

# 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; it was extended in May 2009 through December 31, 2009. 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. An MOU covering the period from January 1, 2010 through December 31, 2011 is under review by the Participating Utilities. The costs 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.<sup>1</sup> 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.

This report summarizes the work completed on the Steering Committee's areas of focus, with detail about specific accomplishments and activities from March 2009 through February 2010.<sup>2</sup> Sections II through IV provide information on the undergrounding research, wind research, and vegetation management workshop respectively. The costs shown for each project are allocated on a percentage basis to each of the Project Sponsors as outlined in the MOU. The costs for the work completed in 2009 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 underground. 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 analyses of recent hurricane damage in Florida found that underground systems may be particularly susceptible to storm surge.

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

<sup>2</sup> Previous reports are available at [http://www.cba.ufl.edu/purc/docs/report\\_PURC\\_Collaborative\\_Research\\_2007.pdf](http://www.cba.ufl.edu/purc/docs/report_PURC_Collaborative_Research_2007.pdf) [http://www.cba.ufl.edu/purc/docs/report\\_PURC\\_Collaborative\\_Research\\_2008.pdf](http://www.cba.ufl.edu/purc/docs/report_PURC_Collaborative_Research_2008.pdf) and [http://www.cba.ufl.edu/purc/docs/report\\_PURC\\_Collaborative\\_Research\\_2009.pdf](http://www.cba.ufl.edu/purc/docs/report_PURC_Collaborative_Research_2009.pdf).

The purpose of the collaborative 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.<sup>3</sup> 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.<sup>4</sup> 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<sup>5</sup> (formerly InfraSource Technology), including the final Undergrounding Assessment Phase III Report and computer program on May 21, 2008 as the culmination of Phase III.<sup>6</sup>

For this project, it is very important to make a clear distinction between the design and the implementation of the computer “tool” that has been developed. The first part, the computer program that Quanta Technologies delivered and the testers have refined, consists of the computer engine that calculates estimated reliability and cost data. In this past year, there has been a collective effort to learn more about the function and functionality of the computer code, and the testing group has accomplished that. We have made significant improvements to the flexibility of selecting input scenarios in which the calculator arrives at results.

The second part, which presents a more complicated issue, concerns the implementation of the calculator. The computer program calculates complex, non-linear interactions between hundreds of input variables. These interactions result in probability distributions of various output parameters including the extent of damage from storm-related events and the time necessary to correct that damage. However, these results are highly sensitive to the input parameters used in the calculation. Some input parameters, like the costs associated with the installation of equipment, are well-known to the utilities, but may be accounted for

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<sup>3</sup> The Phase I report is available at [http://www.cba.ufl.edu/purc/docs/initiatives\\_UndergroundingAssessment.pdf](http://www.cba.ufl.edu/purc/docs/initiatives_UndergroundingAssessment.pdf).

<sup>4</sup> The Phase II report is available at [http://www.cba.ufl.edu/purc/docs/initiatives\\_UndergroundingAssessment2.pdf](http://www.cba.ufl.edu/purc/docs/initiatives_UndergroundingAssessment2.pdf).

<sup>5</sup> The Request for Proposal is available at [http://www.cba.ufl.edu/purc/docs/initiatives\\_HHRequestProposal.pdf](http://www.cba.ufl.edu/purc/docs/initiatives_HHRequestProposal.pdf).

<sup>6</sup> The Phase III report is available at [http://www.cba.ufl.edu/purc/docs/initiatives\\_UndergroundingAssessment3.pdf](http://www.cba.ufl.edu/purc/docs/initiatives_UndergroundingAssessment3.pdf).

in different ways, depending on the internal accounting and work management systems that the utilities employ. Other inputs, such as the initial availability of repair crews and the rate at which additional crews become available are not known and measurable to the utility at the time the calculations are made. For these input parameters, the utility must employ a reasonable assessment of their value. To the extent that this assessment is not realized, however, actual results may vary greatly from what is originally calculated. The testers have improved their understanding of the extent to which this variation occurs, but educating users outside of the testing group will be an important step in the implementation process of the calculator.

Several formal and informal sessions, sponsored by PURC, have facilitated the testing process this year. A testing teleconference took place in June 2009. Two additional testing workshops took place in 2009. The first was in February, at the facilities of the Seminole Electric Cooperative in Tampa, and the second was in November, at the facilities of Progress Energy in Lake Mary. During these workshops, the testing group worked together to refine elements of the program code, as well as to solve practical problems associated with implementation. Participants shared their experiences in working with software systems at their respective utilities, as well as additional sources for input data. The testers have made significant progress in this regard, but have learned that internal processes make it difficult to make some comparisons between them. Despite this, the testers continue to standardize the process as much as possible, though significant heterogeneity will always remain. Thus, the process to refine the inputs used in the undergrounding calculations will always continue to be revised and enhanced.

PURC and the utility sponsors also worked to fill information gaps for model inputs through the forensics sub-group. Significant efforts were invested in developing a forensics data collection form for all utilities to use, towards supplying input information for the undergrounding calculator.

Appendix A provides the 2009 costs for this work.

### **III. Wind Data Collection**

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.

To address the second purpose of this project, namely to better understand the likely failure modes for different severe weather conditions, a group was convened through a series of conference calls to improve forensic data consistency. 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.

#### **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 and the second Vegetation Management workshop was held January 26-27, 2009. Both conferences were informative and revealed nuanced information related to hurricane hardening and vegetation practices. There is interest in another Vegetation Management workshop in the future, though specific plans have not developed.

#### **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 2009) 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 continued state-to-state collaboration with others in the Atlantic Basin Hurricane Zone.

Appendix A. Project Costs for 2009

**RESEARCH COORDINATION FOR ELECTRICITY INFRASTRUCTURE HARDENING**

**Phase VII -** commencing January 1, 2009 and ending May 31, 2009

**Undergrounding Study**

Personnel

PURC Faculty (4 weeks)	\$ 1,200.00
Grad Student (3 weeks)	\$ ,980.00
Administrative (2 weeks)	\$ 2,800.00
Model testing workshop 3/09	<u>\$ 400.00</u>

\$ 16,380.00

Faculty Activities

Coordinating work on model data gaps  
 Reprogramming hurricane model when necessary  
 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

**Wind Study**

Personnel

PURC Faculty (1 week)	\$ 2,800.00
Grad Student (1 week)	\$ 660.00
Administrative (1 week)	<u>\$ ,400.00</u>

\$ 4,860.00

**Vegetation Management**

PURC Faculty (1 week)	\$ 2,800.00
Grad Student (1 week)	\$ 660.00
Administrative (1 week)	\$ ,400.00
Travel (1/09 workshop)	<u>\$ 500.00</u>

\$ 5,360.00

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

**Miscellaneous**

Global Crossing Conference Calls	\$ 500.00
Annual Steering Comm meeting 2/5/09	<u>\$ 250.00</u>

\$ 750.00

Administrative Activities

Proofreading all materials  
 Taking minutes on conference calls  
 Developing all administrative documents, such as contact lists and invoices  
 Developing budgets  
 Financial management

Subtotal

\$ 27,350.00

University Overhead (25%)

\$ 9,116.67

Total

\$ 36,466.67

Phase VIII - commencing June 1, 2009 and ending December 31, 2009

**Undergrounding Study**

Personnel

PURC Faculty (4 weeks) \$ 11,200.00  
Grad Student (1 week) \$ 660.00  
Administrative (2 weeks) \$ 2,800.00

\$ 14,660.00

Faculty Activities

Coordinating work on model data gaps  
Reprogramming hurricane model when necessary  
Developing forensic data input formats  
Coordinating collection of forensic data from utilities  
Facilitating planning meeting(s) and workshop(s)  
Organizing and managing conference calls  
Attending meetings with FPSC staff or sponsors  
Managing PURC staff working on project

**Wind Study**

Graduate Student Activities

Developing forensic data input formats  
Maintaining forensics database  
Testing of undergrounding model  
Participating in and taking minutes for weekly conference calls  
Maintaining PURC work plan for overseeing projects

**Vegetation Management**

**Miscellaneous**

Global Crossing Conference Calls \$ 200.00  
Travel to model testing workshop 11/10/09 \$ 100.00

\$ 300.00

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

Subtotal

\$ 14,960.00

University Overhead (25%)

\$ 4,986.67

Total

\$ 19,946.67