

REPORT
ON
SYSTEM DISTURBANCE

MAY 16, 1977

FLORIDA POWER & LIGHT COMPANY
JUNE 29, 1977

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INTRODUCTION

Florida Power & Light Company experienced a major outage on May 16, 1977 that extended from Ft. Pierce southward along the East Coast to the Florida Keys.

High speed oscillograph records, recording charts and other data have been examined in order to reconstruct the sequence of events that occurred. This report documents the sequence of events, and recommends corrective measures and further system studies.

SUMMARY

At 10:24 a.m. the Ft. Myers-Ranch 240 kV Line, carrying approximately 420 MW, tripped due to a phase-to-ground fault. The east and south areas of the FPL system (See Figure 1) became separated from the north and west areas when three 240 kV and seven 138 kV lines relayed sequentially due to instability. This split of the transmission system resulted in the St. Lucie Plant of the east area being tied only to the north and the Riviera Plant being islanded along with a portion of the east area load.

Frequency in the isolated area dropped rapidly with Turkey Point Units 1 and 2, and Port Everglades Units 1 and 3 generating 1003 MW to supply 2957 MW of load (See Figures 1 and 2). As the frequency declined, underfrequency relays shed approximately 1544 MW in steps beginning at 59.2 Hz and continuing through 57.1 Hz. The load generation imbalance continued and the frequency dropped to a minimum value of 49 Hz (See Figure 3). Turkey Point Unit 1 and

Port Everglades Units 1 and 3 were tripped by operation of generator underfrequency protection set at 57.0 Hz with a 12 second delay. Turkey Point Unit 2 was tripped by a bearing oil low pressure signal.

Approximately four seconds after 10:24 a.m. St. Lucie Unit 1 was tripped manually following a load rejection due to high frequency. Prior to this time the St. Lucie Operator had reported low system voltage, and excessive reactive and armature current on the unit. The Riviera units were carrying approximately 532 MW prior to separation of the system and were isolated into an area with 105 MW of load. After six minutes, the operator opened the generator oil circuit breakers due to operating problems.

The outage then extended from Ft. Pierce to the Florida Keys and affected approximately 1,300,000 customers. Service was restored to almost all customers by 3:00 p.m.

The east and south areas had been importing approximately 1140 MW just prior to the system split due to the earlier forced outage of Turkey Point Unit 3 at 10:08 a.m. This generation loss of 634 MW had isolated Peninsular Florida but the combined spinning reserve of the Florida Systems had been sufficient to cover the loss and arrest the frequency decline at 59.59 Hz. At 10:14 a.m. Peninsular Florida had been tied back to the systems to the north. See Figures 4 and 5 for details of inter-area flows, tie flows, loads, generation and spinning reserve.

DESCRIPTION OF DISTURBANCE

Loss of Turkey Point Unit 3

At 10:08 a.m., May 16, 1977 Turkey Point Unit 3 experienced a reactor and turbine trip as a result of a false relay operation. Chattering contacts in a sensing relay in a reactor coolant pump breaker monitor circuit gave false indication of the loss of a reactor coolant pump. Turkey Point Unit 3 was generating 684 MW at the time of the trip. Peninsular Florida became isolated from systems to the north when Florida Power Corporation's Suwannee-Archer 230 kV line, two Ft. White-Inglis 115 kV lines, and Ft. White-Jasper 69 kV line relayed sequentially due to instability. The frequency dropped to 59.59 Hz where the decline was arrested as a result of governor response.

The system Power Coordinator attempted to order gas turbines started at Ft. Myers Plant. The generators in Peninsular Florida began to pick up the frequency and at 10:14 a.m. the north-south lines were re-established and the frequency returned to 60 Hz. It was discovered that the order to start Ft. Myers gas turbines had not been received. They were again ordered to be brought on line and loaded. In the meantime Port Everglades Unit 2 which had been synchronized to the system at 9:33 a.m. tripped off line carrying 38 MW due to low drum level. Transmission voltage in the Miami area was approximately 95% of normal.

The St. Lucie operator reported low system voltage, excessive reactive on the unit and excessive armature current. The unit was operating in excess of its rated capacity of 1000 MVA. Relief was needed or the unit would have to be removed from service. System

voltage had dropped to 230 kV from a normal of 238 kV. Reactive loading was 700 MVARs. Armature current was 27,000 amps on a maximum rating of 26,000. The Dispatcher was again notified but could not relieve the problem. The Operations Supervisor then instructed the Operator to reduce voltage to protect the unit. System voltage at St. Lucie fell to 219 kV. Reactive loading was reduced to 550 MVARs.

The Southern Division Dispatcher was ordered to switch on all substation capacitors. The Northern Division Dispatcher was ordered to raise the voltage in the Brevard area as much as possible.

An attempt was made to start gas turbines at Lauderdale and Port Everglades from the Power Coordinator's Control Console. None started at Port Everglades. Three gas turbines were started locally at Lauderdale, but failed to synchronize due to low voltage.

Loss of the Ft. Myers-Ranch 240 kV Line

At 10:24 a.m. the Ft. Myers-Ranch 240 kV line relayed due to a phase-to-ground fault. Just prior to this relay action the line was carrying approximately 420 MW. The loss of the Ft. Myers-Ranch 240 kV line resulted in a further increase in flow south from Malabar. This power swing resulted in the separation of the east and south areas from the remainder of the system at 10:24 a.m. (See Figure 1) The sequence of relay and breaker operations is given in Figure 6.

The St. Lucie Unit 1 load spiked from 790 MW to 850 MW just prior to the transmission line separation south of the St. Lucie Plant. The frequency then went high when the transmission lines opened to the south. Governor action decreased the load rapidly. Approximately four seconds later, St. Lucie Unit 1 reactor was tripped manually following load rejection to about 100 MW. The Riviera units were carrying approximately 532 MW prior to the separation of the system. Riviera Units 3 and 4 became "islanded" with 105 MW of load. The boiler fires were lost due to a master fuel trip on the load rejection. The frequency was above 62 Hz and was being lowered by the operator. After about 6 minutes the operator opened the generator oil circuit breakers manually due to frequency instability when the units went above 62 Hz a second time. The units carried their own auxiliaries.

The frequency in the remaining affected area decreased rapidly due to Turkey Point Units 1 and 2 and Port Everglades Units 1 and 3 with 1003 MW of generation being left to serve approximately 2957 MW of load (See Figures 2 and 3). As the frequency dropped, underfrequency relays shed approximately 1544 MW in stages between 59.2 Hz and 57.1 Hz. Load shedding was completed at approximately 2-1/2 seconds at which time frequency was 56.3 Hz. The load and generation imbalance continued and the frequency dropped to a low of 49 Hz in approximately 5 seconds. Port Everglades Units 1 and 3 and Turkey Point Unit 1 were tripped by operation of generator underfrequency

protection set at 57.0 Hz with a 12 second delay. Frequency was 53.8 Hz. Turkey Point Unit 2 was tripped with low bearing oil pressure signal as the turbine speed decreased. Underfrequency relays operated, but one 240 kV oil circuit breaker failed to trip when the lock-out relay contacts failed to make up. See Figure 7 and 8 for a summary of events and summary of plant performance during the disturbance.

In the remainder of the system, north and west of the split, frequency increased to above normal but recovered to 60 Hz as the Florida Power ties to the north were re-established. The remaining system load was 1558 MW and generation was 1798 MW. Net export was 240 MW until scheduled interchange was re-established.

INITIAL SERVICE RESTORATION

The Power Coordinators proceeded to identify the affected area and reconnect the system. Restoration proceeded from the north by energizing the 240 kV transmission lines to the south. At 12:03 p.m. the total system load was 3408 MW with 3318 MW of generation and 90 MW of import from neighboring utilities.

Loss of the Andytown-Orange River 500 kV Line

At 12:03 p.m. the fault pressure relay on the "A" phase 500-240 kV autotransformer at Andytown operated incorrectly when the auxiliary cooling pumps were started. Approximately 652 MW were being carried on the 500 kV circuit when the trip was initiated. See Figure 9 for load, generation, and inter-area flow data. This initiated a power swing which resulted in the separation of the east and south areas

at Ft. Myers and Malabar. See Figure 10 for the area affected. Generation in the affected area, consisting of gas turbines and Riviera Units 3 and 4, was lost.

SERVICE RESTORATION

The affected area was quickly identified and immediate restoration proceeded from the north. Gas turbines quickly picked up isolated areas and were resynchronized with the system. Start-up power was provided to the steam units rapidly from the restored 240 kV system.

Service was restored to all but a few isolated areas by 3:00 p.m. There was no significant damage to generating equipment. All units were returned to service during the day.

SYSTEM CONDITIONS

Prior to the disturbance, the system load was 4660 MW with generation of 4710 MW. The system spinning reserve was 400 MW with an additional 1022 MW of available steam reserve and 1371 MW of fast start combustion turbines and diesels. All line flows were well within limits. Area load and generation data is given in Figure 4 for the loss of Turkey Point Unit 3 disturbance, Figure 2 for the loss of the Ft. Myers-Ranch 240 kV Line, and Figure 9 for the loss of the Andytown-Orange River 500 kV Line. Figure 5 gives the unit loading and reserves at 10:08 a.m. prior to any disturbances.

DISCUSSION

A detailed review and analysis of the events prior to the disturbance and the subsequent restoration of service has been conducted. A number of specific items which individually would be of lesser consequence, together contributed to the disturbance or hindered restoration.

Ft. Myers-Ranch 240 kV Line

The Ft. Myers-Ranch 240 kV line along with the Ft. Myers-Ranch 138 kV line and the Andytown-Orange River 500 kV line are the three transmission ties between the east and south areas and the west coast. The disturbance was triggered by a temporary phase-to-ground fault on B phase while the line was loaded to approximately thermal rating.

Examination of the operating records of certain critical transmission lines (See Figure 11) indicates this line has had 23 actions since January 1, 1976. Of these relay actions, 20 were of unknown origin. A concerted effort is being made to determine the reason for the poor operating record of this line and to develop recommendations for improvement.

Reclosing Practices

Studies of high speed reclosing practices following prior disturbances have shown the danger of high speed reclosing following stability swings. FPL has added relay equipment to sense out-of-step conditions in order to block reclosing following trip due to power swings.

Although tripping of the Ft. Myers-Ranch 240 kV line was initiated by a phase-to-ground fault, the blocking relay at Ft. Myers was made up due to the heavy line loading inhibiting high speed reclosing. The Ranch terminal reclosed. After about three seconds, the Ranch terminal again tripped due to a B phase-to-ground fault, and locked out. It is unknown whether successful high speed reclosing would have prevented system separation, but a review of reclosing practices under present system conditions has been initiated.

Fault Pressure Relays

Fault pressure relays are mechanical devices used on transformers to detect internal faults by the sudden pressures generated by these faults. These relays when set to trip, provide positive backup protection for the transformer on which they are installed. Difficulties with calibration, and false operation from vibration and/or external faults have occurred. While modifications and revised test procedures have reduced the problem, since 1971 fault pressure relays on autotransformers on FPL system have been wired to alarm only.

When the autotransformers at Andytown and Orange River were installed this practice was reviewed. The 560 MVA single phase 500-240 kV units had experienced two failures in test. Delivery schedules had been extended such that the spare units would not be available until after the line was converted. The line, at 500 kV, was needed for

system reliability. Because of these factors, it was decided to initially wire these relays to trip in order to limit transformer damage that might occur from an internal fault.

At 12:03 p.m. the fault pressure relay on "A" phase 500-240 kV autotransformer operated incorrectly when the auxiliary cooling pumps were started. Over 650 MW was being carried over the line and the system was shut down for a second time approximately one and one-half hours into the initial restoration.

Subsequent tests have shown the relay on "A" phase to be oversensitive to pressure. Tripping by all fault pressure relays at both Orange River and Andytown has been disabled. With the installation of spare units at both locations it is planned to wire these relays for alarm only, consistent with current practices.

Gas Turbine Automatic Synchronizing

There are 24 gas turbines installed at the Lauderdale Plant. Twenty were available for service and on remote supervisory control. Four gas turbines were out for routine maintenance.

At 10:13 a.m. the Dispatcher requested that three gas turbines be placed in service. The gas turbines started, came up to speed and at 10:20 a.m. were ready to synchronize to the system. However, the machine/line voltage matching feature of the auto-synchronization system did not allow breakers to close because machine voltage could not be lowered enough to match the extreme low voltage on the system.

The voltage regulator bandwidth on the gas turbines at Lauderdale Plant is presently designed such that automatic synchronizing can be accomplished only when the system voltage is between 15.2 kV and 12.9 kV. During the period following the trip of Turkey Point Unit 3 and prior to tripping the Ft. Myers-Ranch 240 kV, attempts were made by the Power Coordinators to start the Lauderdale and Port Everglades gas turbines. At that time voltage on the Lauderdale gas turbine bus was 11.5 kV or 11% below the lower limit for automatic mode. Before the Operator could synchronize the units manually, the fault had occurred and the system separated.

These settings have since been verified as well as tests conducted with the bandwidth "adjusted" both higher and lower. The manufacturer has been contacted regarding the limits essential for protection of the unit. Power Coordinators were not previously aware of this limitation. In addition, no metering is available in the System Dispatch Office for reading voltage on the Lauderdale bus. Engineering has begun to telemeter the Lauderdale 240 kV bus voltage to the System Dispatch Office. Transformer tap settings at Lauderdale and Port Everglades have been changed to provide better coordination at lower system voltages.

Operating Philosophy

The Operating Committee of the Florida Electric Power Coordinating Group coordinates the operation of all systems within Peninsular Florida and establishes operational guides, practices and procedures

on spinning reserve, load shedding and emergency operating procedures. The Florida systems are designed and operated to allow loss of the largest unit in the state without loss of load. The required spinning reserve to accomplish this is allocated among systems on the basis of unit size and system peak load. Distribution of the spinning reserve allocation within an individual system is a function of area protection, unit availability and economics.

The FPL system had responded in a "normal" manner following the trip of Turkey Point Unit 3 at 10:08 a.m. By 10:14 a.m. ties between Florida and the Southern Company had been re-established and the frequency returned to 60 Hz. There were heavy imports of power into South Florida. It would appear that the system was stable. Stability studies are under way to verify this. At 10:24 a.m. this major power outage occurred as a result of a second contingency outage, loss of a major operating transmission line in addition to the loss of a major generating unit.

Providing sufficient spinning reserve in any area to cover a second contingency outage is a matter of balancing cost and risk. These factors must be dealt with by Power Coordinators daily. Installation of the System Control Center in late 1978 will provide the ability for security analysis to improve reliability. However, until then it must be dealt with on a subjective basis.

Studies to quantify cost versus probability of risk are being conducted and operating guidelines developed.

Transmission Planning

A longer range alternative to additional spinning reserve for double contingency protection is the strengthening of transmission ties into the east and south load areas. An example of this is the Andytown-Ft. Myers 500 kV line. Conversion of this line from 240 kV to 500 kV was advanced from 1979 to 1977 to increase reliability. Acceleration of present transmission plans should be evaluated and weighed against the cost of increased spinning reserve to reach a determined level of reliability.

RECOMMENDATIONS

1. T&D Operations/General Engineering - Conduct investigation and make recommendations to improve operating performance of the Ft. Myers-Ranch 240 kV Line.
2. System Planning/System Protection/General Engineering - Conduct review of current practices and designs relating to high speed reclosing of transmission lines.
3. General Engineering - Review current application of fault pressure relays on autotransformers and generator step-up transformers. Investigate to determine all installations are in conformance.
4. Power Resources - Determine optimum settings for gas turbine voltage regulators considering both generator protection and system reliability. Coordinate settings with System Operations.

5. General Engineering - Procure material and engineer jobs to telemeter Lauderdale 240 kV bus voltage to the System Dispatch Office.
6. System Operations/System Planning - Conduct studies to quantify cost versus benefit of providing spinning reserve for second contingencies. Establish operating procedures accordingly.
7. System Planning - Evaluate acceleration of transmission expansion as an alternative to increased spinning reserve.

Figure 1

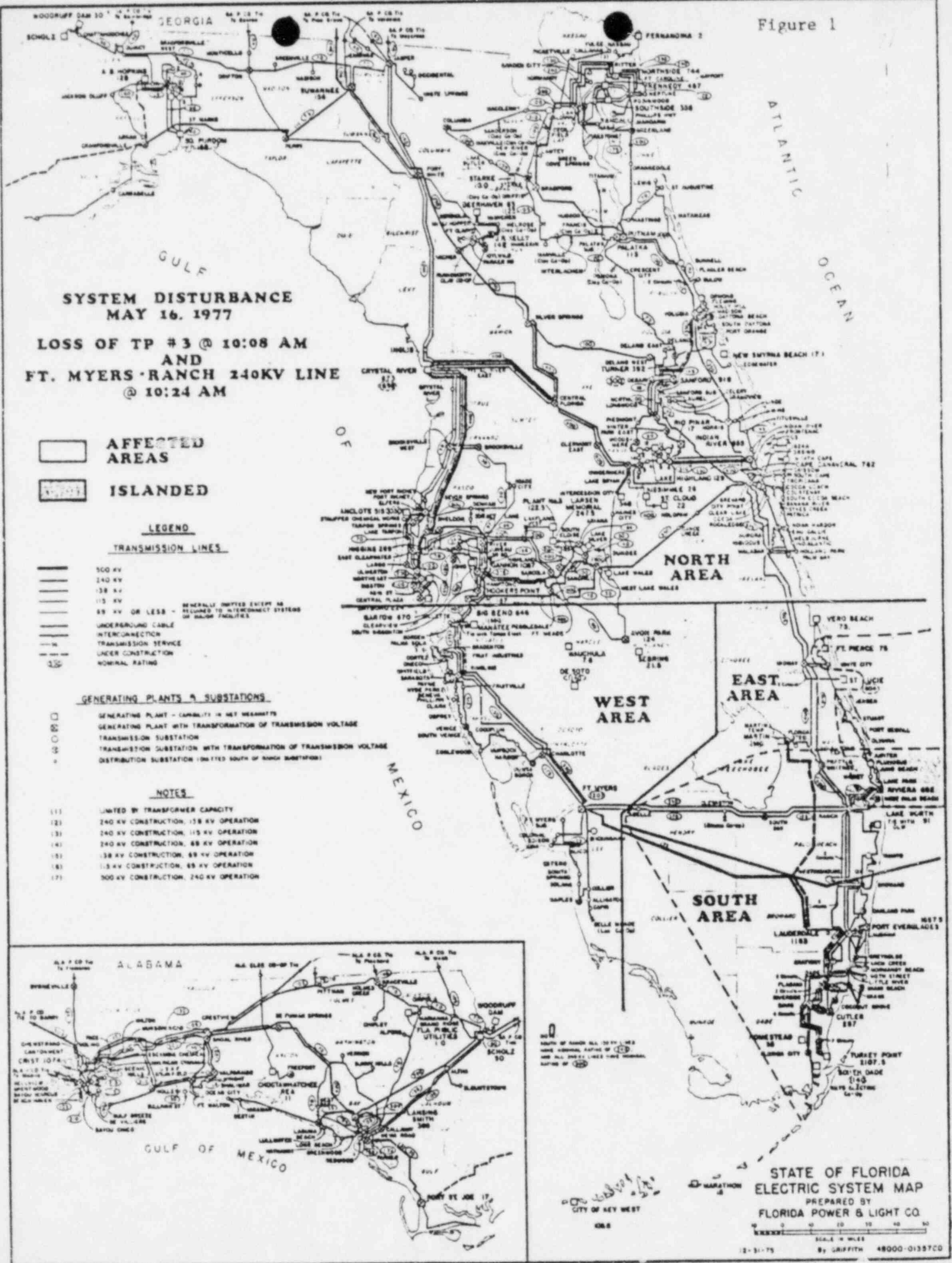
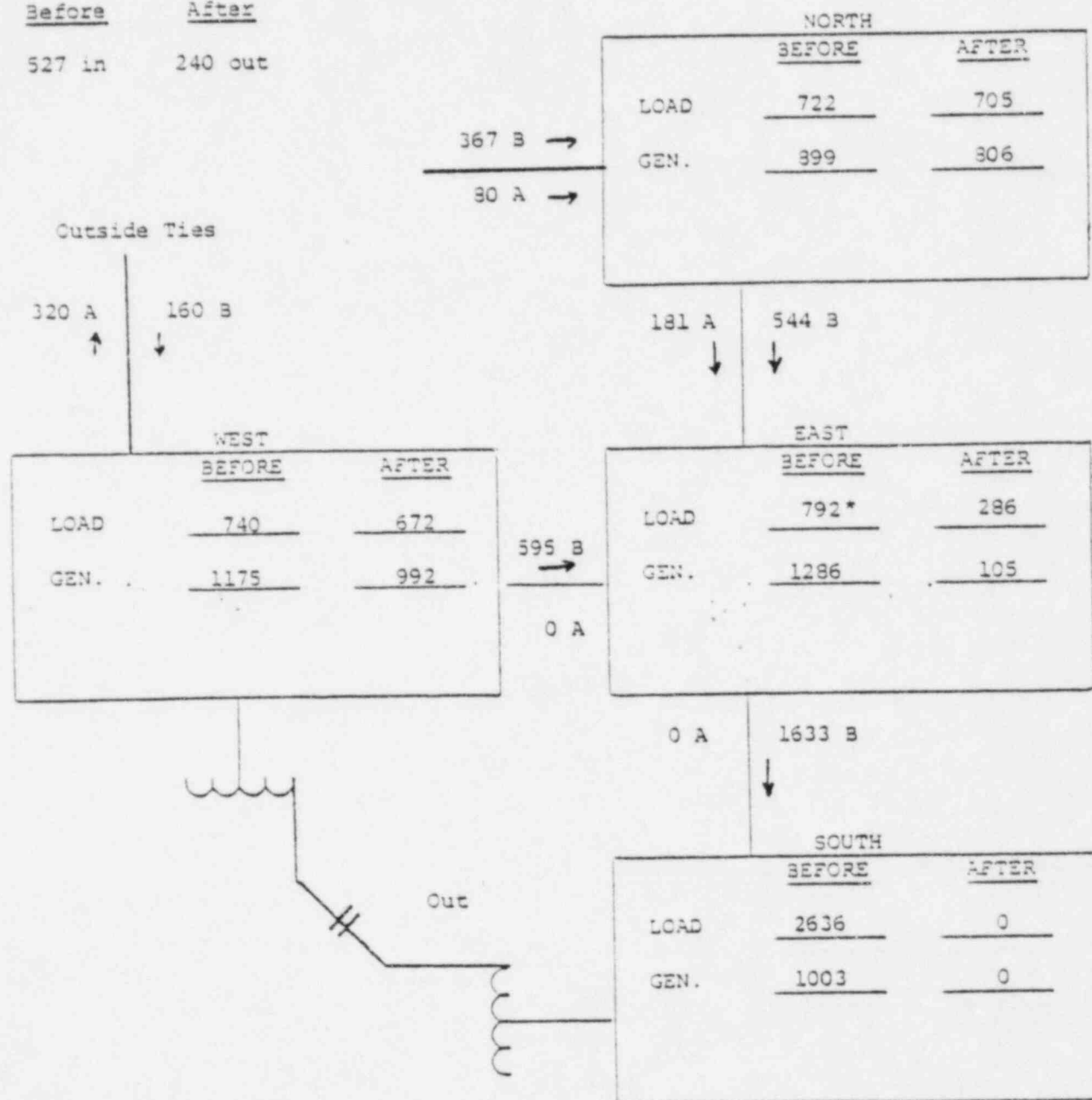


Figure 2

EVENT Loss of Ft. Myers - Ranch 240kV Line TIME 10:24 a.m.

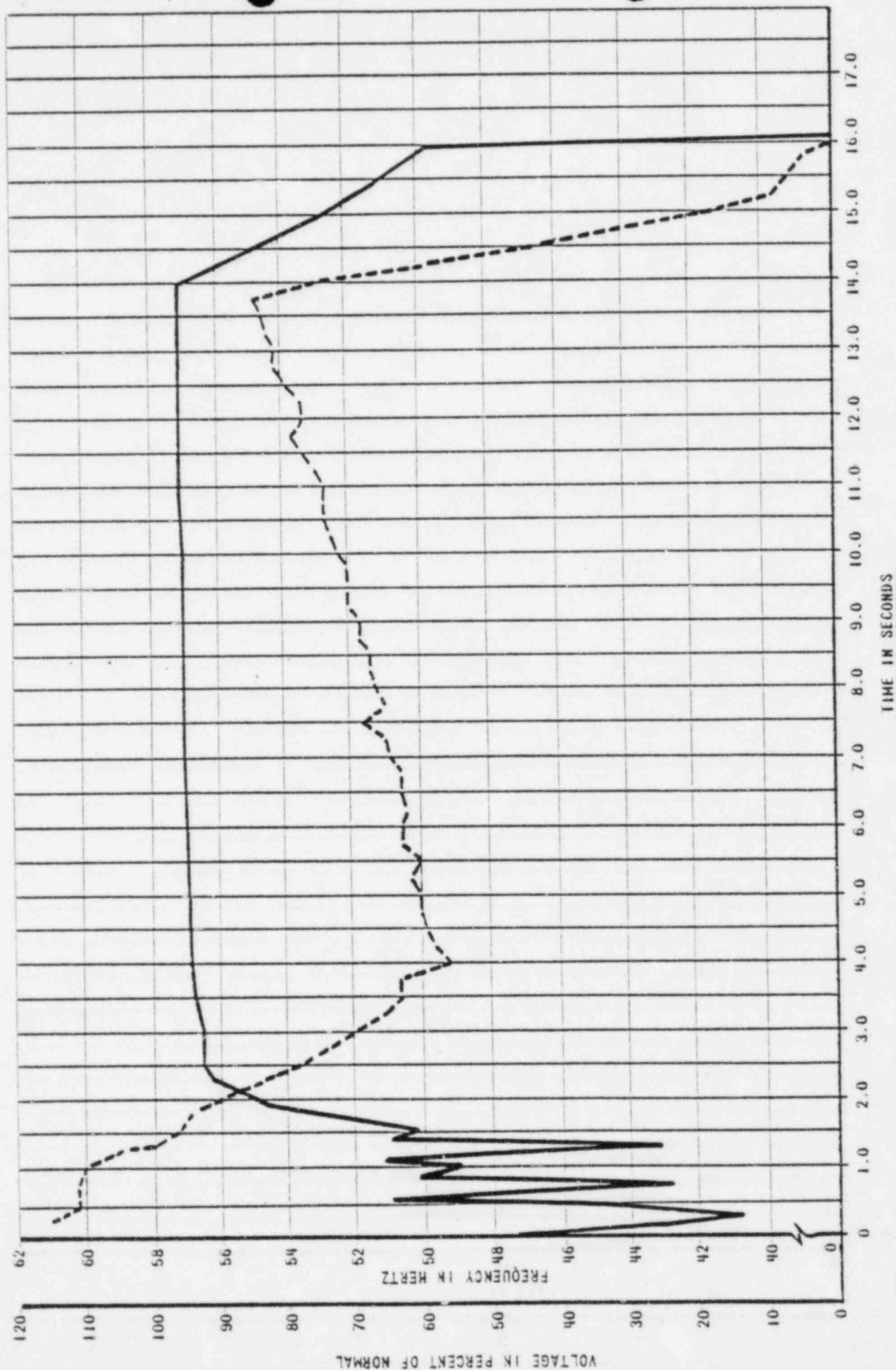
Net Interchange
Before After
 527 in 240 out



<u>SYSTEM</u>	<u>BEFORE</u>	<u>AFTER</u>
LOAD	4890	1663
GEN.	4363	1903

A=After
 B=Before

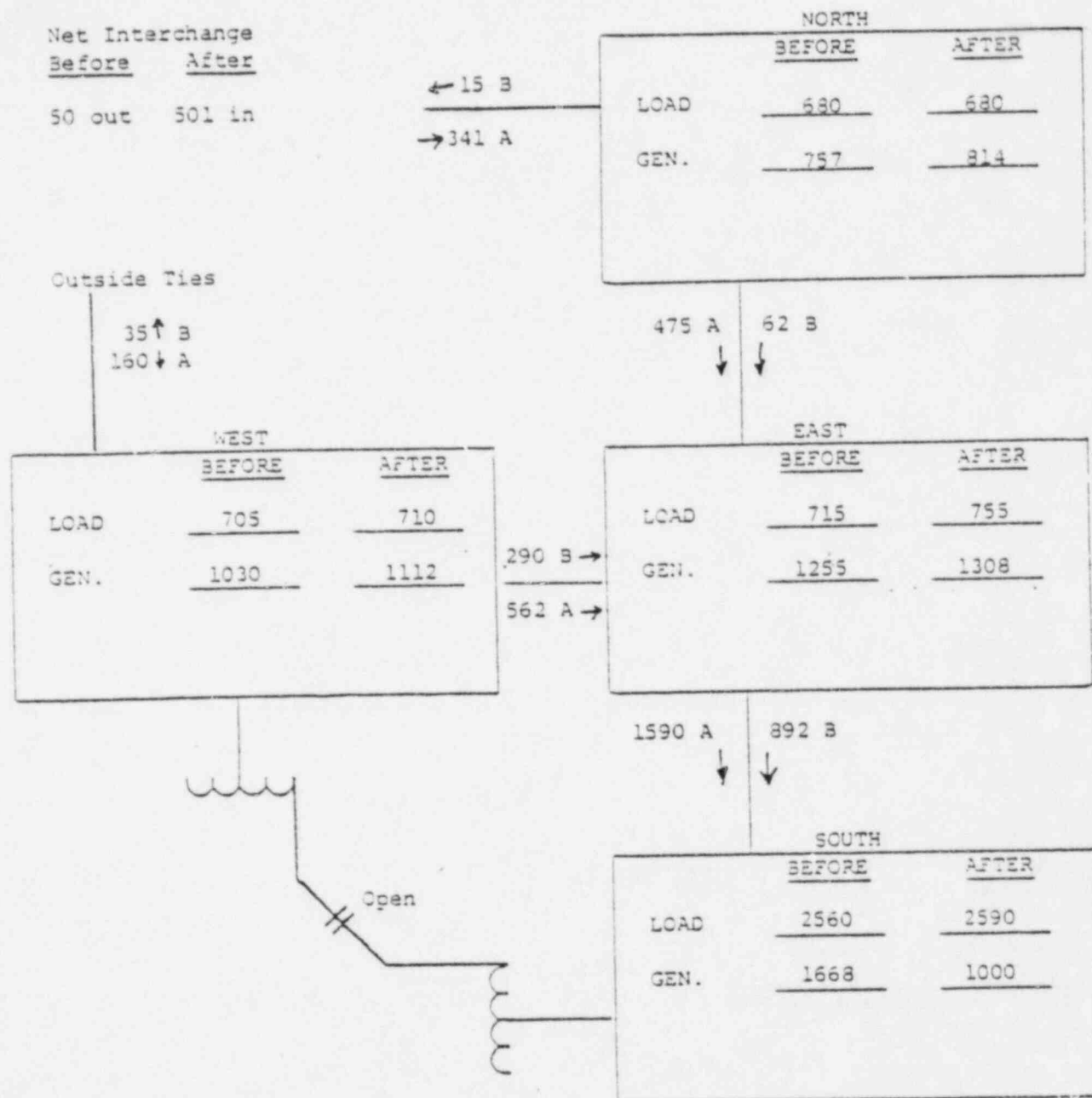
*321 MW isolated with South area after system split.



FREQUENCY & VOLTAGE VS TIME
 MEASURED ON THE RANCH LINE TERMINAL
 AFTER THE PRATT & WHITNEY-RANCH 240 KV LINE OPENED
 AT 10:24 AM FOR MAY 16, 1977 DISTURBANCE

LEGEND:
 — VOLTAGE
 - - - FREQUENCY
 TIME 0 = 10:24:01 AM

Figure 4

EVENT Loss of Turkey Point #3TIME 10:08 a.m.

SYSTEM	BEFORE	AFTER
LOAD	4660	4735
GEN.	4710	4234

A=After
B=Before

FLORIDA POWER & LIGHT COMPANY
NET UNIT CAPABILITY-MW AT 10:08 AM
MAY 16, 1977

PLANT UNIT	CONTINUOUS RATE	EXP.	ACTUAL LOAD	SR	NORMAL	LIMITATION
TP#1	369	369	328	41		
TP#2	369	185	188	0	5 PM	Seal leak "A" BFP.
TP#3	681	681	684	0		
TP#4	681	0	0	-	7-17-77	Refuel.
FL#4	138	0	0	-	RFC 12:30P	
FL#5	138	0	0	-	RFC 2:00P	
PE#1	205	90	90	0		Condenser leak.
PE#2	205	0	38	0	RFC 11:00A	Not released.
PE#3	368	368	340	28		
PE#4	368	0	0	-	5-28-77	Overhaul.
	3522	1693	1668	69		
RV#3	273	273				
RV#4	273	273	501	45		
SL#1	309	751	754	-	Unknown	Heater drain pump out.
	1355	1297	1255	45		
CC#1	369	369	333	36		
CC#2	364	173	166	7	5-18-77	2B FD fan motor repair.
SN#3	138	0	0	-	RFC 2:00P	
SN#4	370	370	258	61		
SN#5	370	0	0	-	RFC 1:00P	
	1611	912	757	104		
FM#1	138	138	106	23		
FM#2	369	369	339	30		
MT#1	772	772	585	129		
	1279	1279	1030	182		
STEAM	7767	5181	4710	400		
DSL	27	24	0	0		PE #2 will not start.
GTPE	338	310	0	0	5-16-77	#12 maint.
GTFL	676	676	0	0		#19 base only.
GTFM	612	561	0	0	5-20-77	#7 gen. ground.
	1653	1571	0	0		
TOTAL	9420	6752	4710	400		

Scheduled interchange = 0

Required Spinning Reserve = 337

Expected Mon. a.m. peak = 5000

Sun. p.m. peak was 4442 MW.

Weather: Mostly sunny today and Tuesday. Hi in lo 80's. Lo in lo 70's.

Wind East 10 MPH.

SYSTEM DISTURBANCE
MAY 16, 1977
SEQUENCE OF RELAY AND CIRCUIT BREAKER OPERATIONS

EVENT NO.	TIME	STATION	CIRCUIT	EVENT	RELAY TARGETS	REMARKS
1	10:08AM	Turkey Point	Unit No. 3	Tripped		Defective type BFD auxiliary relay in Reactor Coolant Pump motor circuit breaker cubicle caused reactor trip.
2	10:09:50AM	Port Everglades	Unit No. 2	Tripped		Manually. Unit had been synchronized to the system at 9:33AM. Boiler tripped due to low drum level.
3	10:24AM	Ft. Myers	Ft. Myers-Ranch 240kV	Opened	PZ1, G1	Broward, Midway and Ringling oscillographs recorded phase to ground fault at this time. Ringling oscillogram indicated B-Phase to ground fault. Ft. Myers terminal did not reclose because out-of-step reclose blocking relay was picked up on load prior to fault.
		Ranch	Ft. Myers-Ranch 240kV	Opened	GP	
4	+5 Cycles	Ft. Myers	Ft. Myers-Ranch 138kV	Opened	A,B,C,PP	Time assumed. Ft. Myers terminal did not reclose because of special circuit to allow reclosing through check synchronizing relay only, and only when line is energized. Area east of Ft. Myers was out of synchronism before check synchronism relay could operate.
5	+20 Cycles	Ranch	Ft. Myers-Ranch 240kV	Reclosed		Time assumed.
6	+53 Cycles	Malabar	Malabar-Midway 240kV No. 1	Opened	B,PP	Out-of-step relay operated to prevent reclosing.
7	+55 Cycles	Midway	Midway-Ranch 240kV	Opened	A,B,PP,Z1	Out-of-step relay operated to prevent reclosing.
8	+55 1/4 Cycles	Plumosis	Midway-Plumosis 138kV	Opened	A,B,C,PP,Z1	Reclosed at +80 cycles and tripped again at +89 cycles. Targets are for two trips.
9	+60 Cycles	Pratt & Whitney	Pratt & Whitney-Ranch 240kV	Opened	B,C,Z1	Out-of-step relay operated to prevent reclosing.
		Ranch	Pratt & Whitney-Ranch 240kV	Opened	A,Z1	
10	+78 Cycles	Broward	Broward-Ranch 138kV	Opened	A,C,PP	Out-of-step relays operated to prevent reclosing at both terminals.
		Ranch	Broward-Ranch 138kV	Opened	A,C,PP	

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EVENT NO.	TIME	STATION	CIRCUIT	EVENT	RELAY TARGETS	REMARKS
11	Unknown	Hartman	Hartman-Midway 69kV	Opened	None Reported	Operations based on supervisory control computer printout.
12	Unknown	Hartman	Hartman-Midway 69kV	Reclosed		
13	+80 Cycles	Plumosos	Midway-Plumosos 138kV	Reclosed		
14	+82½ Cycles	Riviera	Ranch-Riviera 138kV No. 2	Opened	B,C,Z2	
15	+86½ Cycles	Riviera	Ranch-Riviera 138kV No. 3	Opened	B,C,Z2	
16	+89 Cycles	Midway	Midway-Plumosos 138kV	Opened	A,B,C,PP	
		Plumosos	Midway-Plumosos 138kV	Opened	See Event No. 8	
17	+91½ Cycles	Ranch	Ranch-Riviera 138kV No. 1	Opened	A,B,C,Z3	Targets for two trips.
18	+115 Cycles	Ranch	Ranch-West Palm Beach 138kV	Opened	C,PP,Z1	Reclosed at +133 cycles and tripped again at +148½ cycles. Targets are for two trips. Assume zone one relay operated on second trip since its operation blocks reclosing.
19	+133 Cycles	Ranch	Ranch-West Palm Beach 138kV	Reclosed		
20	+148½ Cycles	Ranch	Ranch-West Palm Beach 138kV	Opened	See Event No. 18	
		West Palm Beach	Ranch-West Palm Beach 138kV	Opened	A,B,C,PP,Z1	
21	+195 Cycles	Ranch	Ft. Myers-Ranch 240kV	Opened	GP	Broward oscillograph recorded phase to ground fault.
22	+288 Cycles	St. Lucie	Unit No. 1	Tripped		Manually
23	Unknown	Port Everglades	Unit No. 1	Tripped	UF	
24	Unknown	Port Everglades	Unit No. 3	Tripped	UF	
25	Unknown	Turkey Point	Unit No. 1	Tripped	UF	
26	Unknown	Turkey Point	Unit No. 2	Tripped	Low Bearing Oil Pressure	Underfrequency relays operated but one 240kV circuit breaker failed to trip because lock-out relay contact failed to make up.

Exact time these units tripped is not known, but it can be assumed that underfrequency trips occurred about 12 seconds after Event No. 9. Turkey Point Unit No. 2 tripped sometime later.

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22 22
23 23
24 24
25 25
26 26

EVENT NO.	TIME	STATION	CIRCUIT	EVENT	RELAY TARGETS	REMARKS
27	Unknown	Riviera	Unit No. 3	Tripped		Manually
28	10:30AM	Ranch	Ranch-Riviera 138kV No. 1	Closed		Manually
29	+45 Cycles	Ranch	Ranch-Riviera 138kV No. 1	Opened	See Event No. 17	
30	+48 Cycles	Riviera	Ranch-Riviera 138kV No. 1	Opened	B,C,PP	
31	+63 Cycles	Riviera	Ranch-Riviera 138kV No. 1	Reclosed		
32	+21 Seconds	Riviera	Unit No. 4	Tripped		Manually
33	12:03PM	Andytown	500/240kV Auto Trans Bank	Tripped	FPR A-Phase	Over-sensitive fault pressure relay operated when cooling oil pumps were started. This opened the Andytown-Orange River 500kV line.
34	+33 Cycles	Ft. Myers	Ft. Myers-Ranch 240kV	Opened	PP	Out-of-step relay blocked reclosing.
		Ft. Myers	Ft. Myers-Ranch 138kV	Opened	A,B,C,PP	Reclose through check synchronizing.
		Ranch	Ft. Myers-Ranch 138kV	Opened	A,B,C,PP	
35	+53 Cycles	Ranch	Ft. Myers-Ranch 138kV	Reclosed		
36	+77 Cycles	Malabar	Malabar-Midway 240kV No. 1	Opened	A,B,Z1	
		Malabar	Malabar-Midway 240kV No. 2	Opened	B,C,PP,Z1	
		Midway	Malabar-Midway 240kV No. 1	Opened	A,B,PP,Z1	
		Midway	Malabar-Midway 240kV No. 2	Opened	A,B,Z1	
37	+82 Cycles	Hartman	Hartman-Midway 69kV	Opened		
38	+94 Cycles	Midway	Malabar-Midway 240kV No. 1	Reclosed		Reason for failure of out-of-step relay to block reclosing has not been determined.
39	+96½ Cycles	Midway	Malabar-Midway 240kV No. 2	Reclosed		Reason for failure of out-of-step relay to block reclosing has not been determined.
40	+98 Cycles	Hartman	Hartman-Midway 69kV	Reclosed		

∴ Exact time this unit tripped is not known, but it was off prior to Event No. 28.

70 79
80 81
82 83
84 85
86 87
88 89
90 91
92 93
94 95
96 97
98 99
100 101

SUMMARY OF EVENTS
OF THE
INTERRUPTION AND RESTORATION
OF SERVICE
MAY 16, 1977

10:08 Turkey Point Unit 3 reactor trip.

10:10 Port Everglades Unit 2 tripped.

10:14 Frequency restored to 60Hz.

10:24 Ft. Myers-Ranch 240kV line tripped.

10:24 System separation.

10:24:04 St. Lucie Unit 1 tripped.

10:27 LaBelle picked up from Ft. Myers.

10:27:34 Midway-Plumosos picked up from Midway.

10:30 Riviera Units 3 and 4 removed from service.

10:36 Port Everglades GT's on line from black start.

10:39 Breakers closed at Midway to energize most of
the transmission south of Ranch to Andytown -
Lauderdale - Port Everglades.

10:45 Port Everglades GT's tripped from overload.

10:49 Port Everglades GT's started.

10:49 Ft. Myers - Ranch 240kV tied thru.

10:50 Ft. Myers - Ranch 138kV tied thru.

10:50 Lauderdale 138kV GT's on line from black start.

10:56 The Ranch - Riviera #1 138kV line energized.
to pick up the Ranch - Riviera load area.

10:57 Orange River - Andytown 500kV energized and
tied thru.

11:00 Lauderdale 240kV GT's on line.

11:03 Port Everglades GT's tripped from switching
on system.

11:07 Riviera Unit 4 on line.

11:07 Port Everglades GT's back on line.

11:10 Riviera Unit 3 on line.

11:11 Lauderdale - Dade #2 240kV line energized.

11:17 Dade - Turkey Point #2 240kV line energized.
Lauderdale end of Lauderdale - Dade #2 - 240kV
tripped.

11:18 Lauderdale GT's tripped - switching on system.

11:22 The Plumosus - Riviera 138kV lines energized.

11:26 Lauderdale - Dade #2 240kV line and Dade - Turkey
Point #2 240kV line energized from Lauderdale.

11:27 Lauderdale GT's back on line.

11:31 Turkey Point - Flagami #1 240kV line energized
from Turkey Point.

11:33 Flagami - Miami #2 240kV cable energized from
Flagami.

11:38 The Ranch - Broward 138kV line energized.

11:39 Greynolds - Lauderdale #1 138kV line energized
from Lauderdale to pick up entire Greynolds area
transmission.

11:41 Greynolds end of Greynolds - Lauderdale #1 138kV
line opened.

11:43 The Miami - Railway - Little River 138kV lines
energized.

11:46 The Lauderdale - Little River 138kV line
energized.

11:47 The Davis - Cutler - South Miami 138kV lines energized.

11:47 The Dade - Little River #1 138kV line energized.

11:48 The Lauderdale - Gratigny - Dade 138kV lines energized.

11:51 The Lauderdale - Greynolds #2 138kV line energized to pick up the Greynolds area.

11:51 The Dade - Little River #3 138kV line energized.

12:03 The Dade - Little River #2 138kV line energized.

All transmission lines and distribution substations energized. Distribution feeders were being energized as rapidly as increasing generation and line loadings would permit.

System load was 3408 MW.

12:03 Andytown 500-240kV autotransformers tripped.

12:03 Second system separation.

12:06 The Port Everglades buses stripped.

12:10 The Riviera Plant 138kV bus stripped.

12:11 The Midway 138kV bus stripped.

12:11 The Port Everglades GT's on line.

12:11 The Miami 138kV bus stripped.

12:13 Port Everglades - Hollywood 138kV line energized.

12:16 Port Everglades - Port 138kV energized.

12:16 The Ranch 138kV bus stripped.

12:16 Lauderdale GT's restarted.

12:19 The Ft. Myers - Ranch .40 energized, picking up transmission from Malabar to Lauderdale. The Malabar - Midway also closed.

12:55 Plumosus bus stripped.

12:57 Riviera - Plumosus #1 138kV energized.

13:00 Riviera - Plumosus #2 138kV energized.

13:08 Miami Beach 69kV transmission energized.

13:08 Ranch - Yamato - Broward 138kV transmission energized.

13:12 Orange River - Andytown 500kV tied thru.

13:12 Miami - Market - Little River 138kV energized.

13:13 Dade - Little River #2 138kV energized.

13:13 Dade - Airport 138kV energized.

13:16 Little River - Lemon City 138kV energized.

13:16 Flagami - Coconut Grove 138kV energized.

13:17 Midway - Plumosus 138kV energized.

13:22 Ranch - Ft. Myers 138kV energized.

13:22 Dade - Little River #3 138kV energized.

13:23 Ranch - Broward 138kV energized.

13:24 Lauderdale - Little River 138kV energized.

13:28 Broward - Lauderdale #2 138kV energized.

13:29 Lauderdale - Greynolds - Arch Creek - Normandy 138kV lines energized.

13:29 Broward - Lauderdale #1 138kV energized.

13:30 Hollywood energized.

13:30 Midway - Hartman - West 69kV energized.

13:32 Lauderdale - Hollywood 138kV energized.

13:34 Miami - Miramar 69kV energized.

13:35 Broward - Oakland Park - Ft. Lauderdale 138kV energized.

13:37 Lauderdale Unit 4 on line.

14:00 Lauderdale - Golden Glades 138kV energized.
14:01 Davis - Goulds 138kV energized.
14:01 Lauderdale - Gratigny #1 138kV energized.
14:02 Davis - Cutler - South Miami 138kV energized.
14:02 Davis - Florida City #2 138kV energized.
14:04 Riviera Unit 3 on line.
14:05 Gratigny - Golden Glades 138kV energized.
14:10 Florida City - Princeton energized.
14:13 Turkey Point Unit 1 on line.
14:21 Lauderdale Unit 5 on line.
14:21 Port Everglades Unit 2 on line.
14:37 Port Everglades Unit 3 on line.
14:45 Riviera Unit 4 on line.
15:28 Turkey Point Unit 2 on line.
17:55 Port Everglades Unit 1 on line.
21:18 Turkey Point Unit 3 on line.
21:58 St. Lucie Unit 1 on line.

SUMMARY OF PLANT PERFORMANCE - SYSTEM DISTURBANCE MAY 16, 1977

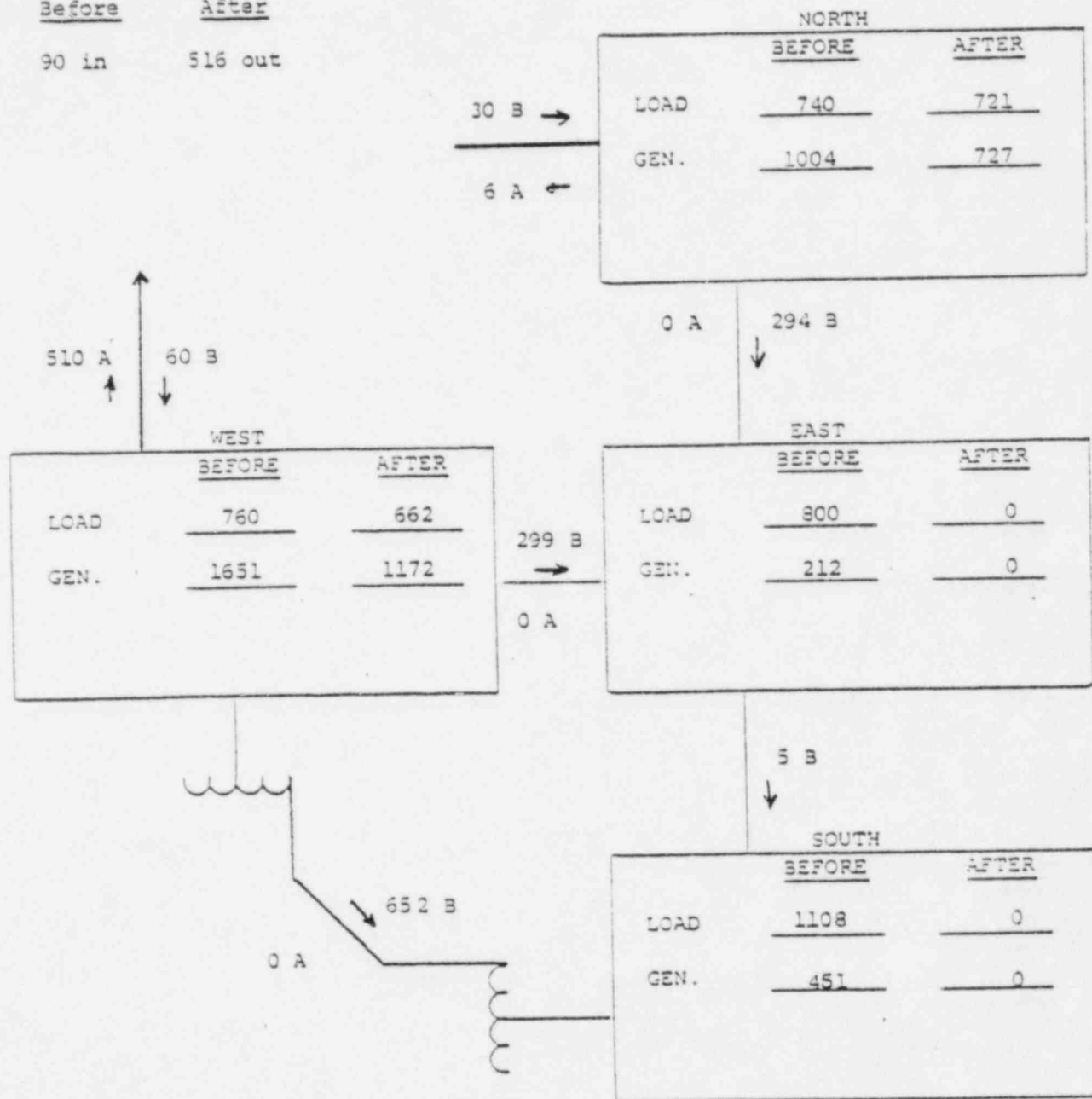
	10:07AM Load Before PTP Unit 3 Trip	10:08AM Load After PTP Unit 3 Trip	10:24AM Load After Ft. Myers/ Ranch Trip	12:02PM Load Before Andytown Trip	12:03PM Load After Andytown Trip	Generator Tripped By	Turbine Tripped By	Boiler Tripped By	Returned To System For Load- ing	Outage Time
	MW (GROSS)	MW	MW	MW	MW					
PTP 1	340	375	500+	0	0	U-F Action	Manually	R.H. Protec- tion	2:13PM	3 hrs-49 min.
PTP 2	200	220	454	0	0	Lockout Relay	Bearing Oil L.P.T.	R.H. Protec- tion	3:28PM	5 hrs-4 min.
PTP 3	720	0	0	0	0	Anti- motoring trip	Reactor Trip	False Relay Action	9:18PM	11 hrs-10 min.
PTP 4	Off For Refueling		-	-	-	-	-	-	-	-
PPE 1	100	112	210	0	0	U-F Action	Manually	M.F.T.	5:55PM	7 hrs-36 min.
PPE 2	40	54	0	0	0	Manually	Manually	Low Drum Level	2:21PM	4 hrs-11 min.
PPE 3	360	383	500+	0	0	U-F Action	Manually	Fuel Trip	2:37PM	4 hrs-13 min.
PPE 4	Off On Overhaul		-	-	-	-	-	-	-	-
PPE-GT	0	0	0	210	210	Over- current	-	-	12:23PM*	20 min.
PFL 4	0	0	0	0	0	-	-	-	1:37PM	-
PFL 5	0	0	0	0	0	-	-	-	2:21PM	-
PFL GT	0	0	0	270	325	Over- current	-	-	12:27PM	24 min.
PRV 3	266	280	283	110	270	10:30 Manually 12:03- Lockout	10:30 Carried auxs. 12:03- Thrust Brg	10:30 Manually 12:03- Loss of Fans	11:10AM & 2:04PM	2 hrs-41 min.
PRV 4	256	268	288	114	270	10:30 Manually 12:03- Lockout	10:30 Carried auxs. 12:03- Thrust Brg	10:30 Manually 12:03- Loss of Fans	11:07AM & 2:45PM	3 hrs-19 min.
PSL 1	790	868	847	0	0	Anti- motoring Trip	Reactor Trip	Manually	9:58PM	11 hrs-34 min.

15
10
00

EVENT Loss of Andytown - Orange River 500kV TIME 12:03 p.m.

Net Interchange
Before After

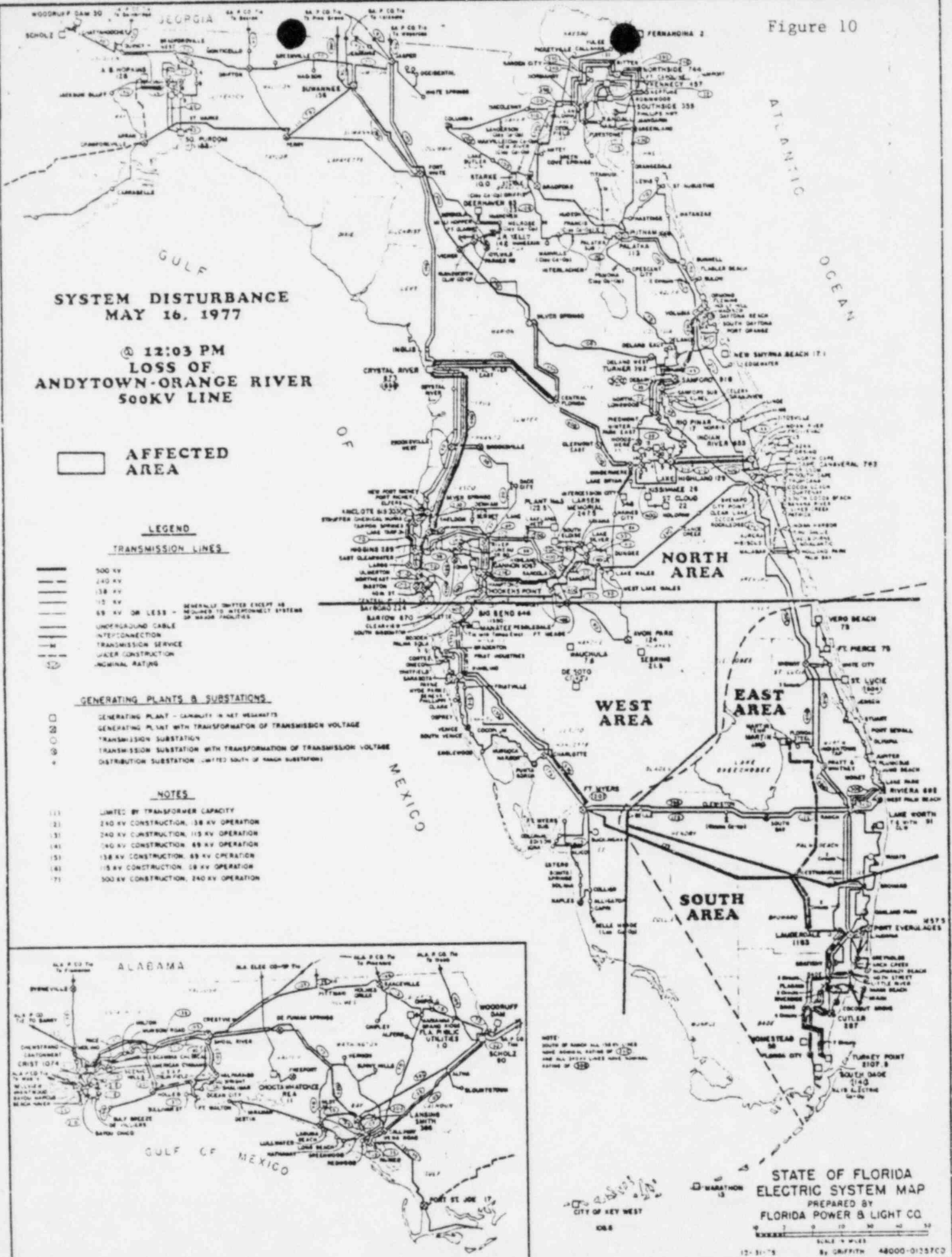
90 in 516 out



SYSTEM	BEFORE	AFTER
LOAD	3408	1383
GEN.	3318	1899

A=After
B=Before

Figure 10



FLORIDA POWER & LIGHT COMPANY
OPERATING RECORD OF CERTAIN
TRANSMISSION LINES
JANUARY 1, 1976 THRU MAY 15, 1977

Ft. Myers - Lauderdale 240kV Line

5/12/76 Lightning caused A-Phase to ground fault. Ft. Myers terminal reclosed successfully high-speed. Lauderdale terminal was closed manually one minute later.

Ft. Myers - Ranch 240kV Line

2/9/76	C-Phase to ground fault, cause unknown. Both terminals reclosed successfully high-speed.
5/25/76	C-Phase to ground fault, cause unknown. Both terminals reclosed successfully high-speed.
6/17/76	B-Phase to ground fault, cause unknown. Both terminals reclosed successfully high-speed.
6/24/76	A-Phase to ground fault, cause unknown. Both terminals reclosed successfully high-speed.
8/8/76	A-Phase to ground fault, cause unknown. Both terminals reclosed successfully high-speed.
10/7/76	Buzzard caused A-Phase to ground fault. Both terminals reclosed successfully high-speed.
11/6/76	A-Phase to ground fault, cause unknown. Both terminals reclosed successfully high-speed.
11/11/76 (8:00PM)	A-Phase to ground fault, cause unknown. Both terminals reclosed successfully high-speed.
11/11/76 (8:37PM)	A-Phase to ground fault, cause unknown. Both terminals reclosed successfully high-speed.
11/16/76	A-Phase to ground fault, cause unknown. Both terminals reclosed successfully high-speed.
11/19/76	A-Phase to ground fault, cause unknown. Both terminals reclosed successfully high-speed.

FLORIDA POWER & LIGHT COMPANY
OPERATING RECORD OF CERTAIN
TRANSMISSION LINES
JANUARY 1, 1976 THRU MAY 15, 1977

Ft. Myers - Ranch 240kV Line (Cont'd)

11/20/76 C-Phase to ground fault, cause unknown. Both terminals closed manually one-half minute later.

12/7/76 A-Phase to ground fault, cause unknown. Both terminals reclosed successfully high-speed.

12/14/76 B-Phase to ground fault, cause unknown. Ft. Myers terminal reclosed successfully high-speed. Ranch terminal closed manually one-quarter minute later.

12/19/76 C-Phase to ground fault, cause unknown. Both terminals reclosed successfully high-speed.

12/20/76 C-Phase to ground fault, cause unknown. Ft. Myers terminal reclosed successfully high-speed. Ranch terminal closed manually three-quarters minute later.

12/25/76
(2:12PM) B-Phase to C-Phase fault, cause unknown. Both terminals closed manually one-half minute later.

12/25/76
(2:13PM) C-Phase to ground fault, cause unknown. Both terminals reclosed successfully high-speed.

1/2/77 A-Phase to C-Phase fault, cause unknown. Both terminals reclosed high-speed.

1/28/77 Cane burning under the line caused a C-Phase to ground fault. Ft. Myers terminal reclosed successfully high-speed and Ranch terminal was closed manually one-half second later.

1/29/77 Cane burning under the line caused C-Phase to ground fault. Ft. Myers terminal closed manually one-half minute later and Ranch terminal closed manually three-quarters minute later.

2/8/77 C-Phase to ground fault, cause unknown. Ft. Myers terminal reclosed successfully high-speed. Ranch terminal closed manually one-quarter minute later.

3/18/77 C-Phase to ground fault, cause unknown. Both terminals reclosed successfully high-speed.

Ft. Myers - Ranch 138kV Line

4/8/76 A-Phase to ground fault, cause unknown. Both terminals reclosed successfully.

FLORIDA POWER & LIGHT COMPANY
OPERATING RECORD OF CERTAIN
TRANSMISSION LINES
JANUARY 1, 1976 THRU MAY 15, 1977

Ft. Myers - Ranch 138kV Line (Cont'd)

- 11/3/76 B-Phase to ground fault, cause unknown. Both terminals reclosed successfully high-speed.
- 12/22/76 Cane burning under the line caused three-phase fault. Ft. Myers and Ranch terminals closed manually one minute and three-quarter minutes later respectively.
- 1/11/77 C-Phase to ground fault, cause unknown. Both terminals closed manually one-half minute later.
- 1/27/77 B-Phase to C-Phase fault, cause unknown. Ft. Myers and Ranch terminals closed manually one-half minute and one-quarter minute later respectively.
- 1/28/77 C-Phase to ground fault, cause unknown. Both terminals reclosed successfully.
- 2/28/77 C-Phase to ground fault caused by failure of potential device at Ranch terminal. Both terminals closed manually one-half minute later.

Indiantown - Midway 240kV Line

No operations

Indiantown - Pratt & Whitney 240kV Line

No operations

Midway - Pratt & Whitney 240kV Line

- 9/29/77 C-Phase to ground fault, cause unknown. Both terminals reclosed successfully high-speed.
- 11/14/77 C-Phase to ground fault, cause unknown. Pratt & Whitney terminal reclosed successfully high-speed. Midway terminal closed manually thirty-four minutes later.

Pratt & Whitney - Ranch No. 1 240kV Line

- 2/17/76 B-Phase to ground fault, cause unknown. Both terminals reclosed successfully high-speed.

FLORIDA POWER & LIGHT COMPANY
OPERATING RECORD OF CERTAIN
TRANSMISSION LINES
JANUARY 1, 1976 THRU MAY 15, 1977

Pratt & Whitney - Ranch No. 2 240kV Line

No operations

Midway - Ranch 240kV Line
(Formerly Midway - Pratt & Whitney No. 1 and
Pratt & Whitney - Ranch No. 1

No operations

STATEMENT ISSUED BY FLORIDA POWER & LIGHT, MAY 16, 1977
CONCERNING POWER OUTAGE

Files

2005
1005

According to a continuing investigation by Florida Power & Light as to the cause of Monday's power outage, company officials said that a faulty relay switch in the protection system caused Turkey Point Unit #3 to trip off the line at 10:12 a.m.

This loss of generation was routinely absorbed by the FPL system as other generating units maintained power output for 12 minutes following the Turkey Point trip.

At approximately 10:24 a.m., a combination of factors triggered a cascading effect which resulted in the loss of power to the southeastern portions of FPL's system.

The St. Lucie Unit #1 was tripped manually at 10:24 a.m. when operators became concerned with wide fluctuations in system voltage. Thereafter, the Riviera, Port Everglades and Lauderdale plants tripped off automatically, along with the two Turkey Point fossil fuel units.

Another contributing factor appears to have been the out-of-service status of a new 500 KV line linking Fort Myers and Andytown, on U.S. 27 and State Road 84 west of Fort Lauderdale. The line, which had been converted from 230 KV to 500 KV, was operative, but was taken out of service late Sunday night for testing. The line is now in service.

First attempts to restore service were thwarted by a malfunction at the Andytown station at 12:04 p.m.

FPL officials expect it may take several days to determine the precise cause of the widespread outage.

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To: Davis, IE

From: Fouchard, OPH

50-250,251
inquiry