HURRICANE ANDREW AND EMERGENCY PREPAREDNESS FOR ELECTRIC POWER RESTORATION

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ABSTRACT

The timely and efficient restoration of electricity after a major natural disaster is an emergency response action of crucial importance for the speedy recovery and socio-economic functioning of the devastated communities. The magnitude and complexity of the problems associated with lengthy power interruptions underline the necessity of emergency response planning and preparedness in the electric utility industry. This paper presents an overview of emergency planning and preparedness for electric power restoration and discusses issues related to the implementation of emergency response plans following the destruction of Hurricane Andrew.

1. INTRODUCTION

Hurricanes are extreme weather phenomena causing enormous destruction upon human lives, private property, and the public infrastructure. A major problem arising after a hurricane disaster is the timely and efficient restoration of public utilities, such as electric power, water supply, gas, telecommunications, etc. In particular, the restoration of electric power is of crucial importance since a number of household, commercial, and industrial activities are completely dependent on the uninterrupted supply of electricity.

The magnitude and complexity of the problems associated with lengthy power interruptions underline the necessity of emergency response planning and preparedness in the utility industry. Indeed the Dade Operations of Florida Power and Light (FPL) has in place electric power restoration strategies for "normal" service disruptions (Zografos et al., 1990), and a comprehensive plan for **storm** service restoration operations (FPL, 1992a, 1992b). The "normal" service disruption plan provides guidelines and a decision making framework for the emergency repair services under usual weather conditions, while the storm plan addresses emergency preparedness issues for extreme weather conditions.

The service restoration experience after Andrew provided a unique opportunity for evaluating the suitability of the existing emergency response plan to cope with a natural disaster of an unprecedented magnitude. The objective of this paper is to present an overview of the effect Hurricane Andrew had on the FPL's facilities and to discuss issues related to the organization and performance of the company's emergency response mechanism.

The rest of the paper is organized as follows: section two presents a brief account on the effect that Hurricane Andrew had on the FPL's facilities; section three describes the structure and the

philosophy of the pre-storm service restoration plan; section four presents the new organizational structure of the company's service restoration plan, and section five summarizes the results of this research.

2. HURRICANE ANDREW AND ITS EFFECT ON ELECTRIC POWER DISTRIBUTION AND TRANSMISSION NETWORK

Hurricane Andrew's eye made landfall near Florida City, approximately 25 miles south of downtown Miami at 4:52 a.m. on Monday August 24, 1992. Andrew's sustained wind speed was reported to be approximately 145 mph (65m/sec), with the highest storm surge reported in Key Biscayne at 16.9 feet. Hurricane Andrew moved through South Florida in a westerly direction with a speed of about 16 mph. According to the Saffir-Simpson Scale Hurricane Andrew was classified as a category 4 hurricane.

The destructive forces of Hurricane Andrew had a devastating effect on the power transmission and distribution facilities in four of the five FPL operational territories. As a result of Hurricane Andrew 1.4 million FPL customers left without power immediately after the storm. Approximately half (690,000) of the affected customers were located within the service boundaries of the Dade Operations (Dade County), while the balance of the affected customers was distributed among the Broward (470,000 customers), Palm Beach (140,000 customers), Collier (61,300 customers), and Lee (16,600 customers) counties.

The damage inflicted on the FPL's power transmission and distribution network by Hurricane Andrew is exemplified by the enormous quantities of materials and labor required for the restoration/rebuilding of the power network. The results of the damage assessment performed by FPL personnel suggest that 2555 miles of overhead conductor were destroyed, almost 13,000 transformers were damaged, and 20,058 poles were installed. Table 1 summarizes the materials and manpower requirements for Hurricane Andrew.

Analysis of the spatial distribution of the damaged facilities suggests that the destruction caused by Andrew was unevenly distributed among the various service centers of Dade County. Areas located at the northern part of the county, outside the eye of the hurricane, sustained repairable damage of their power distribution system. However, areas located in the southern part of the county were destroyed to the point that "rebuilding" rather than restoration of the power system was necessary.

The substantial differences observed on the level of destruction between the northern and southern part of Dade County were rightly reflected on the progress of the service restoration process between the two parts of the County. Thus, the service restoration mechanism of the northern part of the county was able to restore services, according to the pre-determined storm plan, in a fast manner. As it can be seen in figure 1 the service restoration process for the northern part of the county was concluded within 14 days, while the service restoration process for the southern part of the county required almost one month.

Major logistical problems were created due to the devastation of the community and the inability of local vendors to supply the needed resources for supporting the restoration effort. Logistical support statistics for the electric power restoration effort after Hurricane Andrew are presented in table 2. Furthermore, the dismantling of the traffic signal network of Dade County by the hurricane and the blockage of the roadway with debris made the logistical support of the field personnel extremely difficult.

3. THE PRE-STORM SERVICE RESTORATION PLAN

Dade Operations of FPL had in place a comprehensive storm service restoration plan. This plan was substantially improved and updated after FPL personnel visited the South Carolina area following the destruction of Hurricane Hugo. The 1992 Storm Service Restoration Plan (FPL, 1992a; 1992b) had incorporated a number of "lessons learned" from Hurricane Hugo. From an organizational point of view the pre-storm plan was based on a Modular Management Concept which minimizes confusion and wasted time (FPL, 1992a).

The organizational chart of the pre-storm service restoration program involves an operations area headquarters manager who oversees and coordinates the storm-restoration operations. Reporting to the **Area Storm Manager** are coordinators of various functions such as Employee Services, Safety, Switching, Industrial Relations, External Affairs, Governmental Affairs, Media, Customer Service, Commercial Residential Operations, Distribution Restoration, Transmission Substation Restoration, Claims, Storm Accounting, Environment, and Inventory Services/Fuel Staging Areas. Because of the expected increase in workload, the geographical area of each service center was further subdivided into smaller operating areas, called storm centers. **Storm centers** include one or more substations with their respective distribution feeders (FPL 1992a).

From an operational point of view the storm-plan had well established priorities for restoring services. According to the plan the service restoration prioritization scheme was based on a list of essential customers. This list included hospitals, Public Service organizations, Communications organizations, Sewage and water supply pumping stations, and transportation facilities. Power transmission and distribution facilities providing services to the essential customers were identified by the respective storm centers and the repair process was implemented in a hierarchical order following the sequence feeders, laterals, individual services.

Although the pre-storm service restoration plan provided an organizational infrastructure and procedural guidelines for restoring power in a fast and efficient manner, the magnitude of the devastation caused by Hurricane Andrew created unforeseen needs and therefore it had to be modified and enhanced accordingly. The following section presents a brief description of the new organizational structure of the storm emergency plan.

4. THE NEW STORM SERVICE RESTORATION PLAN

An important aspect of the post-hurricane service restoration operations was the establishment and operation of staging areas. The use of staging areas proved to be an extremely beneficial strategy especially in the hardest hit southern portion of Dade County where the magnitude of the devastation called for rebuilding rather than repairing the damaged power transmission and distribution system. The pre-storm plan included the concept of the staging areas as physical sites that would accommodate the storage of the additional equipment needed for the restoration process. The staging areas did not constitute separate organizational/operational units and, therefore, there were not part of the prestorm organizational chart. Early in the restoration process it was understood that the concept and mission of the staging areas had to be modified. Thus, the staging areas evolved from "over-flow parking lots" to autonomous storm centers encompassing all the essential storm restoration functions. Materials, equipment, and supporting facilities for the crews and their equipment became available at the sites of the staging areas. In addition an administrative structure was developed in order to support the operation of the

staging areas.

The results of the operation of the "upgraded" staging areas were tremendous. **The time wasted by the crews to travel to and from their work sites to the places where materials and support functions were available was dramatically reduced. As a result the crews were spending more time productively repairing and rebuilding the power transmission and distribution network.** The provision of essential service and support facilities at the staging areas, such as meals, ice/water, sanitation, communication, check-cashing,etc., improved substantially the working conditions of the crews which otherwise had to work under adverse conditions. The provision of these facilities helped to keep the morale of the working crews high with beneficial effects on their performance and productivity.

From an administrative point of view the establishment of the "upgraded" staging areas was also beneficial since the completed work was more efficiently monitored and reported. **Without doubt the use of the staging areas was instrumental in achieving the target dates in restoring services after the hurricane.** The positive experience derived by the establishment and operation of the "upgraded" staging areas was considered of extreme value and, therefore, the new storm organization includes the staging areas as autonomous and self-standing organizational/operational units.

5. CONCLUDING REMARKS

Hurricane Andrew had a devastated effect on the FPL power transmission and distribution facilities. However, the spatial distribution of the destruction was not uniform. Two drastically different levels of destruction were identified during the post-hurricane damage assessment between the Southern and Northern part of Dade County. In particular, it was found that the power transmission and distribution network located at the Southern part of Dade County was severely damaged and rebuilding of the system was necessary. However, the majority of the facilities located at the Northern Part of the County sustained repairable damage.

The post-hurricane restoration effort was based on a storm-plan that was rehearsed during the dry run that took place during May 1992. Further, it was found that the key personnel of the service restoration mechanism had a very good knowledge of the storm plan and its implementation procedures.

The plan was judged to be adequate in terms of its strategic aspects and without doubt provided the necessary decision making support for the post-hurricane restoration operations. The plan was making explicit reference to priorities and responsibilities and it was covering all of the strategic functions for the efficient restoration of services. The timely and efficient deployment of the field units made essential the development of staging areas. The staging area concept increased immeasurably the speed and efficiency of the restoration process.

The evaluation of the post-hurricane service restoration operations has shown that FPL was successful in providing timely service restoration to its customers. This success is mainly attributed to the existence of an adequate storm-plan, the capabilities, skills, the team spirit, the motivation, and the high-professionalism of the personnel participated in the service restoration effort. The tremendous experience accumulated by the service restoration mechanism during the post-hurricane period constitutes a valuable resource for the future enhancement and improvement of the existing storm-plan and storm-training procedures. The continuous monitoring, evaluation, and improvement of the storm plan and the enhancement and development of the storm training program constitute the main ingredients of

a successful storm preparedness strategy.

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Table 1: Hurricane Andrew: Service Restoration Statistics

CUSTOMERS WITHOUT POWER	1.4	MILLION
OVERHEAD CONDUCTOR	2,570*	MILES
SERVICE CABLE	733	MILES
POLES	21,100	
TRANSFORMERS		
* AERIAL	11,415	
* PAD MOUNTED	730	
STREET LIGHTS		
* HEADS	9,585	
* LAMPS	26,158	
* POLES	285	
* PHOTO CELLS	25,417	

[Source: FPL] (*) Distribution only.

Table 2: Hurricane Andrew: Logistical Support Statistics

PERSONNEL	5,851	
MEALS/DAY	16,000	
BUSES/DAY	110	
SECURITY	176	
HOTEL ROOMS/DAY	2,626	
ICE (FIRST 3 WEEKS)	1,693,040	LBS
REFRIGERATION TRUCKS	29	
WATER (FIRST 3 WEEKS)	63,000	GALLONS
FUEL/DAY	25,000	GALLONS
LAUNDRY/DAY	4,000	FIELD PERSONNEL
NUMBER OF NURSES	20	
CASES TREATED		
BLOOD PRESSURE	2,500	
TETANUS BOOSTER	200	
CUT/ABRASION	1,500	
BURNS	75	
RUSHES	500	
MISCELLANEOUS	3,000	

[Source: FPL]

Dade County Hurricane Andrew

Figure 1: Progress of the Service Restoration Process