Report on Collaborative Research for Hurricane Hardening

Provided by

The Public Utility Research Center
University of Florida

To the

Utility Sponsor Steering Committee

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I. Introduction

The Florida Public Service Commission (FPSC) issued Order No. PSC-06-00351-PAA-EI on April 25, 2006 (Order 06-0351) directing each investor-owned electric utility (IOU) to establish a plan that increases collaborative research to further the development of storm resilient electric utility infrastructure and technologies that reduce storm restoration costs and outages to customers. This order directed IOUs to solicit participation from municipal electric utilities and rural electric cooperatives in addition to available educational and research organizations. As means of accomplishing this task, the IOUs joined with the municipal electric utilities and rural electric cooperatives in the state (collectively referred to as the Project Sponsors) to form a Steering Committee of representatives from each utility and entered into a Memorandum of Understanding (MOU) with the University of Florida's Public Utility Research Center (PURC).

The MOU has a term beginning March 1, 2006 and ending May 31, 2009, and may be renewed by mutual agreement of the Project Sponsors and PURC. In serving as the research coordinator for the Project outlined by the MOU, PURC manages the work flow and communications, develops work plans, serves as a subject matter expert and conducts research, facilitates the hiring of experts, coordinates with research vendors, advises the Project Sponsors and provides reports for Project activities. PURC's budgets for this work are in Appendix A.

The work in this effort began with a workshop in June 2006 at which utility managers and hazard research professionals discussed means to prepare Florida's electric infrastructure to better withstand and recover from hurricanes.[1] The presentations and subsequent dialogue indicated interest in wind research, materials development and analysis, forensic analysis, cost-effectiveness of storm hardening options, joint-use loads, and the economics of undergrounding.

Based in part on the results of the initial workshop, the Steering Committee at its initial meeting identified four primary research areas, namely the economics of undergrounding, the measurement and analysis of hurricane winds at a granular level, best practices in vegetation management, and improved materials for distribution facilities. The Steering Committee decided to initiate research on the first two topics, to hold a workshop on the vegetation management topic, and to look to vendors to conduct research on improved materials. The Steering Committee continues to hold regular conference calls and meet on a regular basis, with the 2009 annual Steering Committee meeting held February 5, 2009 in Gainesville, FL.

This report summarizes the work completed on the Steering Committee's areas of focus, with detail about specific accomplishments and activities from March 2008 through February 2009.[2] Sections II through IV provide information on the undergrounding research, wind research, and vegetation management workshop respectively. The budgeted dollars shown for each project are allocated on a percentage basis to each of the Project Sponsors as outlined in the MOU. PURC's budgets for work completed in 2008 are listed as Appendix A. The Conclusion of this report provides an overall assessment of the collaborative research program to date, including operational and financial viability and future planning to the extent these items are not already covered in the other sections of this report.

II. Undergrounding

An important consequence of hurricanes is that they often cause major power outages, which can last for days or even weeks. These outages almost always lead to a public outcry for electric utilities to move overhead power lines under ground. To some it seems intuitive that undergrounding facilities should protect them from damage. However, research shows that this is not necessarily the case: while underground systems on average have fewer outages than overhead systems, they can sometimes take longer to repair. Furthermore forensic

[1] Presentations and the workshop report are available at http://www.cba.ufl.edu/purc/research/energy.asp under the heading "Hurricane Hardening Workshop."

[2] Previous reports are available at http://www.cba.ufl.edu/purc/docs/report_PURC_Collaborative_Research_2007.pdf and http://www.cba.ufl.edu/purc/docs/report_PURC_Collaborative_Research_2008.pdf.

analyses of recent hurricane damage in Florida found that underground systems may be particularly susceptible to storm surge.

The purpose of the collaborate research on undergrounding is to address the lacuna in existing research on the economics and effects of hardening strategies, including undergrounding, so that service providers, regulators, and customers can make informed decisions about the desirability of undergrounding policies and specific undergrounding projects.

The initial project was divided into three phases. Phase I was a meta-analysis of existing research, reports, methodologies, and case studies.[3] Phase II examined specific undergrounding project case studies in Florida and included an evaluation of relevant case studies from other hurricane prone states and other parts of the world.[4] Phase III developed an *ex ante* methodology to identify and evaluate the costs and benefits of undergrounding specific facilities in Florida. Each phase of the project included tasks of data collection, analysis, and reporting. Although the primary focus is the impact of undergrounding on hurricane performance, this study also considered benefits and drawbacks of undergrounding during non-hurricane conditions.

The Steering Committee received the final deliverables on the Undergrounding project from the vendor Quanta Technologies[5] (formerly InfraSource Technology), including the final Phase III model. The final Phase III model was delivered on May 21, 2008 as the culmination of Phase III.[6]

The utility sponsors and PURC are currently testing the model for validity and robustness to ensure that it provides useful and reliable results. The testing culmination is scheduled for 2009. PURC and the utility sponsors are also working to fill information gaps for model inputs. Some historical data needed to examine the economics of undergrounding do not exist. These data needs have been identified and the utilities are putting in place procedures to gather or approximate the information that is needed.

Appendix A provides the 2008 budgets for this work.

III. Wind Data Collection

[3] The Phase I report is available at http://www.cba.ufl.edu/purc/docs/initiatives_UndergroundingAssessment.pdf.
[4] The Phase II report is available at http://www.cba.ufl.edu/purc/docs/initiatives_UndergroundingAssessment2.pdf.
[5] The Request for Proposal is available at http://www.cba.ufl.edu/purc/docs/initiatives_HHRequestProposal.pdf.
[6] The Phase III report is available at http://www.cba.ufl.edu/purc/docs/initiatives_UndergroundingAssessment3.pdf.

Appropriate hardening of the electric utility infrastructure against hurricane winds requires: 1) an accurate characterization of severe dynamic wind loading, 2) an understanding of the likely failure modes for different wind conditions, and 3) a means of evaluating the effectiveness of hardening solutions prior to implementation.

The Project Sponsors addressed the first requirement by contracting with the University of Florida's Department of Civil & Coastal Engineering (Department) to establish a granular wind observation network designed to capture the behavior of the dynamic wind field upon hurricane landfall. Through a partnership with WeatherFlow, the network plans were expanded to include permanent stations around the coast of Florida that capture wind, temperature, and barometric pressure data 24/7. In 2008 the opportunities for data collected on wind continued to expand this year with the addition of 50 wind stations. Appendix B details the locations of the wind data collection sites. Appendix C has a detailed annual report prepared by Dr. Kurt Gurley.

To address the second purpose of this project, namely to better understand the likely failure modes for different severe weather conditions, PURC developed a uniform forensics data gathering system for use by the utilities and a database that will allow for data sharing and that will match the forensics data with the wind monitoring and other weather data. The data gathering system consists of a uniform entry method that can be used on a tablet PC or entered onto the web once gathered by another means. Once a hurricane occurs and wind data is captured, forensic investigations of utilities infrastructure failure, conducted by the utility companies, will be overlaid with wind observations to correlate failure modes to wind speed and turbulence characteristics. Utility sponsors and PURC will analyze such data.

Investment in research collaboration reached outside of the State of Florida this year with expertise and resources invested in the states of Texas and Louisiana. PURC is reaching out to officials in those states to determine if synergies can be developed that will add information to the Florida research and economize on costs.

IV. Vegetation Management

The goal of this project was to improve vegetation management practices so that vegetation related outages are reduced, vegetation clearing for post-storm restoration is reduced, and vegetation management is more cost-effective. The initial Vegetation Management workshop was held March 5-6, 2007; based upon the success of the workshop, the Steering Committee decided to host the workshop again in 2009.

The second Vegetation Management workshop was held on January 26 & 27,

2009. The meeting hosted representatives involved with all aspects of vegetation management for two days in Orlando, FL. Based upon the success and collaborative benefits reaped from the initial workshop, this meeting once again brought together industry experts in the field of vegetation management within Florida utilities and afforded time to share best practices in a collaborative learning environment.

The workshop began with an introduction from Mr. Barry Moline, Executive Director of FMEA, and Dr. Mark Jamison, Director of PURC. Mr. Moline gave a brief overview of the events that led to the March 2007 workshop on vegetation management, and the work that was accomplished there. Dr. Jamison also welcomed the participants, introduced representatives from the FPSC and PURC in attendance, and offered a short discussion on the three other research initiatives of the steering committee: wind research, the economics of undergrounding, and forensics.
Representatives in attendance were then requested to deliver presentations on the status of their respective utility's vegetation management practices. Presentations included detail about trimming cycles, budgetary and staffing information, best practices, and other issues. Presentations were delivered by: Mr. Ken Lecasse of Sumter Electric Cooperative, Mr. Barry Grubb of FP&L, Mr. Mark Brown from the City of Winter Park, Mr. Dennis Spellicy of Progress Energy, Mr. Luke DiRuzza of TECO, and Ms. Diana Gillman of Lee County Electric Cooperative.

After each presentation, participants engaged in question and answer sessions. The issues raised during the presentations and during the question and answer periods included: problems with hiring and retaining qualified crews, the usefulness of third party audits of vegetation management practices and crew performance, growing support for reliability-based vegetation management programs, the relationship between best practices for day-to-day reliability versus reliability for extreme weather events, data gathering to learn more about costs and reliability for undergrounding versus overhead line placement and the formulation of new best practices.

Mr. Devlin Higgins then delivered the FPSC staff presentation. The presentation discussed the severity of the 2004-2005 storm seasons and how the FPSC tried to learn from these events. This led the PSC to open dockets to discuss undergrounding, initiate the storm plan process, and review distribution construction standards. He reported that the FPSC has ten on-going initiatives, of which vegetation management is included, and that all investor owned utilities (IOUs), municipally-owned utilities, and cooperatives are on track in the third year of the program. In response, the volume of customer complaints is down and utility reporting is going well. He also pointed out that all reports to the legislature and other documents are on the FPSC website.

Mr. Higgins then answered questions on the criteria considered by the FPSC to evaluate trim cycles, the level of review given to utility reports, and the status of regulatory changes that might be introduced based on these reports. Finally, Mr. Higgins reminded the participants that utilities can always bring their concerns to the FPSC.

Mr. Moline's presentation addressed the development of public policy relevant to vegetation management and how utilities can work with the FPSC on these issues. He talked about how vegetation management tends to be a post-hurricane issue because that is when it is urgent and noticeable. Otherwise, the legislature is generally occupied with more pressing matters. He also talked about the difficulties that utilities and cities encountered when pursuing standards for vegetation management practices that would have improved uniformity across governmental and community organizations.

The last presentation of the day was from Mr. Ted Kury, Director of Energy Studies at PURC, who summarized the roundtable findings from the 2007 workshop. This presentation sought to frame the issues from the 2007 workshop and lay the foundation for the discussion of these, and other issues, on the second day of the workshop.

V. Conclusions

In response to the FPSC's Order 06-0351, IOUs, municipal electric utilities and rural electric cooperatives joined together and retained PURC to coordinate research on electric infrastructure hardening. Costs have been incurred according to the funding schedule set by the Steering Committee. This year, costs incurred have been towards research in the initiatives of granular wind research, undergrounding research, vegetation management, and PURC's coordinating work. The Steering Committee is currently considering next steps in these research areas.

The benefits of the work realized from the time of the last report (March 2008) to the time of this report include increased and sustained collaboration and discussion between the members of the Steering Committee, greater knowledge of the determinants of damage during storm and non-storm times, greater knowledge and data from wind collection stations and post-hurricane forensics in the State of Florida, and increased state-to-state collaboration with others in the Atlantic Basin Hurricane Zone.

Appendix A. PURC Budgets for 2008

RESEARCH COORDINATION FOR ELECTRICITY INFRASTRUCTURE HARDENING

Phase V - commencing January 1, 2008 and ending June 30, 2008

Undergrounding Study			
Personnel			
	PURC Faculty	$ 11,200.00	
	Grad Student	$ 1,650.00	
	Administrative	$ 2,800.00	
			$ 15,650.00
Wind Study			
Personnel			
	PURC Faculty	$ 11,200.00	
	Administrative	$ 2,800.00	
			$ 14,000.00
Travel & Meetings			
	Steering Comm. Mtgs	$ 300.00	
	Tallahassee Meetings	$ 500.00	
	Forensics Workshop	$ 300.00	
			$ 300.00
Miscellaneous			
	Conference Calls		$ 2,500.00
Subtotal			$ 32,450.00
University Overhead (25%)			$ 10,816.67
Total			$ 43,266.67

Faculty Activities

Examining & editing reports on work plan for testing ex ante methodology

Investigating hurricane models

Performing background research on hardening issues

Drafting report for FPSC

Plan steering committee meeting for early 2008

Planning Forensics Workshop - spring 2008

Coordinating webinar for model testing

Organizing and managing weekly conference calls

Attending meetings with FPSC staff or sponsors

Managing PURC staff working on project

Graduate Student Activities

Participating in and taking minutes for weekly conference calls

Maintaining PURC work plan for overseeing projects

Administrative Activities

Proofreading all materials

Taking minutes on conference calls

Organizing conference calls and meetings

Developing all administrative documents, such as contact lists and invoices

Developing budgets

Financial management

Phase VI - commencing July 1, 2008 and ending December 31, 2008

Undergrounding Study			
Personnel			
	PURC Faculty	$ 7,000.00	
	Grad Student	$ 3,960.00	
	Administrative	$ 2,800.00	
			$ 13,760.00
Wind Study			
Personnel			
	PURC Faculty	$ 11,200.00	
	Grad Student	$ 1,320.00	
	Administrative	$ 2,800.00	
			$ 15,320.00
Miscellaneous			
	Grad Student	$ 1,320.00	
	Conference Calls	$ 1,000.00	
			$ 2,320.00
Subtotal			$ 29,080.00
University Overhead (25%)			$ 9,693.33
Total			$ 38,773.33

Faculty Activities

Coordinating work on model data gaps

Developing forensic data input formats

Plan vegetation management workshop for early 2009

Plan steering committee meeting for early 2009

Coordinating testing of model for report to FPSC

Organizing and managing conference calls

Attending meetings with FPSC staff or sponsors

Managing PURC staff working on project

Graduate Student Activities

Developing forensic data input formats

Maintaining forensics database

Planning vegetation management workshop for early 2009

Testing of undergrounding model

Participating in and taking minutes for weekly conference calls

Maintaining PURC work plan for overseeing projects

Administrative Activities

Proofreading all materials

Taking minutes on conference calls

Organizing conference calls and meetings

Developing all administrative documents, such as contact lists and invoices

Developing budgets

Financial management

Appendix B. Wind Stations

Appendix C: Wind Report by Dr. Kurt Gurley

Testing the WeatherFlow instrumentation package for the fixed wind monitoring network

2/12/2009

The Weatherflow (WF) instrumentation package was tested in a full-scale hurricane simulator facility located on the University of Florida Eastside Campus. This facility produces full-scale hurricane intensity winds and wind driven rain over a large enough cross section to immerse the entire WF instrumentation hardware package in these extreme conditions.

The purpose of these tests was to evaluate the performance of the WF instrumentation package when subjected to extreme wind and rain conditions similar to actual hurricane conditions. “Performance” includes the ability of the instrumentation package to collect and transmit data to the WF online data center during high wind and rain events, and the ability to physically withstand these conditions with no apparent damage.

The instrumentation package that was tested includes the anemometer (wind velocity measurement device), the pressure sensor, the two power supplies (mounted solar panel and battery pack), the data collection, data storage, and remote transmission (cellular modem) hardware, and the lightning rod. The batteries, data collection and storage, and cellular communication hardware are contained within a water tight casing. In actual field installation, this casing, anemometer, pressure sensor, solar panel, and lightning rod are mounted in close proximity to each other on either a concrete pole or existing communications tower. The relative orientation of these components to each other was accurately replicated during testing.

The specialized concrete pole to which this instrumentation package is mounted in actual field application was not tested for three reasons. 1) logistics and expense of properly installing the custom pole at the UF testing facility were prohibitive, 2) the wind field generated by the hurricane simulator is not wide / tall enough to properly envelop the entire pole in hurricane conditions (making any results of such a pole-resistance-to-wind experiment of little value for accurate performance evaluation), 3) the performance of concrete poles in hurricanes indicates that the expected performance of the Valmont poles (custom designed, constructed and installed for much higher winds than standard concrete poles) is of far less concern than the performance of the WF instrumentation package. That is, the WF instrumentation package is more vulnerable than the pole it is mounted to, and therefore represents the weakest link and the logical focus of testing.

Test procedure

The WF instrumentation package was mounted to the top of a 6' tall wooden pole that represents the concrete pole. The bottom end of the wooden pole was fixed within a metal sleeve, which was fixed to a heavy scissor lift beneath wind field. By design, the pole was thus impervious to the simulated hurricane winds and rain, and the WF instrumentation package was evaluated as it would have been mounted in an actual installation.

The sleeve housing the bottom of the mounting pole allowed for controlled 360 degree rotation of the pole, clamped into the desired position between tests. This allowed tests of the WF instrumentation package from all possible wind/rain approach angles (wind approaching the front face of the solar panel, the back face, the side, etc.).

A series of tests were conducted at wind approach angles from 0 degree (solar panel facing wind, through 235 degrees, at 45 degree intervals. Each test subjected the WF instrumentation package to simulated full-scale hurricane winds a rain for less than five minutes. The package was inspected for damage during and after each test. Twice, the water tight casing for the batteries, data storage and cellular hardware was opened between tests to inspect for water infiltration. Video was taken of each test, and numerous digital photographs were taken. Testing was conducted on June 20, 2008.

Testing results

Analysis of the testing video footage revealed very slight (expected) vibration of components during testing, but no large magnitude vibrations that would indicate potential problems with fatigue of components or their fasteners. No failures of any components occurred.

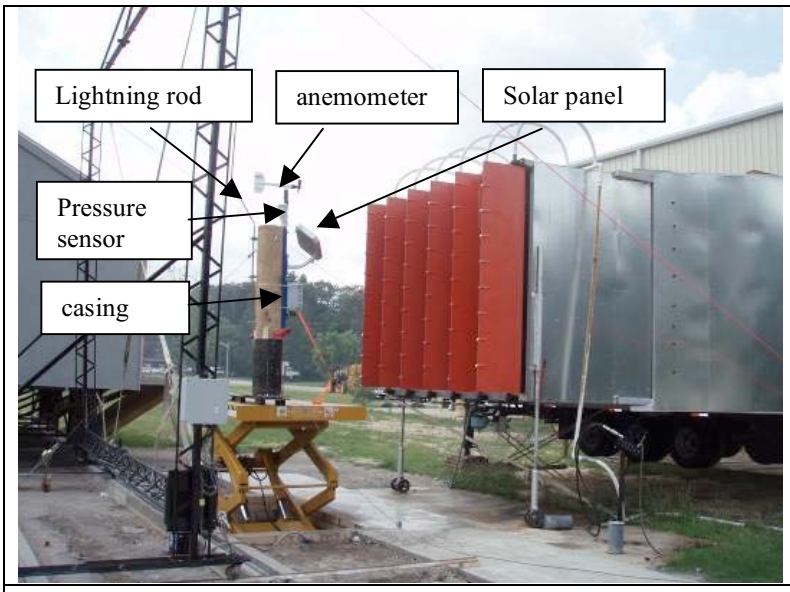
The data transmission of wind speed and pressure during testing was successful, indicating that the extreme conditions did not interfere with proper functioning of data collection and transmission.

No problems were found regarding water penetration of the water tight enclosure that contains the data storage, batteries, and data transmission hardware.

Summary and comments

The results of the testing did not reveal any causes for concern regarding the proper functioning of the WF instrumentation package during high winds and heavy wind driven rain. While the testing cannot guarantee that the system will function as designed during an actual hurricane event, these results do suggest a high degree of likelihood of the survivability and functionality of the system.

See next page for photos



Test subject mounted to wooden pole

Mounted test subject

Simulator and test subject

Test subject during wind/rain test