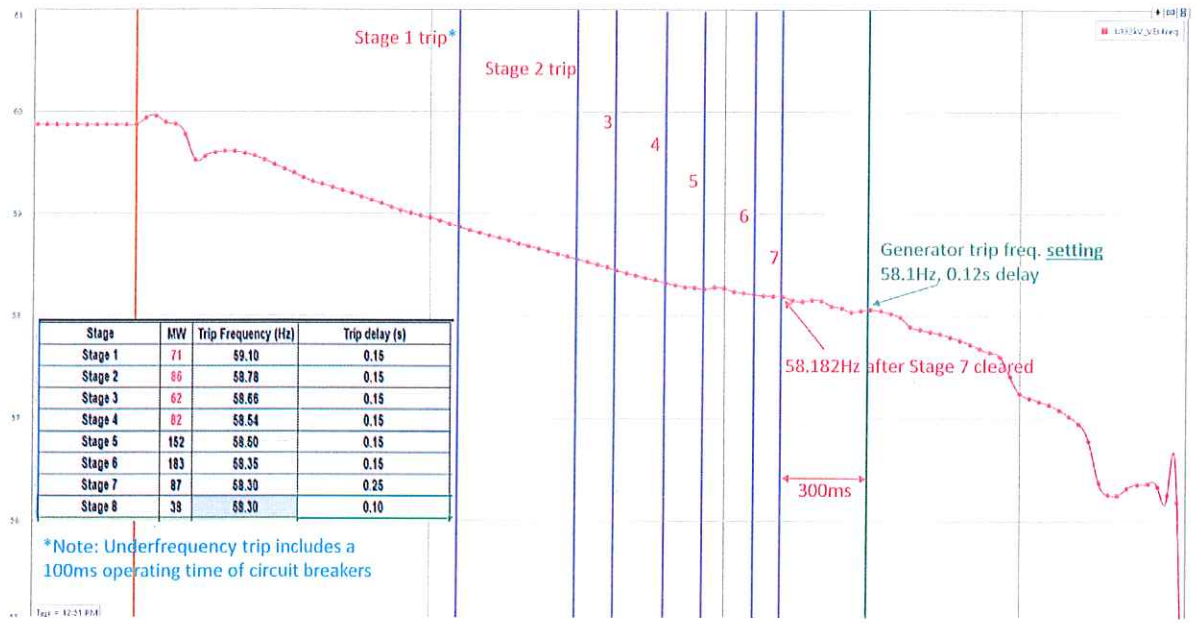


Figure 8: System power flow at fault time (top) and TGU power flow (below)

The large imbalance between available running (on the bars) generation supply (557 MW) and load (68.75 MW) resulted in a very rapid increase in generator speeds at TGU, as the essentially unloaded turbines accelerated. The data shows that the frequency increased very rapidly from 59.87 Hz to approximately 70.35 Hz (114%) in 570.3 milliseconds. The primary overspeed trip on the gas turbines are (Manufacturer) set at 110% (66 Hz) and a secondary trip at 112% (67.2 Hz) to protect the machine from physical damage from rotating too fast. Thus, the TGU turbines tripped on overspeed protection, disconnecting all the generators at TGU from the transmission network. On the northern section of the electricity grid, there was a large imbalance between available running (on the bars) generation (736.7 MW) and load (1196.5 MW). This resulted in a 459.8 MW deficit that manifested as a very rapid reduction of generators' speeds and system frequency. As intended, the automated underfrequency load shedding scheme, shown in Figure 9, was initiated to attempt to rectify the imbalance.



Stage	MW	Trip Frequency (Hz)	Trip delay (s)
Stage 1	71	59.10	0.15
Stage 2	86	58.78	0.15
Stage 3	62	58.66	0.15
Stage 4	82	58.54	0.15
Stage 5	152	58.60	0.15
Stage 6	183	58.35	0.15
Stage 7	87	58.30	0.25
Stage 8	38	58.30	0.10

Figure 9: Underfrequency load shedding scheme

Whilst the total load shed in the time window by this automated scheme was insufficient to rectify the imbalance, there was a more critical issue in that the rate at which the frequency was decaying, was too fast for the system's circuit breakers to physically respond to remove loads from the network to match the available generation. The time taken for the load shed scheme to fully operate, allowed the frequency to fall to a point where all the Point Lisas and Penal generators tripped on underfrequency protection. As more generation was lost the frequency fell even faster, creating a cascading domino effect. The end result of which was that all the generating facilities in Trinidad tripped *within 3.6 s* of the initial fault.

As designed, the Tobago grid was isolated (islanded) from Trinidad within 0.5 s of the detection of the fault. Tobago, therefore, was left unscathed.

c. *Determination of what, if any measures could have been taken to mitigate the impact of these fault(s) on TGU's generating capacity;*

The implementation of a new suitably rated double circuit 220 kV line from Union to Brechin Castle using another geographical path would provide the redundancy required to mitigate this event. Simulation studies performed, confirm that this event would not have led to a cascading islandwide outage with this additional 220 kV double circuit installed. This recommendation is the primary change needed to ensure that all power from TGU shall still be available for export on the T&TEC system for a loss of the existing U-G double circuit.

Given that the time elapsed from normal operation to blackout was approximately 3.6 s, there was no possible human intervention that could have changed the sequence of events. Any underfrequency load shedding scheme would not have averted the power system collapse, due to the very high rate of frequency decay.

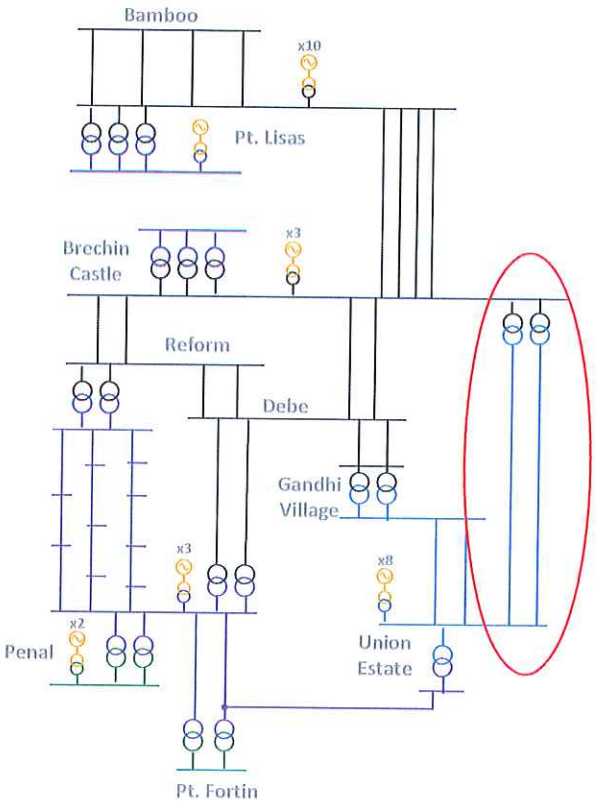


Figure 10: Additional 220 kV circuit to be added (circled in red)

However, had one or more of the TGU units transitioned to a FSNL condition (when the power plant was disconnected from the transmission system but still supplying its internal auxiliary loads), in the event of this sudden loss of load, system restoration would have theoretically been much faster. Such a transition would have ensured that the TGU facility would not have shut down completely and hence black-start capability would not have been required. The implementation and testing of a full load rejection scheme, at all power plants, would provide this capability.

Additional mitigating measures for consideration include:

- Converting the remaining ten (10) 12 kV circuit crossings of the 220 kV lines to underground cables.
- Perform a risk assessment of any circuit crossings on the sub-transmission 132 kV and 66 kV networks.
- Conduct a review of periphery of rights-of-way for such critical transmission circuits to refine vegetation management procedures to identify adjacent risks.

d. *Determination of what, if any measures could have been taken to mitigate the loss of TGU's generating capacity and the loss of generating capacity at the other IPPs;*

In a stable power system, the generating capacity must be able to supply the demand or load. A significant mismatch in this relationship can cause the cascading effect seen in this incident. The sudden loss of the two (2) main power exporting arteries (transmission lines) from TGU would have resulted in units at TGU reacting to an overspeed condition and disconnecting from the transmission system. This led to the national power system losing TGU's generating contribution to the system demand. However, as noted above, had one or more of the TGU units transitioned to a FSNL condition in the event of this sudden loss of load, this transition would have led to a shorter duration to full power system restoration and should be explored.

In order to prevent a total blackout condition and maintain electricity supply to a portion of the national power system, a fast response power system islanding scheme is needed. This scheme severs the interconnected national transmission network into several independent generating islands. Each island will comprise a power plant with surrounding suitably sized electrical loads. Had such a power system islanding scheme been in existence and operational at that time, the under-speed and under-frequency conditions experienced by the other IPPs may have been avoided. System restoration would then be a matter of synchronizing and reconnecting these separate islands back into the complete national grid. Further investigative analysis which will include a fast-acting load rejection scheme and the cooperation of both the Utility and IPPs, is required to determine the final configurations of such an islanding scheme. Figure 11 shows a suggested islanding segmentation that should be investigated for possible implementation in case of major generation failure in the future.

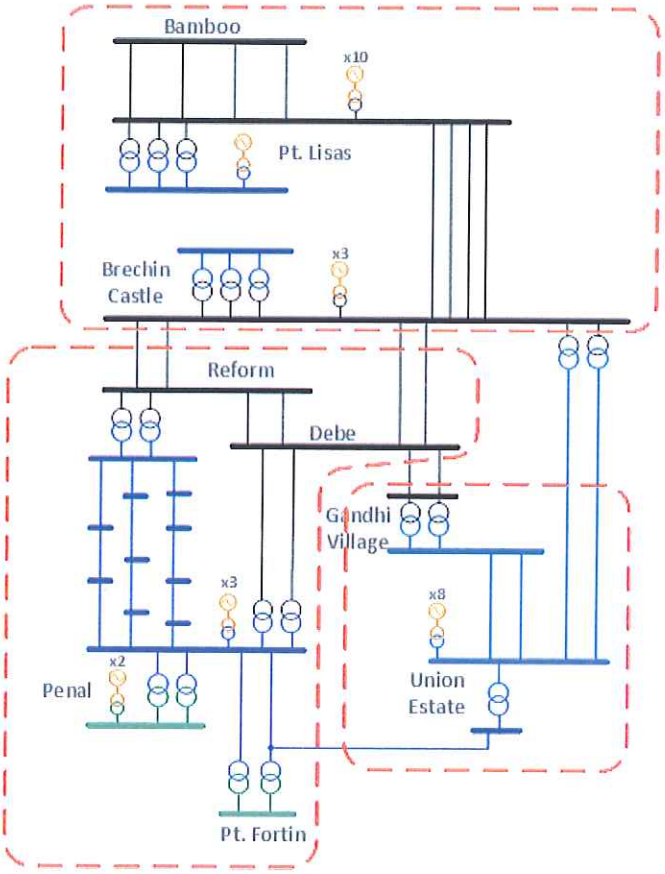


Figure 11: Suggested islanding segmentation for further technical investigation

"An islanding scheme is a defense mechanism for the power system in which a part of the system is islanded from a disturbed grid so that this subpart could survive in isolation from rest of grid and provide continuity of supply to the essential load in this area." (https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1747577)

In the absence of a second 220 kV line, an uninformed observer would suggest that the redistribution of power from the TGU facility to other IPPs would provide more security thereby resolving this issue. However, this is not an economically feasible option at this time due to the large penalty in scarce natural gas that would be incurred. The far superior efficiency (lowest heat rate available) of the TGU plant is critical in minimising local natural gas consumption for power generation and hence the maximum output of the TGU facility must be utilized.

e. *Examination of the methodology and approach utilized by TGU and all other IPP's in re-establishing electrical power supply on the island following the complete loss of generating capacity.*

The safe and timely re-establishment of power on the island following a total shutdown is a complex and critical task that involves close coordination between T&TEC and the IPPs. Special units that are capable of starting under these blackout conditions (black start units) must be kept in a state of readiness and tested frequently to ensure startup. The investigation solicited and reviewed the actual logs and recordings of the various parties and pieced together a sequence of events that was then analysed to determine what gaps existed. The investigative team also reviewed the recovery procedures from the IPPs and scrutinized all the documentation provided. As recovery requires a coordinated effort, an examination of the methodology employed must include all the IPPs with T&TEC as the coordinating entity.

In the event of a total power failure at any generating plant, the power station's first priority is to ensure that the previously online generating units come to zero speed safely and go onto turning gear without any damage. These large gas turbines can take between twenty to thirty minutes to get to rest after tripping. Failure to go onto turning gear could cause the hot turbine shafts to bow and cause problems as well as delays on restart. The next priority is to ensure that generating station's internal power is restored to provide an electrical supply to station auxiliaries in preparation for full station restoration. This is done by starting the black start units according to written procedures. Finally, once the station power is restored and generating units are available for dispatch, power system restoration under the control and direction of T&TEC can then proceed.

There is a need for a clearly articulated and closely coordinated power system restoration procedure as evidenced by the following observations gleaned from the supplied documentation (and audio recordings during the said failure) on the restoration process:

- Generator breakers were tripped instead of the line breakers. Tripping line breakers would have kept the generators operating at FSNL.
- Audio recordings advising the use of power system recovery procedures that were deemed unsuccessful when they were used before at other generation facilities during the outage.
- Many "low" battery alarms indicative that the ability to remotely switch circuits would be lost.
- Unorthodox network reconfiguration operations for executing the system restoration procedures.

3.1.2 IPP Approach

At the time of the outage, three of the four power stations in Trinidad had available black-start capability. TPL had previously declared the unavailability of their black start units which T&TEC was aware of a priori.

Within one (1) hour of the outage, all three generation stations, following their procedures, attempted starting their black start units. However, problems with the units at both Penal and Point Lisas led to the units tripping again and returning offline. TGU was able to bring one of their units online and started supplying power to the electricity grid, but this unit tripped due to misjudgement in the restoration operations on the power system.

What followed in the hours after were a series of problems that led to multiple failed attempts at each of the IPPs that showcased the lack of in-depth technical knowledge of the behaviour of the units under these abnormal conditions which in turn led to the significant delays in a successful restoration of the power system. Power was eventually restored at 6:50 pm to Penal and from there the rest of the power system was re-energized.

Thus, while each of the facilities had documented procedures for black-start testing which were followed, these procedures did not address the abnormal situations that arose when the entire power system was dead and what should be done in situations such as this. In one case, the documentation provided from one generating facility was last revised in 2011, two years before the 2013 outage.

This delay and associated challenges were consistent with the findings of the T&TEC Report on the Extreme System Disruption of Friday 29th March 2013. This meant that lessons were not learnt for that event.

3.1.3 Utility Approach

Given the various permutations of emergency situations possible, and the situational pressure that operating personnel would experience, it is unfortunate that there was no documented power system restoration plan governing the sequencing of procedure(s) to be followed, after a total loss of power in the

island. Thus, personnel were forced to think through restoration sequencing on the fly and several lessons had to be learned whilst in the process of restoration. In addition, a lack of a clearly documented procedure left personnel open to multiple competing scenarios with no single trained and competent person coordinating the recovery. There also seemed to be a lack of knowledge and understanding of power system operation under these abnormal conditions, which led to significant delays in the execution of the restoration. This included an urgency to re-energise the transmission system too quickly at the expense of station availability and reliability, resulting in an online generator's protective system operating because of high magnetizing inrush currents to connected transformers and forcing the unit back out leading to a restarting of the entire restoration sequence. The mitigation of unavailable black start of units can also be achieved by the immediate deployment of the T&TEC 1 MVA mobile substations to those power generating facilities. T&TEC should consider revising/renegotiating the procedures and penalties in the existing PPAs for extended unavailability periods of black start units.

4 INVESTIGATION OF T&TEC'S T&D NETWORK

2. *Investigation of the current design/configuration/installation of T&TEC's electrical transmission and distribution system to determine whether there are systemic design/installation features which make it vulnerable to a repeat of a similar event, whether by accident, natural or man-made causes.*

4.1 REVIEW & FINDINGS

Software analyses have identified several modifications that can be made to increase the resilience of the grid. The primary change to be implemented as a matter of urgency was identified before and was displayed in Figure 10. It is proposed that a new 220 kV double circuit line connecting Union directly to Brechin Castle would have mitigated the effects of the failure of the U-G 220 kV lines. This was proven to be effective via detailed software power system stability simulation analysis done subsequent to this failure. The analysis showed that from the fault start time (FS) of 4 cycles mark to 900 cycles, although no load tripping was done, the generators on the power system all remain connected albeit with a larger load angle. This is graphically illustrated in Figure 12 and Figure 13. The results indicated that the power system will remain in synchronism for fault clearing (FC) times from 5 cycles (83 ms), typical of T&TEC's transmission circuit FC times; through 30 cycles (0.5 s), which would be typical of a Zone 1/Zone 2 distance protection clearance. The simulation was executed to 900 cycles (15 s), which is much longer than any plausibly likely FC time and still showed that even in the very unlikely event that the FC time went to 15 s, all the generators in the power system remained in synchronism, proving beyond a doubt that with the new lines, the T&TEC electricity grid would have been remained intact without the loss of any generators.

In addition to the above, the ten-remaining "*underbuilts*" (one was redone subsequent to the fault) line crossings of the 220 kV U-G lines should be reviewed to ensure this "black-swan" event does not occur again at any of these crossings. Armed with the knowledge of this event, all line crossings on the 132 kV and 66 kV transmission network should also be reviewed for the possibility of a similar event occurring at each location.

There should also be a comprehensive review of the T&TEC transmission grid with the aim of increasing its resilience with particular reference to the possible addition of the following circuits, if feasible:

- An additional 66 kV circuit from TGU to the SW ring. This will increase power flow through the "*backdoor*".

- Another double circuit line from Brechin Castle to Gateway using another geographical path. This would provide an additional path for power to the Port of Spain area. Of course, a new power plant located in the North would remove this issue.

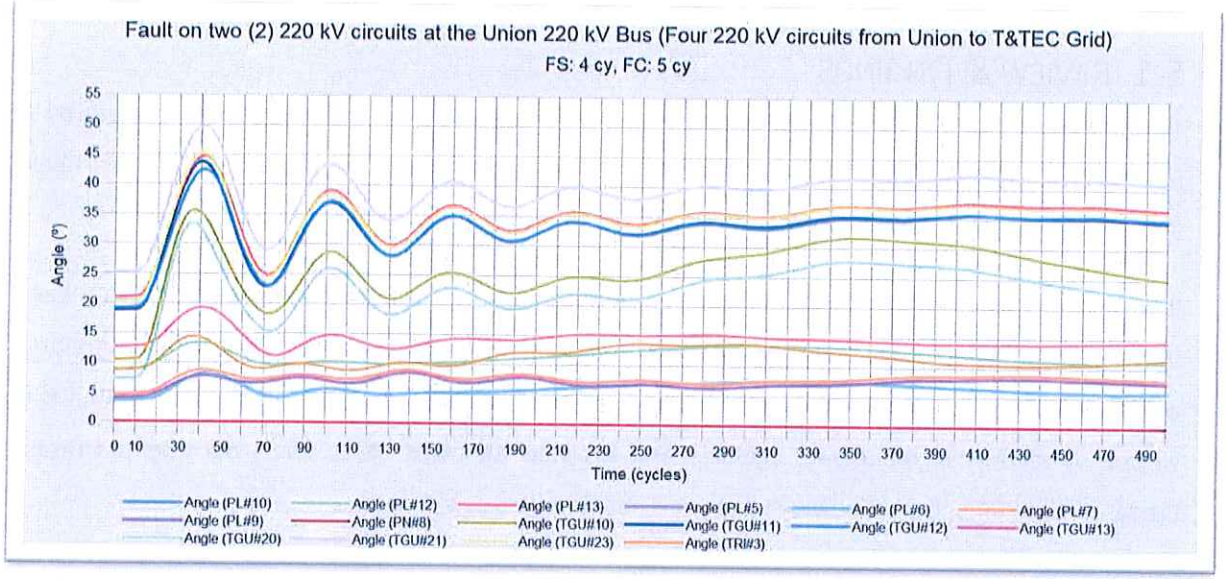


Figure 12: Fault on for 5 cycles (83 ms)

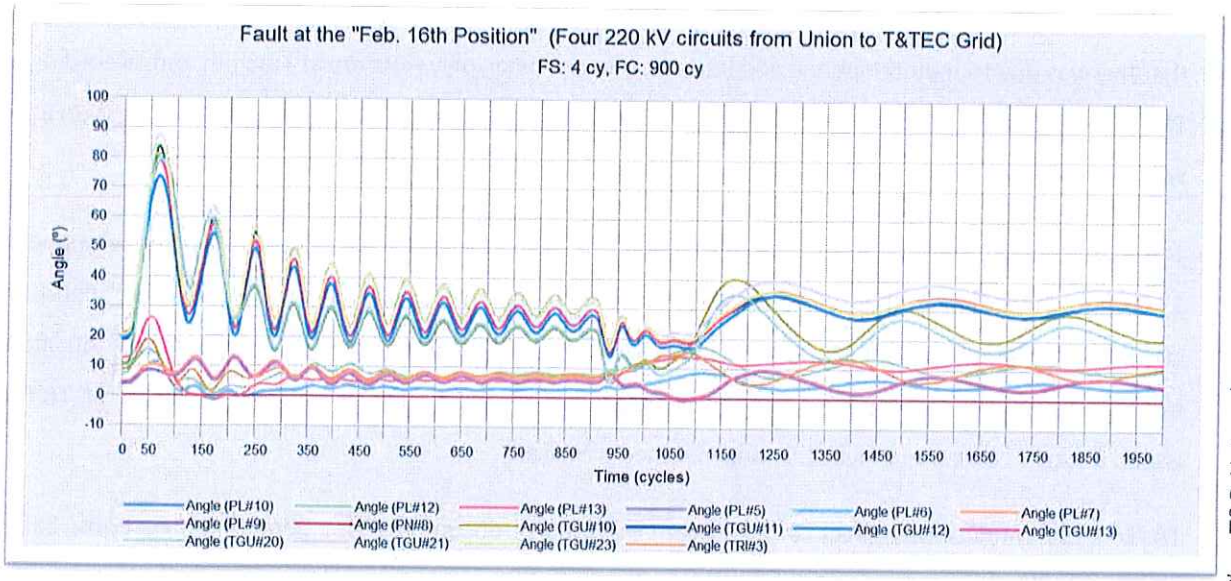


Figure 13: Fault on for 900 cycles (15 s)

5 Assessment of Communications

3. *Examination of the effectiveness and appropriateness of the communication by T&TEC, ODPM and any other state agency responsible for communication in the situation, on the nature of the problem and on the progress being made to restore electrical power to the national population.*

5.1 Review & Findings

The responses (or lack thereof due to tardy notification by T&TEC of the total power failure) by the protective services and other relevant agencies, in particular the ODPM, are detailed in this report below in section National Security Response.

It was clearly discerned from the reports given by these agencies referred to above, that there was no formally documented policy that dictated which organisation should have taken control of this important aspect of information dissemination and public awareness existed. Indeed, an islandwide blackout is not viewed by security or emergency agencies as a disaster. Although T&TEC has a documented Disaster Preparedness Manual, a nationwide blackout is not identified as a disaster.

T&TEC, being the organisation with responsibility to pronounce on the nature of the failure and the anticipated time for restoration, issued its first post via Facebook advising of a disturbance on the system at 1:31 pm some 39 minutes after the blackout had occurred. T&TEC Public Relations, Port of Spain, advised that this was due to their telephone and internet services being only restored at 1:25 pm and, according to T&TEC, no alternative medium was available at the time of the system failure. This begs the question as to why was cell phone communication not used?

Thereafter, intermittent updates were given, again via Facebook and WhatsApp, culminating with one at 11:07 pm which advised that full restoration would be completed by 1:00 am on Thursday 17th February 2022. Apart from the advisories referred to above, it should be noted that the TTPS received notification from T&TEC at 2:08 pm through a phone call by the commission's Chief Operations Officer. In all, T&TEC issued a total of 12 communiques through 24 media houses.

T&TEC's communications policy is dictated through three documents viz., General Instructions, Social Media Handbook and Disaster Preparedness Manual. These are appended herein as Appendix 3 – Communications Documentation. By and large, the procedures followed for this event was in conformance with The Commission's documented requirements. However, the effectiveness of the communication was severely impaired by the fact that the country was without electricity which inhibited access to radio and

television broadcasts and that a relatively small percentage of the population during the event would have access to internet services. Moreover, none of these documents specifically addresses the communication requirements for islandwide blackouts. The existing policy has worked well for The Commission regarding matters of outages due to planned maintenance, weather disturbances and discrete localised failures due to equipment malfunction. The policy did not contemplate an islandwide blackout.

Trinidad's well recognised "*peoplegram*" may have mitigated the impacts referred to earlier, even if distorted and/or exaggerated, but this ought not to be a significant factor to be depended on when dealing with a clear and unequivocal process for responsible dissemination of crucial information.

Security, industry, businesses, traffic, utilities, healthcare and households all depend to greater or lesser degrees on electricity for successful operations. It is therefore imperative that pertinent information regarding loss of supply, the cause and nature of the loss and the anticipated time for restoration of supply is disseminated in an appropriate and timely manner. This will facilitate customers to modify or refocus their operations depending on the data received.

Telecommunication, a vital mode for information transfer was impacted by the blackout.

Digicel for example, in its response to the effect of the blackout on operations, indicated that during a period of one hour, 150 of their sites were impacted after consumption of battery stored power. Contractors were engaged to deploy generators to strategic sites but again, uncoordinated and timely access to data on the progress of restoration resulted in power being restored in these areas shortly after the installation of the mobile generators. This is but one example of how timely receipt of status reports could assist operators in better managing their operations.

TSTT similarly, also suffered impaired services as although their system is designed with redundancy in battery and generator backup power, the long duration of the outage exceeded the battery capability. Quoting from their report "*that even for generator backup sites where the Network equipment and services remained operational, customers could not benefit from the availability of service as the commercial failure resulted in loss of power in both their residences and businesses which rendered the respective equipment necessary for communications inoperable*". For their mobile users, service remained operational "*once they were with a Wireless Network site with Generator or Battery backup*". The responses from TSTT and Digicel to the Committee are attached as Appendix 3 – Communications Documentation.

In recognition of the complex and varied circumstances that could impact various organisations and operators that depend on electricity, the Committee recommends that the lead agency for information coordination and dissemination should be the OPDM. T&TEC will of course be the source of the information but matters such as the order in which information is issued having regard to security risks, the most effective platform to reach the maximum number of stakeholders would be better handled by the ODPM as expertise, applicable technology, know-how and practice reside in this organisation.

6 National Security Response

4. *Examination of the national security response to the event of February 16th, 2022 to determine the following:-*
    a. *The country's state of preparedness in response to the incident that occurred; and*
    b. *The country's vulnerability to a repeat occurrence, given the current design/configuration/installation of T&TEC's electrical transmission and distribution system and the current capability of the IPP's to respond quickly and efficiently in a similar situation in the future.*
    c. *The nature of the response by the protective services, national security agencies and other relevant agencies, such as the Office for Disaster Preparedness and Management, to the power outage.*

6.1 Review & Findings

6.1.1 Methodology

In achieving its mandate in respect of the national security response, the Committee undertook an Evaluation of the Country's State of Preparedness; a Threat Assessment of the Generation, Transmission and Distribution of Electricity in Trinidad and Tobago; Vulnerability Assessments of the IPPs; an Evaluation of the Responses of the Protective Services and other relevant agencies; Fall-out effects on other critical institutions; an Analysis of Communication Protocols; and Stakeholder Engagement.

6.1.2 Timeline of Events

At 10:30 am on Wednesday 16th February 2022, the TTMS issued a national yellow alert of high winds for Trinidad *(see Appendix 4. ii)*. At 12:52 pm the said day, a *Roystonea Oleracea*, commonly called a Palmiste Palm, measuring fifty-eight feet six inches (58" 6'), fell and brushed a T&TEC distribution line located between LP 69 and LP 71 Grant Trace Extension, Rousillac causing a *"whipping motion"* that resulted in the upward reversal of the natural sag on the line. See Figure 5 and Figure 14.

Figure 14: Fallen Palmiste tree (Roystonea Oleracea) at Grant Trace Extension, Rousillac

The resultant wave on the distribution line, came into contact with the blue phases of the overhead TGU 220 kV transmission line causing both circuits to trip.

The situation immediately manifested on T&TEC's SCADA system as the initial fault, which led to TGU being unable to transmit power onto the islandwide electrical grid. Consequently, the other IPPs were unable to carry the generation load which led to a domino effect of generation power plants going offline. T&TEC immediately dispatched crews to ascertain the problem, at 1:01 pm the said day. T&TEC control at around the same time asked the IPPs to prepare themselves to go online which led to a series of generation startup related issues causing a prolonged period of blackout conditions and a resultant cascading domino effect which affected the country's national security, telecommunications, water distribution, traffic grid and other related health, manufacturing, and transportation apparatus. A detailed timeline of events is attached in *Appendix 4 i.*

The Committee re-visited the site of the initial fault at Grant Trace Extension, Rousillac with Mr. Jason Mungalsingh, Forest Officer I attached to the Southwest Conservancy of the Forestry Division of the Ministry of Agriculture, Lands and Fisheries. Mr. Mungalsingh examined the fallen Palmiste Palm (*Roystonea Oleracea)* and determined that the tree (Figure 14 and Figure 15) *"showed signs of heavy rotting and fungal decay"*. He also concluded that *"there was no evidence of power saw markings or cutlass blazes to indicate felling by human intervention"* and deduced that *"given the height of the tree when it was standing and the heavy rotting at the base, it can be concluded that the tree fell due to natural occurrence" (see report at Appendix 4 iii).*

Figure 15: Photographs showing heavy rotting and fungal decay

6.1.3 Evaluation of the Country's State of Preparedness

The electrical grid of the ROTT comprises the CGTP Plant, located at Railway Road, Couva; the PowerGen Plant at Caspian Drive, Point Lisas Industrial Estate; the PowerGen Plant at Syne Village, Penal; and the TGU Plant, situated at Lot #3A Union Industrial Estate, Vessigny Village, La Brea. These four (4) power generation plants supply electricity for the entire island of Trinidad, whilst Tobago receives power from the Cove Power Station situated at Lowlands, Tobago. The electrical power generated by these 4 plants, is transmitted along a grid which is controlled by T&TEC, routed through a series of sub-stations into a distribution network, where it is sent to its requisite customers. Both islands are connected electrically via a 10 MW undersea cable from Toco to Pigeon Point.

In evaluating the country's state of preparedness for the blackout event which occurred on Wednesday 16th February 2022, the Committee first examined the initial fault to determine if same was a result of any criminal, subversive or industrial action; the likelihood of a recurrence; the response of the entities involved in the generation, transmission and distribution of electrical power during the event; the response of the security services; the effects on telecommunications and utilities; and existing response procedures to similar critical incidents.

6.1.4 Criminal

After analysing all the facts such surrounding the islandwide blackout which occurred on Wednesday 16th February 2022, the Committee determined that there was no evidence that the event was criminal in nature or was a result of deliberate sabotage or malicious damage to any of the plant, equipment or machinery involved in the generation, transmission, or distribution of electricity in Trinidad and Tobago. Statements were recorded from Aneel Ramharrack of #258 Grant's Road Extension, Rousillac *(see copy at Appendix 4 iv)* and Vera Bhola of LP #69 Grant's Road Extension, Rousillac *(see copy at Appendix 4 v)* which do not suggest that any criminal or subversive act was responsible for the event.

The entire security apparatus of the IPPs, their plants and the T&TEC transmission and distribution grid were examined and found to be well protected utilising regular security patrols; aerial assessment of transmission lines and installations by the Transmission Maintenance Department utilising DJI Matrice 210 drones; CCTV systems at all power stations, sub-stations and critical infrastructure which are monitored 24/7; intrusion alert technology; stringent security entry protocols at all power plants; as well as the SCADA system which triggers an immediate notification relative to loss of power anywhere on the grid so that the

requisite crews can be dispatched and remedial action taken. At no time was neither any intrusion detected nor was there any breach of the security apparatus of T&TEC or any of the IPPs.

The TTPS indicated that there was no information to suggest that the cause of the blackout was deliberate, criminal in nature or done to facilitate criminal activity; however, the crimes which occurred during the event were said to be opportunistic as persons utilised the event to carry out criminal acts.

6.1.5 SUBVERSIVE

The Committee did not receive any evidence or information which suggests that the blackout was an act of terrorism, subterfuge or perpetrated to deliberately create mayhem and panic among the citizenry. Reports obtained from the major arms of national security indicated that there was no evidence, intelligence, or data to suggest that same was linked to any subversive intention or fell under any action which can be classified as *"terrorist act"* under Section 2 of the Anti-Terrorism Act Chapter 12:07.

6.1.6 INDUSTRIAL

An analysis of the current industrial environment suggests that it is in a precarious position that engenders rumour mongering, as salary negotiations for several trade unions have been frozen since 2014, with the outstanding periods for 2015 to 2017; 2018 to 2020 and the current 2021 to 2023 seemly heading along a similar path. Added to the stalled bargaining processes, was the December 18th 2021 announcement by the Government that all its workplaces would be designated as *safe zones* and that only vaccinated employees would be allowed to enter. This announcement brought an immediate response from the Trade Unions, social activists, and anti-vaccination movement. The safe zone designation was scheduled to take effect on Monday 17th January 2022 but the deadline was postponed to Thursday 17th February 2022. Owing to the blackout occurring on Wednesday 16th February 2022, uncontrolled rumours began circulating that the cause was directly linked to the Government's vaccine mandate and deadline.

The Committee also engaged the OWTU, which is the recognised bargaining body for workers employed with T&TEC and PowerGen, to discuss matters as it related to the blackout and the current industrial climate as the union was a key stakeholder in the industry. The OWTU dispelled rumours that its members were involved in the blackout event; reiterated its earlier statements in the media and commended employees of both companies for going above and beyond in the performance of their functions on that day. The details of this stakeholder engagement are contained in the section entitled Stakeholder Engagement.

6.1.7 Accidental

The Committee acknowledges that there were no reported accidents which could be linked to this event. Investigations were undertaken at each of the IPPs and T&TEC, which concluded that there were no accidents which occurred on that day. Further, each of the IPPs and T&TEC utilise a SCADA control system interface for high-level supervision of machines and processes. These interfaces collect real-time data from all the remote stations and sub-stations; as well as immediately detect and trigger visual and audible alarms at each of the control rooms if there is any intrusion; loss of power or electrical problems on the system and displays them in the control room.

6.1.8 Equipment Malfunction

The Committee undertook an evaluation of the plant, equipment and machinery involved in the generation, transmission, and distribution of electricity throughout the island and it was discovered that there was no equipment malfunction which caused the blackout event of February 16th 2022. However, the IPPs all reported various problems with their restart process following the power outage. These ranged from tripping of electrical fuses; the automatic engagement of equipment failsafe protections; problems with and in one instance, the non-availability of, a black-start generator. In the latter instance, the lone black-start generator at CGTP was reported as being offline since Wednesday 22nd December 2021 as it was undergoing repairs; however, same was reported to T&TEC daily as part of its reporting procedures.

With respect to the IPPs, the Committee found that the PowerGen plants in Point Lisas and Penal were over forty (40) years old; CGTP has been operating for over twenty (20) years, and TGU was commissioned about thirteen (13) years ago. Despite the ages of these plants, the machinery and equipment are well maintained via robust in-house maintenance schedules and the intervention of manufacturer upgrades and improvements to various facets of plant operations and key machinery. It is noteworthy that all scheduled plant and machinery maintenance were done through strict coordination with T&TEC to ensure that adequate power is still supplied to the grid whilst any equipment is taken offline.

6.1.9 Acts of God

According to (Lauta 2014, 112) an Act of God, also referred to as a force majeure, is defined as "*a providential occurrence or extraordinary manifestation of the forces of nature which could not have been foreseen and the effect thereof avoided by the exercise of reasonable prudence, diligence and care, or by the use of those means which the situation renders reasonable to employ*". It is also referred to as "*an unusual, sudden and unexpected manifestation of the forces of nature which man cannot resist*". Within the

scope of this investigation, the Committee finds that the initial fault which caused the blackout event can only be classified under this heading and as such falls within the realm of *"Actus Dei Nemini Facit Injuriam"* (An Act of God Does No Injury to Anyone) as no person, entity or organisation can be held accountable for it.

However, even though culpability for the event cannot be ascribed to any person, entity or organisation, there are several mitigating circumstances which resulted in the over 12-hour delay in T&TEC being able to restore full electricity to the island as well as an unacceptable lack of communication to the general public.

6.1.10 Likelihood of a Recurrence

The chances of a recurrence of such an event by virtue of the same method is *extremely low* as all eleven (11) underpasses where 220 kV transmission lines crosses over lower voltage lines along the TGU to Gandhi Village sub-station were checked and found to be within the internationally recommended specifications of 1.88 m. Additionally, The Commission maintains a robust line clearing regime for trees and undergrowth via its Line Clearing Crews located in each of T&TEC's five (5) Distribution Areas as well as thirty-six (36) Contractors who are on the commission's pre-qualification listing. The line which is located at Grant Trace Extension, Rousillac is contracted to Laing Contractors and at the time of the incident, the vegetation was cleared in accordance with T&TEC's thirty (30) m requirement. Following the blackout, T&TEC moved the faulted section underground and rechecked the clearances and positions of the other 10, 220 kV circuit crossings.

The likelihood of such a blackout recurring by virtue of any of the other mentioned causes in this section *(criminal, subversive, industrial, accidental, equipment malfunction or act of God)* have all been listed as *low probability* based on the Threat Analysis and Vulnerability Assessment undertaken by the Special Branch of the TTPS *(Report SB/TA/20220324 refers)*.

The Committee also examined the Technical and Operational processes and determined that the likelihood of a recurrence is also *low*. The robust maintenance of plant and equipment, vigorous work processes and monitoring of the generation, transmission and distribution network, act as buffers to mitigate against such risks. T&TEC and the IPPs also possess the human resources, with the requisite skillsets and experience, to analyse problems within the system and respond with timely interventions.

The Risk Mitigation Strategies; Critical Incident Response, and Business Continuity Plans of T&TEC, TGU, PowerGen and CGTP were all examined and found to be within industry standards and guidelines. However,

despite being organisations involved in the generation, transmission, and distribution of electricity, none of the aforesaid companies factored *"power outages"* as a critical incident of concern. Nonetheless, the emergency response procedures and business continuity processes were found to be within international specifications and best practices.

In examining T&TEC's Business Continuity Model, the Committee found it to be suitable for the scope and magnitude of its operations, and its strategy of maintaining offsite backup and redundancy systems would bolster well for business continuity in the event of a critical incident. The Business Continuity Model at PowerGen was also examined and found to be suitable for the scope and magnitude of its operations; however, since the company operates two (2) Power Plants under the same hierarchal management structure, with variances at the plant management level, it was felt that there should have been a greater integration between the two plants, more so with respect to backup and operational redundancy *(Report SB/TA/20220324 refers)*.

The CGTP and TGU Plants are both standalone plants with no other branches. Their Business Continuity Models were examined and found to be suitable for their scope and magnitude of operations. The current structure of the nation's electrical grid utilises an average of 1100 MW per day and goes as high as 1250 MW during peak usage times. Before the incident, TGU was providing a daily average of 650 MW (52%); PowerGen Penal was providing 200 MW (16%), CGTP was providing 75 MW (6%) and PowerGen Point Lisas was providing 300 MW (24%).

Based on their individual Critical Incident Response Plans, each of the entities involved in the generation, transmission, and distribution of electrical power during the event responded accordingly during the event; Incident Commanders took control of their respective areas of concern and after analysis, commenced both internal and external communication protocols to restart operations. However, the prolonged delay in the restart of electricity was not as a result of any issues with regard to this section of the analysis, but rather was dealt with in the Sections of this report entitled *Investigation of the Events on Wednesday 16th February* 2022 and *Investigation of T&TEC's T&D Network*.

The response of the security services to the blackout event varied from excellent to dismal. With the initial loss of power, the TTPS reacted immediately by dispatching personnel to undertake traffic control functions at the major intersections and increased visibility within key areas throughout the island as a strategic deterrent method. The TTPS was ably assisted in this regard by Joint Army Police (JAP) patrols, as well as patrols from the Transit and Municipal Police Departments. The use of Air Support and Riverine Patrol units

also assisted in additional patrols and law enforcement visibility. The TTDF did not deploy any extra patrols; SSA's response was centred on in-house protection and their business continuity model, whilst the ODPM merely regurgitated updates from T&TEC whom they labelled as the *"sector lead"*. A detailed account of the security services response is covered in the Section entitled *Evaluation of the Responses of the Protective Services and Other Relevant Agencies* of this document.

6.1.11 Threat Assessment of the Generation, Transmission and Distribution of Electricity in Trinidad and Tobago

6.1.11.1 Investigative Process

The Committee utilised interviews; site visits; witness statements; document analysis; stakeholder reports; as well as current and historical data for comparative analysis to assess the facts surrounding the islandwide loss of power which occurred on Wednesday 16th February 2022. The Committee also examined all the circumstances surrounding the event to determine if the blackout was as a result of any criminal, subversive, or industrial action; an accident, equipment malfunction, inept operations or caused by an act of God.

A. State of Preparedness:

The Committee examined the communication strategies utilised by all the stakeholders to inform the public about the event and the resultant updates. Communication of the event was basically done via T&TEC using regular updates on its Facebook page. There were no official alerts, public statements, or media releases from the ODPM, NOC or other arms of the national security apparatus, save and except for the regurgitation of T&TEC updates via their respective Facebook pages. The first public interview occurred when the Honourable Minister of Public Utilities Marvin Gonzales and T&TEC's General Manager Kelvin Ramsook appeared on the CNC 3 News programme at 7:00 pm. However, at that time most of Trinidad was still without electricity and thus were unable to view television.

The medium of alerting the public about such an event should have utilised a NAS or EAS that included media alerts, social media, FM radio and telecommunication services. Checks within the various arms of the national security apparatus have revealed that no NAS or EAS was used. However, it was discovered that the TTPS had an ad hoc alert system which only utilised its TTPS mobile app and Facebook page to send out alerts to the public. However, this is *"NOT a National Alert, but a coded system to assist the TTPS in the performance of its duties"* (TTPS Media Release dated Thursday 14th February 2019 – *see Appendix xvi*). This system, though well intentioned, was one which merely operated in a silo and as such was

ineffective outside of the TTPS internal mechanisms, thus a NAS or EAS would have been the most appropriate communication system for such an event. The reader should be reminded that most stakeholders would not have been able to access these alerts and they had all lost internet services.

The Committee discovered that in December 2013, the Government had approved a NAS for the country which was contained in the National Alert State, Public Warning and Information Policy *(see copy at Appendix 4 vi)* for the ROTT (Trinidad and Tobago Government News 2014). This system was geared towards alerting the relevant groups via a secured GAS and members of the public via the use of a PAS, media releases and broadcasts. The coordination of this system fell under the remit of the National Security Agency, which was restructured into the current NOC and now falls under the Director of the SSA. Elements of this system also fall under the purview of the ODPM.

Despite the existence of a National Alert State Policy which outlines five (5) key policy objectives; lists specific roles and responsibilities for particular agencies; mandates that the said policy be monitored, evaluated and reviewed *"annually"*; as well as defining the various alert states and corresponding actions, the document does not contain clear directives and operational guidelines, nor does it refer to any such document, to direct how the various elements involved should engage in the realm of communication. This document appears to be strategic in nature, and from all apparent indicators, was possibly shelved and never utilised during the blackout event, thus leaving the public literally and figuratively, *"in the dark"*. The Committee later discovered that the Public Warning and Information Policy *(see Appendix 4 vi)* document was currently being reviewed by the ODPM but none of the relevant agencies provided information as to its implementation, historical use, as well as if and how, it was utilised during the blackout event.

The NOFC was contacted via letter dated Monday 7th March 2022 relative to the existence of the National Alert State Policy, its use for such events and the reasons why same was not utilised during the event to which the Committee received a response from that organisation Ref: NOFC 01/2022 dated Thursday 24th March 2022, which merely stated that *"the NOFC is housed within the SSA and as such shares the same resources inter alia"*. Further, the correspondence indicated that *"there is no additional information that can be added based on the response already provided by the SSA"*.

The Committee notes the vague responses given by the SSA and NOFC with regards to the specific information that was requested, as both organisations appear to be hiding behind a cloak of secrecy and national security confidentiality, to avoid scrutiny of their actions or inactions, as it related to the blackout event. Despite confirmation from the SSA *(Appendix 4 ix)* that it is charged with the responsibility of

"operational coordination" and is outfitted with equipment and resources to provide *"operational support on a 24/7 basis 365 day a year"*, their response to the blackout was basically centered around *"monitoring the national landscape", "ensuring business continuity"* and *"protecting internal databases"*.

The Agency also noted its close working relationship with "relevant national authorities", including the ODPM, and boasted that the SSA "operates as a supporting Agency providing facilities, technical support, specialized equipment towards the coordination of a response and communication facilities for both operations and public awareness". No information was provided to the Committee as to what these organisations actually did during the blackout, save an except to batten down their hatches and await the passing of the storm, which has left the Committee perplexed as to why the SSA did not utilise its resources in the manner described above.

B. Vulnerability to a Repeat Occurrence:

The Committee discovered that there was an overall *"low probability"* that there can be a recurrence of an electrical blackout event in the ROTT. A national blackout can occur due to several factors, which include but are not limited to:

i. Low Gas Power Generation Failure *(Low Probability)* – This can result from low gas transmission to any or all of the IPPs due to equipment failure at the NGC or any related processes. This situation last occurred on Monday 21st December 2021 after the supply of natural gas to TGU was disrupted because of work being done by the NGC and prior to that on Thursday 28th March 2013, a nationwide blackout occurred which was caused by a problem with the gas supply from Phoenix Park Gas Processors Limited, Point Lisas.

ii. Adverse Weather *(Low Probability)* – The ROTT borders the Atlantic hurricane belt, where several adverse weather systems have affected the country. Records at TTMS and ODPM, indicate that since 1933, nine (9) major storms and hurricanes, have directly or indirectly affected the country. Historically, none of these weather systems have impacted the country's power generation capacity but landslides, falling trees and flying debris have reportedly affected the electricity distribution, and to a lesser extent transmission, in the ROTT.

iii. Earthquake *(Low Probability)* – The Committee engaged the UWI Seismic Research Centre to obtain a historical overview of seismic activity that affects the ROTT so that a proper vulnerability assessment could be made. The department Report Serial No: 202203_TRN_01 dated Tuesday 22nd March 2022 *(see Appendix 4 xiv)*, indicated that over the past ten (10) years, *"there were about*

4,500 earthquakes located in Trinidad and Tobago" of which four (4) were *"magnitude 6.0 and above"*, *"28 between magnitudes 5.0 and 5.9"* and *"267 in the magnitude range 4.0 – 4.9"*. The largest *"ever recorded in instrumental era"* was magnitude 6.9 which occurred on Tuesday 21st August 2018. This seismic event caused structural damage to numerous buildings and other infrastructure; however, none of the power generation plants or T&TEC's transmission or distribution network were negatively affected. This was due to the structural integrity and standards used in the design of the related infrastructure.

iv. Equipment Failure *(Low Probability)* – The plants and equipment associated with the country's electrical grid are constantly upgraded and serviced by T&TEC and the IPPs via a stringent servicing regime. The modernization of plant, equipment and machinery is an ongoing process which works in tandem a robust employee training and retraining programmes.

v. Terrorism *(Low Probability)* – There is no historical data or current intelligence emanating from the requisite national security agencies to suggest that there are any plans for a terrorist attack on the country's power grid. However, owning to the tactics observed in other countries where terrorist utilised IEDs to disrupt electrical power, transportation and communications, there is a possibility of *"copycats"* or lone wolf terrorists seeking to conduct similar operations locally.

vi. Criminal Sabotage *(Low Probability)* – The TTPS, TTDF and SSA, which are the major law enforcement entities within the national security apparatus with the responsibility for intelligence gathering, analysis and dissemination, reported to the Committee that there was no information to suggest that the event was a deliberate act of sabotage. However, the TTPS reported having on *"07.03.2022"*, received a report from the SSA via memorandum SSA 9/1 dated *"04.03.2022"* regarding a Special Report on Counter Terrorism & Radicalisation, regarding the Trinidad and Tobago Power Outage. This report indicated that *"unknown individuals"* had sabotaged the electrical grid through *"a deliberate act of obstruction, by unidentified employees of the T&TEC"*. The information was subsequently checked by the TTPS but could not be substantiated. This report is at variance with the documentation supplied to the Committee by the SSA and can only be viewed as an attempt to conceal the information from the Committee.

vii. Industrial Unrest *(Low Probability)* The Committee did not receive any information that sabotage has ever occurred as a result of industrial action. Traditionally, industrial situations have more so taken the form of placard protests and demonstrations, as representing unions negotiate for improved wages and terms of employment.

6.1.12 Vulnerability Assessments of T&TEC and the IPPs

T&TEC's transmission and distribution infrastructure network traverses the length and breadth of the twin island state. This network is susceptible to inherent risks, hazards, and threats to the various locations; sites; transmission and distribution overhead lines; switch houses; sub-stations; and underground cable installations. The IPP's generation sites are located at the Southern and Central areas. The undermentioned sectors are susceptible to inherent risks, hazards and threats to the various locations and sites; generation power lines linked to substations; and switch houses. A full Vulnerability Assessment of the assets involved in the generation, transmission, and distribution of electricity was undertaken and the report is attached at *Appendix 4 xvii.*

In order to support the nation's electrical grid, there must be an understanding of probable risks to assets within the electrical grid as an essential criterion for developing power sector resilience. It is important to assess both current and future threats, as well as the likelihood of these threats over time. The various threats can be highlighted into various categories as outlined in *Appendix4 xvii.* According to the Oxford Dictionary of Disaster Management, a disaster is defined as *"a sudden event with grave consequences, often used synonymously with catastrophe"* (Rubin and Dahlberg 2017). Disasters can either be natural or man-made but the basic precepts of disaster and crisis management must apply to both spheres. The relevant resources should be deployed in an effective manner and communication should be timely, applicable and must emanate from an official source to prevent rumours and speculation from spreading through grapevine communication and uncontrolled viral social media.

In order to attain the efficacy of sound security policies, procedures and practices at the various establishments involved in power generation, transmission or distribution, a Security Risk Management approach is required which will coordinate, operationalise, identify, assess, mitigate and monitor what has to be protected. Security related risks to physical assets and Human Resources can emanate from external and internal threats, and as such it is recommended that the most efficient *before-the-loss* arrangement be adopted to accommodate the *after-the-loss* business continuity.

The physical assets of T&TEC and the IPPs are satisfactorily maintained and secured but are exposed to the risk of *"opportunities of larceny"* owing to gaps identified in Report *SB/TA/20220324*. Access Control measures at the aforementioned facilities are vital to address existing gaps which exist as a result of design, age of the infrastructure, and routine operations *(Appendix 4 xvii)*.

Training and sensitisation of Estate Police Officers and contracted security services are critical to risk mitigation. On observation, contracted security officers at various facilities appeared to be dedicated to their jobs and performed their tasks as directed by management; however, in the absence of documented security policies, perceived operational procedures can result in errors in judgement and procedures. These inconsistencies tend to occur during responses to emergencies, which can pose an inherent risk to both capital assets and human resources.

Internal controls are also necessary to monitor physical security assets across the various facilities and establishments, to ensure that mitigation strategies remain effective in addressing the current physical security requirements and inherent identified risks. The gaps identified were shared with the various facilities' representatives after each site visit and these included the development of security plans; Critical Asset Registers; Risk and Vulnerability Assessments to evaluate susceptibility and resilience to hazards and determine adequate safeguards; Risk Treatment Methodology, Counter-Terrorism Techniques and other security, threat and risk mitigation recommendations, the details of which are outlined in Report *SB/TA/20220324*. These facilities form part of the critical infrastructure in Trinidad and Tobago and as such, every necessary action should be taken to mitigate threats or attacks against personnel, plant, equipment, or machinery.

The vicarious responsibility of the protection of critical assets involved in the country's electrical grid, fall upon the leadership of the various companies at the board and senior management levels, and as such, the burden of responsibility to the ROTT is overarching. In most cases, the protection of these critical assets has been contracted to private security firms but apart from fulfilling the various contractual obligations and general supervision, the management of T&TEC and the IPPs do not have any direct control over the hiring practices, qualifications, recruitment requirements, training, vetting and background checks of these private security officers and rely solely on the discretion of the security contractors. In the case of T&TEC, which maintains an in-house Estate Police Department, it is recommended that this unit assumes full control of the security of its assets, whilst the IPPs adopt the recommended mitigation and internal controls contained in Report *SB/TA/20220324*.

One of the vulnerabilities identified during the Committee's assessment of T&TEC's Security Department is that it is critically understaffed to effectively perform its current functions. The unit has a sanctioned strength of 310 officers but at present fuctions with only 243 members of staff which prevents the section from having a dedicated RRU for the East-West corridor, and the RRU Unit – South is currently being run with an acute staff shortage and thus incurring significant overtime costs.

The RIC has mandated that T&TEC institute and run the RRU to assist the commission in escorts and crew security but due to staff shortages, the department is currently utilising TTPS to person RRU functions in PoS and environs, which incurs a cost to the commission. Moreover, T&TEC is currently in the process of implementing a Command Centre which will place the department under additional strain relative to staffing. At present the T&TEC Estate Police Investigations Section has a backlog of over 1000 reports which would be alleviated with the filling of vacancies within the department.

6.1.13 Evaluation of the Responses of the Protective Services and Other Relevant Agencies

6.1.13.1 TTPS

The TTPS first became aware of the blackout when the OCC experienced a loss of power at 12:58 pm on Wednesday 16th February 2022. Via the use of wireless communications, the organisation was able to verify that the said power outage was islandwide and at 1:30 pm updated the TTPS Executive via telephone. At 1:58 pm the OCC alerted all mobile and foot patrols to pay particular attention to banks, government buildings, gas stations, business places, traffic congestion and all major intersections within their divisions. At 2:08 pm, the TTPS received its first official communication from T&TEC. This was a WhatsApp message from Mr. Curtis Francois, T&TEC's Chief Operations Officer; which indicated that there was an islandwide power outage and the estimated timeframe for rectification of the problem and restoration of electricity may take between 2 to 3 hours.

At 2:10 pm, Mr. Mc Donald Jacob, the Ag. Commissioner of Police, instructed that all Police Officers be vigilant whilst on patrol and to establish a Compound Sentry in accordance with Police Standing Order #38. He also instructed that the GEB and IATF communicate with their active patrols and make necessary preparations in the event that the loss of electricity went beyond T&TEC's estimates. This was to safeguard against looting, robberies, and breaking offences, particularly in the city of PoS and environs. These instructions were disseminated via wireless communication to all Divisions, Sections, Branches and Units of the TTPS.

At 2:27 pm, the OCC received a telephone call from the ODPM informing of the national power outage and the similar restoration time indicated by T&TEC. At 6:11 pm, the OCC received another telephone call from the ODPM which outlined that T&TEC was experiencing challenges in the restoration of power as IPPs were having problems restarting. It was during this update that the TTPS first received confirmation that the restoration of electricity would take longer than earlier anticipated.

The COP was thereafter updated and the TTPS Executive instructed that strategic patrols, station compound sentries and police visibility be maintained in all areas of Mass Transit *(Vehicular & Pedestrian)*, in addition to areas susceptible to acts of criminal activities. From 6:30 pm onwards, periodical status updates at 30-minute intervals were sent from all Units, Sections, Branches and Divisional Operations Centres to the TTPS OCC and E999 Command Centre, outlining the details of deployed patrols and the areas of concern until the full restoration of electrical power to the island.

It was noteworthy that even though the TTPS Critical Incident, Event and Disaster Management Plan did not specify blackouts or electrical power disruption, immediately following the blackout event, the various arms of TTPS responded and through the use of variants of its Critical Incident Response plan, as well as the department's Standing Orders; Departmental Orders and other instructional memoranda; SOPs and applicable laws, were able to respond to the event. Moreover, members of the Municipal Police Departments in both the north and south; as well as Transit Police Unit would have also performed patrols within their respective areas, thus ensuring a protective security blanket during the blackout.

A detailed list of the one hundred and twenty-seven (127) Operational Command Centre (OCC) controlled patrols; twenty-seven (27) TTPS Traffic Control patrols; twenty (20) *"Municipal and Transit Police Patrols"*; *and* fifty-four (54) islandwide patrols performed by Municipal Police throughout the fourteen (14) Regional Corporations *(Municipal Police Response to Power Outage on 16.02.2022)*; are attached to *Appendix 4 vii.*

Hereunder depicted is a CAPA *"Temporal Analysis of Serious & Minor Crimes"*. It is a comparison of all reported crime which occurred on Tuesday 16th February 2021 as compared against Wednesday 16th February 2022, which notes no significant increase in all categories of crime during the event. In examining the TTPS Critical Incident Event and Disaster Management Plan and Policy *(see Appendix 4 vii)*, it was clearly evident that despite blackouts not being included in the plan, other than as a side effect of *"thunderstorm activity"*, the organisation catered for such dynamic eventualities and this critical incident would have been defined under a *"Level 3 Rating"*, as it was one which affected *"multiple divisions and or sections"*, and which required *"the involvement of resources from external agencies at a national level"*.

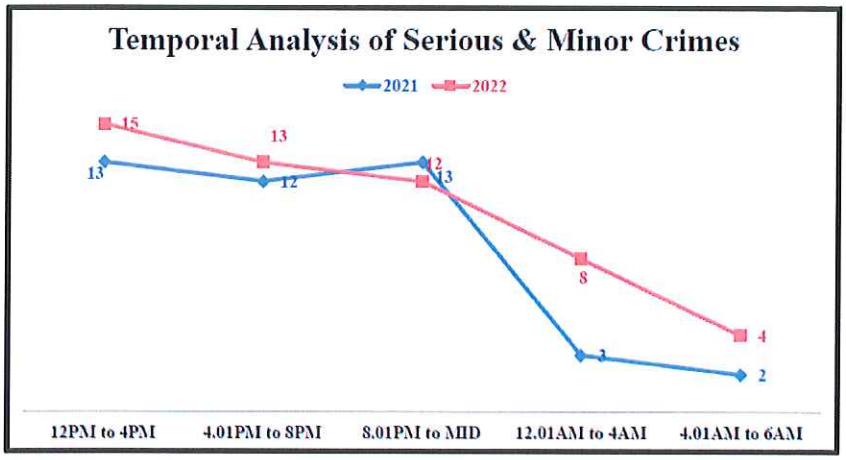


Figure 16: Temporal Analysis of Crimes on February 16th 2021 and February 16th 2022. Source – TTPS CAPA.

6.1.13.2 TTDF

The TTDF submitted Report Ref: TTDF 2/5/5 dated Monday 21st March 2022 *(see Appendix 4 viii)* to the Committee which outlined that as soon as the blackout occurred, the organisation's Executive Officer held an immediate briefing with the *"Branch Commanders with responsibility for Operations, Engineering and Logistics"*, where instructions were given to increase security protocols at all its bases, and *"identify personnel to be placed on standby as the QRF to assist the TTPS with MACP operations"*.

In response to the Committee's question as to if the TTDF was in possession of a Critical Incident Response Plan and if the details were communicated to all relevant personnel prior to and adopted during the said event, the organisation referred to the different arms individually, indicating that at its HQ, *"Unit and Formation SOPs were activated"*. It further explained that *"this necessarily involved doing internal readiness and deficiency checks and then updating the status of each unit or Formation through established communication channels across the TTDF"*, whilst at the TTR, *"the increase in alert state would ensure that the TTR would be in a position to respond"*, as well as to *"assist in any increase in criminal activity and attacks on critical infrastructure"*. The TTCG's *"response to this incident consisted of a combination of standard and emergency procedures that have been developed over time based on operational experiences"* and the TTAG does not have *"any Critical Incident Plans in relation to such events"*.

Despite its well-articulated response to the question, the TTDF did not indicate if it possessed the requisite Critical Incident Response Plan and noted that it essentially utilised organisational SOPs and acquired institutional knowledge to respond to the blackout event. The organisation did indicate that although there was *"no night coverage for both Fixed Wing and Rotary Wing Assets"*, the TTAG did perform three (3) mobile patrols in the St. Augustine, St. Joseph and Arouca districts, the latter of which was in the vicinity of the

Maximum-Security Prison, in addition to maintaining *"routine Joint Patrols within ALL Police Divisions inclusive of IATF"*.

The TTDF indicated that it did not possess information which suggested that the event was *"linked to any criminal, subversive or industrial action"* and in response to the Committee's question as to if the TTDF has ever undertaken any national risk or threat assessments which would have factored such an event, the organisation revealed that it has engaged in *"many national risk assessments"* but that the most applicable *"relates to those done under the purview of the ESSI for critical infrastructure in the energy sector"*, the details of which reside with the ESSI.

In responding to the Committee's question regarding the deployment of extra patrols during the event, the TTDF indicated that there were *"no special deployment of extra patrols (land, sea, and air)"* on the date of the blackout, noting that *"no additional requests were made by the TTPS or any other external agency"*. The organisation revealed that during the period, the TTCG had repositioned *"capital assets"* and relocated its Control Room to one of its vessels so as to *"ensure continuity of Command-and-Control functions"*.

The TTDF intimated that it utilised telecommunications, wireless radio, social media as well as *"joint and inter agency communications"* as its sources of information during the event, which included established communications with the *"DCP Operations TTPS to advise that the TTDF was ready and able to provide augmented assistance"*. The organisation also reported having assisted the SSA *"in getting the generators at one of its principal facilities back online"* during the blackout. It is noteworthy that although the TTDF did not indicate that it possessed any Critical Incident Response plans relative to incidents of this nature, it did utilise existing SOPs and institutional knowledge in making decisions relative to the blackout event.

6.1.13.3 SSA

SSA via correspondence Ref SSA 9/6 dated Tuesday 8th March 2022 *(see Appendix 4 ix)* indicated that its mandate included *"operational coordination"* but at no point was any evidence brought to the fore that this mandate was undertaken during the blackout event. The agency indicated in its report that it had *"no confirmed intelligence in its possession to suggest that the events of Wednesday 16th February 2022 were linked to any criminal, subversive or industrial action"*. However, the TTPS in its submission to the Committee, indicated that the SSA had sent a report to the Special Branch *(Ref SSA 7/6 dated Wednesday 2nd March 2022)*, indicating that the blackout was a result of sabotage by *"unknown persons"*.

The agency failed to indicate if it was in possession of a Critical Incident Response Plan but instead intimated that it "*supports the operationalisation of national level critical response plans and also has such plans built into many of its SOPs – as it is expected to seamlessly operate during critical events*". Interestingly, the SSA noted that "*in partnership with the relevant national authorities including the ODPM, the SSA operates as a supporting Agency providing facilities, technical support, specialised equipment toward the coordination of a response and communication facilities for both operations and public awareness*" and highlighted the provision of an "operational command centre" and "media centre" as being among the services it provides.

Nonetheless, on the day of this critical incident, the absence of these crucial elements resulted in a communication vacuum which left the citizenry *in the dark* and fuelled unfounded speculation via unsubstantiated reports on social media and *grapevine* communication, which alleged that the nation's electrical grid was sabotaged. Rumour mongering and false information fed the false assumptions that the blackout was as a result of sabotage and retaliation by the union to current stalled negotiations, as well as resistance to the government's public sector safe zone initiative.

6.1.13.4 ODPM

The ODPM via correspondence reference ODPM: 88/2/6 SubFile 1 *(see Appendix 4 x)* indicated that it does not have a National Disaster Preparedness and Response Plan as it related to blackouts or power outages, but rather utilises the draft National Response Framework (NRF) as its *"guiding document on Disaster Preparedness and Response";* however, this document is also silent on blackouts and power outages. The agency also stated that they are currently executing three (3) projects which are directly related to the Committee's terms of reference, vis-à-vis: the *"Development of a CDM Policy"* which will set out the strategic direction; which will then be enforced by the *"Review and Revision of the Disaster Measures Act (1978), the nation's principal disaster law"*, and implemented through the *"Development of a Multi-Year CWP for Disaster Risk Reduction"*.

The ODPM does not have an established policy or given time frames for conducting Vulnerability and Risk Assessments and the organisation indicated that past assessments would have *"resulted from opportunities either offered or negotiated"*, the last such being a National Disaster Preparedness Baseline Assessment which was funded by the US Government and conducted by the PDC in 2019. Prior to this assessment, the ODPM last conducted a *"Preliminary Vulnerability Assessment of Trinidad and Tobago"* in 2014 but this analysis was performed from a *"disaster management perspective"* under six broad categories of

"environmental, social-organisational, industrial-technological, biological, hydro-meteorological, and seismic" and as such *"power outages were not referenced"*.

Moreover, in 2011 the ODPM undertook vulnerability assessments at the municipal level as a joint effort with the Ministry of Local Government. This project provided an overview of the existing levels of vulnerabilities in five (5) Regional Corporations *(Couva/Tabaquite/Talparo, Penal/Debe, San Fernando, Sangre Grande and Tunapuna/Piarco)* and *"assessed hazards such as flooding, high winds, and seismic events"* but once again did not include electricity blackouts.

In responding to a question from the Committee as to if power outages were factored into any of the previous assessments in relation to CDM, the ODPM indicated that *"on account of the extremely low frequency of large-scale power outages, past vulnerability assessments did not consider these as major hazards of note"*, but instead focused on *"hydro-meteorological hazards such as tropical cyclones, flooding, and severe weather, as well as geohazards/seismic hazards such as earthquakes and tsunamis"*.

The ODPM posited that the CDM Policy (2022-2032), which is currently being drafted, takes into consideration a multi-hazards approach which are categorised in accordance with the updated *"Hazard Definition & Classification Report published in 2020 by the UNDRR"*. The organisation noted that under this new classification, *"technological hazards such as 'Infrastructural Failures' will now benefit from targeted attention as guided by the updated CDM Policy Framework"*. The ODPM revealed that historically, their training exercises have challenged national agencies to *"respond to power outages as 2nd and 3rd order effects, of a primary hazard such as an earthquake or a hurricane"*.

In response to a question from the Committee as to the responsibility for alerting members of the public of such events, the ODPM noted that *"public alerts are dependent on the hazard type"* and posited that *"jurisdictional responsibility"* for managing a power outage and alerting the public, would fall under T&TEC as the *"sector lead"*. The organisation noted that *"this was also the case with the other utilities, TSTT and WASA, which as leads in their sectors, established and maintained communication with the public"*. The institution stated that *"in the event any of the sector leads required assistance, that entity could have requested the ODPM's support"* and indicated that *"this was not the case during the power outage"*.

Despite not being the "lead agency that communicated directly with the public on Wednesday 16th February 2022" or being asked for assistance by T&TEC, the ODPM intimated that it "*obtained and shared information with the national security leadership and strategic and operational leaders of various other sectors*", as well as "*shared information with the public on its Facebook page*".

The ODPM indicated that it was relying on information "*released by T&TEC, TSTT and WASA to understand the scope of the problem*" and "*therefore did not have much, if any, new information to share with the nation*". The organisation revealed that it merely re-shared T&TEC's information on its Facebook page and did not make any public releases. However, as events unfolded during the days following the blackout, the ODPM reported that it "*observed some concerning comments in the media where the ODPM and other National Security bodies were referenced*" and as such prepared a release to be published but same was not done by any of the Newspapers and the organisation posited that this was "*probably because Carnival events and the Paria incident dominated the papers*".

In examining the ODPM's Event Log for Wednesday 16th February 2022, the organisation reported that following the initial loss of power, their PRU initiated communication with T&TEC, TTPS, TTFS, TSTT, Digicel, WASA, MEEI, NSFC and TEMA at 1:20 pm. At that time, T&TEC was unable to give a cause for the power outage; TTPS reported that personnel were responding to the traffic situation and public safety concerns; TSTT reported *"no critical power failures"* but that there was a *"drop in network service being caused by congestion on the network"*; and WASA reported that eighty percent (80%) of their water facilities were down and all their booster stations were affected. None of the other areas reported any critical areas at that time and TEMA reported that Tobago was unaffected.

At 3:20 pm, the ODPM provided a status update about the power outage to the National Security Leadership chat group and thereafter at 5:30 pm, T&TEC reported that all its attempts to return power to the La Brea, Point Fortin and Siparia areas had failed. At 5:45 pm, TSTT indicated that their remote cell sites were starting to *"go down"* and TTPS indicated that there were no major incidents. At 6:41 pm, reported that there was *"no potential critical disruption to their network"*, whilst at 6:52 pm, T&TEC reported that power was restored to a *"few customers in Penal and Central"*. At 7:00 pm, T&TEC notified the public via the nightly news broadcast that it could take up to five (5) hours for the restoration of power to the island and at 11:30 pm, the commission indicated via a social media post that "*power had been restored from Penal to Mt. Hope*" and that *"the supply was expected to be restored to the rest of the island by 1:00 am"*.

6.2 National Security Concluding Remarks

Historically, islandwide blackouts are not a regular phenomenon in Trinidad and Tobago and as such the major entities never factored it as a critical incident in their response planning. In examining the 2003 blackout which occurred in the USA, (Beatty, et al. 2005) indicated that *"during an emergency, individual agencies operate under their own command structure responding to aspects of the emergency that fall*

under the range of that agency's mandate. However, since multiple agencies are involved, the overall response must be coordinated. This improves communication, allows for pooling of resources, enhances the collaboration between agencies, and improves the efficiency of the response". In this report, the Committee also identified one of the key areas for improvement was *"communications during the event".*

Similarly, the Committee finds that communication during the Wednesday 16th February 2022 blackout also lacked cohesion and that it would have been a proper platform for a NAS. Due to its overall mandate of protection of the citizenry and being the vanguards for public safety, the TTPS response was characteristically instinctive as the organisation seamlessly executed its Critical Incident Response Procedures. It is noteworthy that although the organisation did not have blackouts listed as a critical incident, its dynamic functionality allowed them to seamlessly coordinate their resources and counter the various elements associated with the blackout. During the event, the TTDF did not deploy any additional resources to assist in patrols and public safety but merely placed their human resource assets on standby alert; increased security at their bases and repositioned their capital sea assets as part of its institutional knowledge business continuity plan.

The Committee noted that this particular incident presented an ideal opportunity for the various security agencies to take the mantle of leadership during a critical incident but instead were *ball watching* to see if anyone else would *take the catch*, and in the end, *dropped the ball* entirely. According to the ODPM, T&TEC was the lead agency in this situation and as such dealt with the incident response and communication, giving regular updates via social media using the Facebook page. The ODPM also indicated that T&TEC did not ask for assistance, but considering the situation, does a lifeguard await the screams of a drowning individual to render assistance, or does due diligence and prudent critical thinking resonate into appropriate action.

T&TEC does not have a mass communication or alert system and the use of Facebook was limited to persons with access to internet during the blackout. The RAU of the TTPS via Report Ref: RAU2022RR001 dated Thursday 17th March 2022 *(see Appendix 4 xv)*, noted that Facebook is the most popular of all the social media platforms, with an estimated 1.19 million accounts being registered to users in the ROTT. Interestingly, the blackout created instant connectivity issues which affected telecommunications and the internet, which in essence should have signalled to the ODPM, SSA or NOFC to assume responsibility for public alerts.

In the sphere of Mass Alert Systems, the departments which failed to take advantage of the opportunity to notify and update the citizenry on the initial blackout and ensuing delays in the resumption of power, would be mindful to take cognizance of the procedures adopted by the TTMS, who in their report to the Committee, outlined their seamless model of distributing public communication via *"website, social media, media channels, mobiles app, email and sms"* whilst simultaneously giving advice to the *"emergency management sector, including via embedded staff"*.

Fall-out effects on other critical institutions

In an immediate response to the blackout, The Honourable Terrance Deyalsingh, the Minister of Health issued a public release on Thursday 17th February 2022 which indicated that the event did not affect patient care at the nation's hospitals as all backup systems had kicked in and worked according to plan. It was stated that patient care was not compromised and that contrary to rumours being circulated, that there were no deaths in the public health system which resulted from the national power outage, as all public hospitals were equipped with emergency backup generators with adequate onsite fuel storage.

Conversely, the power outage adversely affected TSTT as the company reported to the Committee via correspondence Ref. No.: 10000/049/2022 *(see Appendix 4 xi)* that one of the most *"critical challenges posed by the outage was the extended period in the restoration of commercial power which led to the Wireless Transmitter sites that were on battery backup having exhausted the designed capacity going offline. Over half of the mobile network elements lost power in a rolling outage pattern at approximately four hours (4) after the start of the outage"*. The company highlighted that its *"radio access network in Trinidad was severely affected resulting in a degradation of service in some cases and a full loss of services in others"*.

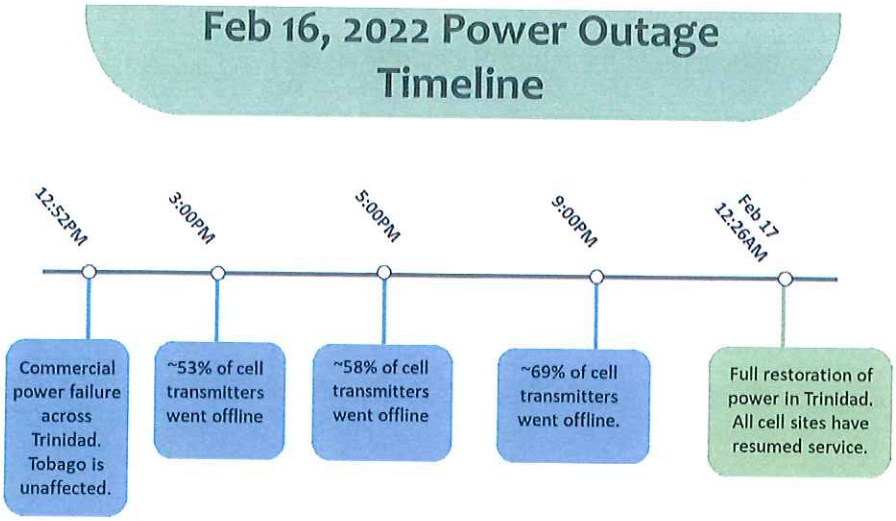


Figure 17: TSTT power outage timeline. Source: TSTT Report Ref. No.: 10000/049/2022

Digicel indicated via correspondence dated Wednesday 23rd March 2022 (*see Appendix 4 xii*) that its data centres were "*unaffected by this incident as redundant power systems were automatically engaged to facilitate uninterrupted power*" but that its "*cellular network infrastructure was impacted at the site level with some sites losing power after backup batteries discharged*". The company complained that "*the lack of information from T&TEC on the sequence of areas for service restoration resulted in some instances*" of Digicel deploying generators to sites where power was restored shortly thereafter; the "*lack of proper communication from T&TEC*" which "*severely impacted the efficiency of recovery operations*"; the lack of proactive information by the commission; and "*numerous attempts*" to contact T&TEC during the event without success.

Operations at the WASA were also adversely affected as pumping and booster stations went offline, and the supply of water throughout the country was disrupted. WASA, via report dated Thursday 24th March 2022 *(see Appendix 4 xviii)*, indicated to the Committee that its operation included the *"production, transmission and distribution"* of water throughout Trinidad and Tobago; however, the authority's *"Tobago facilities were unaffected and remained in full operation".*

WASA noted that it produces 242 IMGD and on the day of the blackout, its Water Treatment Facilities at *"Hollis, Tompire and Trinity in Trinidad were operated at full capacity on generator supply"* whilst *"40 WTPs, 107 Booster Stations, 210 groundwater sources and Desalination and Wastewater sources located across North and South Trinidad"* were out of operation. The Authority also stated that *"some water treatment facilities such as Acono, Siparia and Carapal operated on generator supply at partial production"*. It was

concluded that three hundred and seventy-six (376) schedules were disrupted and full restoration was realised between 72 to 96 hours after the return of electrical power.

The organisation revealed that its nine (9) Customer Service Centres, as well as Banks and other external collection agencies and its online payment portal, were affected thus resulting in the estimated loss of collections of $750,000.00; cash on hand had to be vaulted thus creating a security risk; loss of telecommunication services which affected its debt recovery and bill generation processes; and overall negative effects on its communication network. However, there were no *"long-term and ongoing effects of the power outage on the operations of the Business Centres and the Communication Mediums"*.

6.2.1 Analysis of Communication Protocols

Statistical data obtained from the RAU department of the TTPS, indicated that Trinidad and Tobago has an approximate population of 1.4 million persons, from which an estimated 78.4% of the population uses social media platforms including Facebook, Pinterest, Twitter, Instagram, and YouTube.

In examining the effectiveness of T&TEC's use of Facebook to provide timely updates, the RAU noted that the commission was aware that *"the majority of persons in Trinidad and Tobago use social media"* and hence their choice was apt. The department concluded that *"considering the speed at which news spreads on social networking sites, it was a good idea to communicate with the populace in a timely manner by placing the updates on Facebook"*. Nonetheless, it was discovered that during the blackout, the connectivity of persons on both the Bmobile and Digicel network were affected.

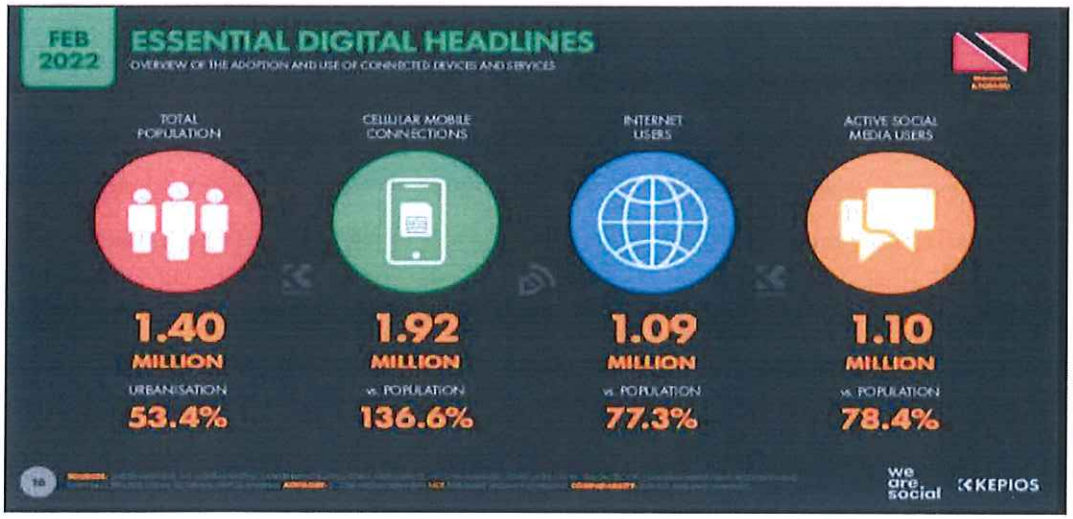


Figure 18: Connected devices. Source: TTPS – RAU Report RAU2022RR001

In examining the actual reach of social media on the day of the blackout, the RAU posited that this would depend heavily on the number of customers on both networks who had connectivity, considering that Wi-Fi connections would have been affected. The Committee found that the more applicable solution would have been to utilise an integrated system of SMS type notification system; AM/FM Radio; a myriad of social media platforms; website; mobile apps and email, similarly to what is utilised by the TTMS. The Committee noted that considering T&TEC's role as a sector lead, whose mandate was the transmission and distribution of electricity, the company should not have been the primary source of communication to the public and this remit should have fallen to the agencies whose primary responsibilities include mass communication.

6.2.2 Stakeholder Engagement

Because the loss of electricity would have affected all persons, businesses, and organisations in Trinidad, which are representative of the health, telecommunications, security, manufacturing, food, wholesale, retail, transportation, processing, and service sectors, as well as all the related and linked industries, the Committee considered the time given to complete its assignment, in determining its stakeholder engagement. The direct input of all stakeholders could not be facilitated with the stipulated time and as such the Committee engaged several stakeholders to submit reports; engaged in direct interviews; site visits; examined media releases and public statements made by key stakeholders to obtain their opinions, recommendations, and general comments of the blackout event, as well as how they were affected and their recommendations on preventative measures to mitigate a recurrence. Apart from the other stakeholders already mentioned throughout this section, the undermentioned comments were also considered.

6.2.3 OWTU

The OWTU is the sole trade union representing workers at T&TEC and PowerGen, and as such is considered a key stakeholder in the generation, transmission, and distribution of electrical power in the country. Over ninety percent (90%) of T&TEC employees and eighty-five percent (85%) of PowerGen workers are members of the union. The OWTU stated that it wished to place on the official record that none of its members at PowerGen or T&TEC were involved in the blackout event but instead heralded them as heroes, who worked tirelessly and commendably in ensuring that power was restored to the island

The Union indicated that there were several systemic issues plaguing the generation, transmission, and distribution of electricity within the ROTT, which if not addressed in a timely manner, will result in a recurrence and outlined that based on its information, the cause of the blackout was a *"tree which fell onto*

a distribution line at an under-build situated along the Transmission lines from TGU to the Gandhi Village sub-station". The OWTU claimed that the *"under-build"* was not constructed to requisite standards and recommended the use of a *"basket"* on the poles in the identified area or the *"placement of the lines underground"* as mitigation strategies which would have avoided the situation which caused the blackout.

The organisation claimed that T&TEC was abusing Clause 9 of the Collective Bargaining Agreement 2012-2014 which stated that contracts were not to exceed six (6) months and in so doing, were utilising inexperienced contractors within the Vegetation Management and Line Clearing Divisions, which is a potential hazard for a similar recurrence. The Union claimed that the North Coast 12 kV line was not being properly maintained and as a result was causing regular trips on the circuit, thus resulting in power outages in that area. They noted that following these trips, T&TEC's Line Clearing Department must revisit the job site and fix the shoddy work done by the contractors and as such recommended that the commission's Line Clearing Department be given adequate manpower to avoid these issues, as the training given to the T&TEC workers are of an international standard.

The OWTU claimed that the Commission has refused to share the results of a manpower audit which was undertaken in 2017 and as such, the union utilised a historical comparative analysis to determine that T&TEC had a critical manpower shortage which included 300 linesmen as well as shortages in all other departments. The union claimed that to counter the effects of the manpower shortage, T&TEC has resorted to the use of overtime, which had led to overworked employees, who are now susceptible to stress related issues and employee burnout. The organisation also claimed that it was not included in T&TEC's post-mortem investigation into the blackout as the Recognised Representative Union.

The union informed the Committee that the three (3) John Brown black start units at PowerGen *(2 in Penal and 1 in Point Lisas)*, were part of the 1994 PPA which is scheduled to end in 2029 and thus the black starts are to be removed from the system. They intimated that PowerGen has not indicated what black start systems will be used to replace the aforesaid units and as such claimed that *"maintenance and upgrades were being sacrificed for dividends"*. The OWTU stated that PowerGen was suffering from the loss of institutional knowledge and a lack of skill-based training since its apprenticeship programme was stopped, despite the organisation needing a regular supply of technical staff, who possess institutional knowledge to effectively mitigate a recurrence of Wednesday 16th February 2022, when the power plants had difficulties restarting their operations. The Union also recommended that the country return to an "*integration model*" of power generation, transmission and distribution which would include TGU and PowerGen, to ensure seamless coordination.

7 THE COMMITTEE'S RECOMMENDATIONS

A single point of failure exists along this 220 kV circuit from Union to Gandhi and will remain so until another double circuit is built along another route. Thus, currently any tower failure/double circuit failure could result in a similar incident. However, there are short term mitigation measures that should reduce the restoration time.

In considering the islandwide outage on Wednesday 16th February 2022, the Committee has reviewed the supplied documents, audio recordings and has had several discussions with key representatives from the IPPs and T&TEC (Appendix 2 – Technical Documentation). The Committee has also reviewed documentation provided by the several security arms of the state, Digicel and TSTT (Appendix 3 – Communications Documentation). Arising out of this review, the following are strongly recommended:

- Another 220 kV circuit should be built connecting the Union Substation to the Gandhi substation. It would be prudent that this new circuit does not use the same route as the existing Union to Gandhi circuit.
- An emergency response plan must be developed as a matter of urgency for the power system operation. This response plan must include an incident commander who is an aptly trained point person who would be vested with the authority and responsibility for the restoration of the grid during the duration of the emergency.
- An annual independent power system resilience review and power system risk assessment shall be performed to identify power system vulnerabilities that can lead to catastrophic power system failure. This should be reviewed by an independent technical standing Committee.
- Power system restoration procedures must be developed, discussed and disseminated. Once confirmed, a printed copy of these procedures must be readily available and lodged in each control room. These procedures should be periodically reviewed for improvement and updated after changes to available generation, transmission and distribution infrastructure, particularly generation plant retirements or additions.
- A perusal of the logs and a review of the communication amongst the operators highlighted the need for improved understanding of the power system operation under emergency conditions. Appropriate technical training for IPP operators as well as T&TEC operators including joint rehearsal of emergency incidents scenarios is highly recommended. This may be facilitated with appropriately developed software simulations of varying scenarios.

Amongst its other recommendations for the industry, the Union stated that all future PPAs should be negotiated so that T&TEC pays for *"power used"* as opposed to the current *"take or pay"* system; the construction of a strategically located power plant close to the Barataria Exchange where key power lines are located, thus decentralizing the country's power generation from the south of the island; increased authority to the Interface Committee whereby random inspections can be done at the IPPs to ensure that the declared daily assets were indeed functional and in a state of readiness; ensuring that all IPPs have functional black start machines as CGTP was under no obligation via its PPA to have one; ensuring that the compulsory acquisition of lands is hastened so that T&TEC can construct the second 220 kV transmission line along the *"right of way"* from TGU to Gandhi sub-station; that T&TEC revisit the construction of all *"underbuilts"* along critical transmission lines; and the government appoint the requisite Boards for T&TEC and PowerGen.

6.2.4 APETT

In an immediate response to the blackout, the APETT issued a media release calling for an immediate review of the national infrastructure to ensure that the country can withstand and recover from such disasters. The Association noted that the event needed to be examined in its entirety and not merely from a blackout perspective as all critical aspects of infrastructure that rely on electricity, are expected to have been designed with backup systems to allow for the uninterrupted functioning of critical services and an orderly shutdown of non-critical systems.

The Association noted the nation's dependency on telecommunications and mobile communications which can be adversely affected and called for similar investigations into the performance or failure of the various telecommunication networks. APETT revealed that most of the traffic signals along the East-West corridor were non-functional, which resulted in chaos at the intersections, traffic gridlock and severe congestion but commended the TTPS for maintaining order at these intersections. The Association questioned the absence of battery back-up for the traffic lights at these critical intersections and called upon the MOWT to address the situation.

- There should be at least one generating unit at each facility on load rejection. This capability should be periodically tested, results documented and shared.
- An islanding scheme of the power system, where the power system is separated into several independent regions with supporting generation, should be developed and implemented as a matter of priority.
- A review of the battery condition of the control networks within the substations should be urgently conducted. The reports confirmed a significant number (> 80%) of low battery alarms within minutes of the outage.
- At the power generating facilities the emergency DC supply should be reviewed to ensure that the operational voltage levels for critical machinery is appropriately maintained.
- From the audio recordings, many calls were channelled through the IPPs' PBX leading to operational delays. The use of this channel should be reviewed.
- The communication providers should consider improving the battery back-up for cell services from four (4) hours to (8) hours.
- An islandwide power failure event should be now labelled as a special case of a "Natural Disaster". This would ensure that, when triggered, it shall initiate emergency protocols of all players utilised in such an event. In this way, the ODPM will now take over the social management of the event leaving the T&TEC to concentrate on the coordinated restoration of power.
- A national committee should be established comprising the power sector, WASA, the NGC, the communications providers, national security agencies, ODPM and the TTPS to relook at national disasters (including its definition) and the management of such scenarios. National disaster should not just be seen as due to nature.
- Consideration should be given to providing battery back-up for the traffic lights at all major intersections.

8 THE COMMITTEE'S SUMMARY & CONCLUSION

Winston Churchill's famous observation - made during the bleakest days of World War II – that one should "never let a good crisis go to waste" is apt at this time. This unfortunate event has thrown up several issues pertaining to all parties involved including those who should have been involved. It is fortunate that all the digital protection relays in the power sector have, inherent in their design, auto event recorders. In addition, this type of event must be included in the country's disaster plans. This event has generated a veritable mother lode of usable data. It is for T&TEC to now mine this data to optimize their current models of the power system as well as updating the time constants used in modelling the generators and turbines. This would also be of help for those at the RIC.

The Committee found no evidence of sabotage as the trigger for the failure. This event was like a perfect storm with a high wind causing a fungal affected Palmiste tree to fall on to the 12 kV line. It was abundantly clear there was a lack of a systemic approach in the restoration process. The IPPs and T&TEC staff made many unforced errors in the re-energization process. This can be easily remedied by ensuring that the operators be schooled in the understanding of the issues involved in a de-energised grid and the safe process to re-energize such a grid. The Committee is of the opinion that there was no single person who took the role of an Incident Commander and had overall authority as well as detailed knowledge of the restoration process and the inherent pitfalls that an untrained operator can make. Most believe that in an emergency the Senior-most executive oversees the process. This is a major error as the restoration and management of an emergency require a well-trained person who has been aptly schooled to do so.

It was evident also, that none of the agencies involved (including T&TEC and the IPPS) or who should have been involved (the absence of the ODPM was noticeable) ever contemplated a total power failure as one of the many "national" disasters that could occur and be prepared for. If they did, they would have known that the internet would have been lost and hence using internet enabled communications should not be the primary communication medium. (As a reminder, all routers in homes require a 120 V AC supply to function!) Also, a sizable percentage of the public does not use these social apps. No one even thought about FM radio! Everyone uses radio yet radio reports were not the chosen medium. Everyone has access to radio either as a smart phone tuner or a standalone battery-operated alternative.

Despite the lack of effective communication to all stakeholders, the protective services took the initiative to trigger a creditable response and should be commended for so doing. There was no evidence that

"criminal" elements were able to take advantage of the situation. Maybe they were also affected by the power failure and could not communicate amongst themselves?

Except for the loss in productivity, personal refrigeration losses and production losses in manufacturing, there was no loss of life attributable to the outage. The outage, however, has laid bare the many shortcomings in our Disaster Preparedness and restoration procedures. It is for us to learn from this and implement the mitigating actions needed to be better prepared if such an incident were to recur.

9 REFERENCES

Beatty, Mark E, Scot Phelps, Chris Rohner, and Isaac Weisfuse. 2005. "Blackout of 2003: Public Health Effects and Emergency Response." *Public Health Reports* (Public Health Report) 121 (1): 36-44. doi:10.1177/003335490612100109.

IEEE. 2000. "The Authoritative Dictionary of IEEE Standards Terms, Seventh Edition." *IEEE Std 100-2000* 1-1362. doi:10.1109/IEEESTD.2000.322230.

Lauta, K C. 2014. *Disaster Law.* 1st. Routledge. Accessed 2022. doi:10.4324/9781315867670.

Raoufi, Habibollah, Vahid Vahidinasab, and Kamyar Mehran. 2020. "Power Systems Resilience Metrics: A Comprehensive Review of Challenges and Outlook." *Sustainability* 12 (22). Accessed March 25, 2022. doi:10.3390/su12229698.

Rubin, O., and R. Dahlberg. 2017. *Oxford Dictionary of Disaster Management.* 1st. Oxford University Press. Accessed 2022. doi:10.1093/acref/9780191829895.001.0001.

Trinidad and Tobago Government News. 2014. *The National Alert State, Public Warning and Information Policy.* May 5. Accessed March 1, 2022. http://www.news.gov.tt/content/national-alert-state-public-warning-and-information-policy.

APPENDIX 1 – TERMS OF REFERENCE

TERMS OF REFERENCE

Committee to Investigate the Causes of, and National Response to, the Islandwide Power Outage in Trinidad on Wednesday February 16, 2022

(Appointed on February 22, 2022)

The Committee appointed is required to investigate, make site visits, review documents and interview witnesses, stakeholders and interested parties, regarding the following:-

1. Investigation of the incident that occurred on February 16, 2022, that led to an island-wide electrical power outage in Trinidad, including, inter alia, the following: -

    a. Investigation of the circumstances that caused fault(s) to develop on T&TEC's lines at Gandhi Village/Union Estate and any other location;
    b. Investigation of how these fault(s) resulted/contributed to a loss of generating capacity at the Trinidad Generating Unlimited (TGU) power plant and knock-on effect at other Independent Power Producer (IPP) power plants;
    c. Determination of what, if any, measures could have been taken to mitigate the impact of these fault(s) on TGU's generating capacity;
    d. Determination of what, if any, measures could have been taken to mitigate the loss of TGU's generating capacity and the loss of generating capacity at the other IPP's; and
    e. Examination of the methodology and approach utilised by TGU and all other IPP's in re-establishing electrical power supply on the island following the complete loss of generating capacity.

2. Investigation of the current design/configuration/installation of T&TEC's electrical transmission and distribution system to determine whether there are systemic design/installation features which make it vulnerable to a repeat of a similar event, whether by accident, natural or man-made causes.

3. Examination of the effectiveness and appropriateness of the communication by T&TEC, ODPM and any other state agency responsible for communication in the situation, on the nature of the problem and on the progress being made to restore electrical power to the national population

4. Examination of the national security response to the event of February 16, 2022 to determine the following: -

    a. The country's state of preparedness in response to the incident that occurred; and
    b. The country's vulnerability to a repeat occurrence, given the current design/configuration/installation of T&TEC's electrical transmission and distribution system and the current capability of the IPP's to respond quickly and efficiently in a similar situation in the future.
    c. The nature of the response by the protective services, national security agencies and other relevant agencies, such as the Office for Disaster Preparedness and Management, to the power outage

Having completed (1) to (4) above, the Committee is to make observations, findings and conclusions, as well as recommendations to avoid a recurrence of a nationwide power outage, The Committee is to report to the OPM within one (1) month of the Committee's date of appointment, i.e. by March 22, 2022. and may co-opt any other expertise and resources that it requires.

APPENDIX 2 – TECHNICAL DOCUMENTATION

Original documents supplied

ENTITY	DOCUMENT NAME	DATE
T&TEC	Draft Report on System Disturbance that occurred on 16 02 2022	22/02/2022
T&TEC	Summary Report on Major System Disturbance of 16 02 2022	17/02/2022
T&TEC	Shift Log - 2022.02.16 to 17	
T&TEC	Graphical Representation Island-wide Blackout to Trinidad on 20220216	
T&TEC	T&TEC Underfrequency Scheme as of 2021-11-05 Stage 1	
T&TEC	Report on Union-Gandhi circuits	
T&TEC	February 16th 2022 Event Report - Distribution South	22/02/2022
T&TEC	Timeline for Public Communications Wednesday 16th February 2022	
T&TEC	SCADA Alarms 20220216 and 17	
	Independent Power Producers Blackstart Capability	
T&TEC	Powergen - Facility Islanding Operating Procedure	02/09/2019
T&TEC	TGU - FACILITY 'ISLANDING' OPERATING PROCEDURE	20/08/2019
T&TEC	Trinity - Facility Islanding Operating Procedure	02/09/2019
	PowerGen PPA1994X Interface Minutes - Jan 2022	
	PowerGen PPA2005 Interface Minutes - Jan 2022	
	TGU Interface Meeting Minutes - Dec 2021	
	Trinidad Power Limited Interface Meeting Minutes -2021-11	
T&TEC	Transmission System Single Line Diagram December 2020-Model	
T&TEC	Report on the Island wide Outage (For 210)	

Additional documents supplied

ENTITY	DOCUMENT NAME	DATE
Met Office	Letter of Response	21/03/2022
Met Office	Report for Cabinet Appointed Expert Committee _Power Outage Feb 16, 2022	
PowerGen	PTL.xlsx	
PowerGen	PEN.xlsx	
PowerGen	PowerGen Letter to Investigation Committee on Blackout 16 Feb.2022- Blackstart Procedures and Training	11/03/2022
PowerGen	Penal 6 Black Start Procedure	
PowerGen	Penal Blackout Station Recovery Procedure-Implementation on 16Feb2022	
PowerGen	Pt Lisas Blackout Station Recovery Procedure-Implementation on 16Feb2022	
PowerGen	Pt Lisas GT3 Black Start Procedure-Implementation 16Feb2022	
PowerGen	Penal Power Plant Operations Report	05/03/2022
PowerGen	Penal shift Engineer logs 0700-0700	
PowerGen	Point Lisas Power Plant Operations Report	02/03/2022
PowerGen	Pt Lisas Shift Engineer Logs 0700-0700	
PowerGen	2013_Response_T+TEC Letter_PPGPL	
PowerGen	Gen Data at PowerGen 1988	
PowerGen	Graph of NGC Gas pressure versus time showing PTLS 3 trips	
PowerGen	PowerGen Letter to Investigation Committee on Blackout 16 Feb.2022- Blackstart Procedures and Training	11/03/2022
PowerGen	PowerGen Letter to Investigation Committee on Blackout 16 Feb.2022	05/03/2022
PowerGen	PTLS 3 Start Up Technical Difficulties R4-signed	07/03/2022
TGU	TGU.xlsx	
TGU	Final Response to Technical Committee 08.03.2022	08/03/2022
TGU	Response to the Cabinet appointed Expert Committee- March 4-2022	04/03/2022
TGU	TGU-OPS-00-PR-00001 - Dead Bus Closure - Gas Turbine Generator Breaker	
Trinity	Trinity.xslx	
Trinity	Cabinet Appointed Committee Feb 16th Report	
Trinity	Trinity Response to Outage	
Trinity	Trinity S01-EMERGENCY RESPONSE PLAN and SPCC-March 2022	07/03/2022
Trinity	Trinity Trip Log	
T&TEC	2013_Report on the Extreme System Disturbance	
T&TEC	Grants Road Survey_REV02	
T&TEC	GRANTS TRACE EXT - BEFORE AND AFTER INCIDENT including previous span with UPSWEEP metres	08/03/2022
T&TEC	GRANTS TRACE EXT - BEFORE AND AFTER INCIDENT including previous span with UPSWEEP metres_v3	
T&TEC	GRANTS TRACE EXT - BEFORE INTERIM AND AFTER INCIDENT_FINAL	
T&TEC	Grants Trace Feb 16 2022 ttec-Pre	
T&TEC	Island-wide Blackout to Trinidad on 20220216 v4	
T&TEC	Removal of single phase HV and LVs - Grant Trace Ext	
T&TEC	SA_Event Report Final 2022-03-08	08/03/2022

T&TEC	Scorch Marks Union Ghandi #1 & #2 220kV ccts	
T&TEC	Station Battery Low Alarms	
T&TEC	TXM_Report_Final_Union-Gandhi circuits - 20220308	08/03/2022
T&TEC	Active power for gen blackout Feb 2022	
T&TEC	Angle 4 cy, FC 5 cy -Fault near Union 200 kV bus with four 220 kV ccts	
T&TEC	Angle FS 4 cy, FC 20 cy -Fault near Union 200 kV bus with four 220 kV ccts	
T&TEC	Angle FS 4 cy, FC 42 cy -Fault at the 'Feb. 16th position' with four 200 kV ccts	
T&TEC	Angle FS 4 cy, FC 32 cy-Fault near Union 220 kV bus with four 220 kV ccts v2	
T&TEC	Angle FS 4 cy, FC 900 cy -Fault at the 'Feb. 16th position' with four 220 kV ccts	
T&TEC	Freq Plot (nP and nQ at 1, Hz at 30 %)	
T&TEC	FW_ Graphs for System Black out on Feb_ 16th 2022	25/03/2022
T&TEC	Mech Power for Gen on Feb 2022 (Black out)	
T&TEC	Total Mech Power for Gen on Feb 15th 2022 (Black out)	
T&TEC	Total power output of gen on Feb 16th 2022 (Black out)	
T&TEC	Voltage at major buses during black out Feb. 2022	

APPENDIX 3 – COMMUNICATIONS DOCUMENTATION

ENTITY	DOCUMENT NAME	DATE
T&TEC	Communications on Feburary 16 2022 island wide outage	23/03/2022
T&TEC	Disaster Preparedness Manual- digital	23/03/2022
T&TEC	Social Media handbook- Final Jan 2020	23/03/2022
T&TEC	General Instruction- Communication in the workplace	23/03/2022
T&TEC	DRAFT Report - 2022.03.26	23/03/2022
TSTT	Report - Nationwide Power Outage and Effects 15.03.22	15/03/2022
TSTT	Letter to Commitee re electricity outage	15/03/2022
Digicel	Letter to Cabinet Committee re Power Outage	23/03/2022

APPENDIX 4 – NATIONAL SECURITY DOCUMENTATION

Appendix 4 i	-	Timeline of Events
Appendix 4 ii	-	Met Office Adverse Weather Release for Wednesday 16th February 2022
Appendix 4 iii	-	Report from Forestry Division *(Forrester I Jason Mungalsingh)*
Appendix 4 iv	-	Statement of Aneel Ramharrack
Appendix 4 v	-	Statement of Vera Bhola
Appendix 4 vi	-	Public Warning and Information Policy for the Republic of Trinidad and Tobago
Appendix 4 vii	-	Report from the TTPS
Appendix 4 viii	-	Report from the TTDF
Appendix 4 ix	-	Report from SSA
Appendix 4 x	-	Report from the ODPM
Appendix 4 xi	-	Report from TSTT
Appendix 4 xii	-	Report from Digicel
Appendix 4 xiii	-	Report from the Meteorological Services Division
Appendix 4 xiv	-	Report from the UWI Seismic Research Facility
Appendix 4 xv	-	Report from the RAU of TTPS
Appendix 4 xvi	-	TTPS Media Release dated Thursday 14th February 2019
Appendix 4 xvii	-	TTPS – Special Branch Threat, Risk and Vulnerability Assessment
Appendix 4 xviii	-	Report from WASA
Appendix 4 xix	-	Report from NOFC
Appendix 4 xx	-	List of Docs from T&TEC
Appendix 4 xxi	-	Documents from PowerGen
Appendix 4 xxii	-	Documents from TGU
Appendix 4 xxiii	-	Documents form CGTP
Appendix 4 xxiv	-	Letter to OWTU