

# Report on Collaborative Research for Hurricane Hardening

Provided by

The Public Utility Research Center  
University of Florida

To the

Utility Sponsor Steering Committee

February 26, 2007

## **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, facilitates the hiring of experts coordinates with research vendors, advises the Project Sponsors and provides reports for Project activities. PURC's budgets for work completed in 2006 are listed as Appendix A and Appendix B. Appendix D provides PURC's projected budget for the first part of 2007.

This report summarizes the research activities of the Steering Committee, PURC and the researchers to date in the area of hurricane hardening research. Section II of this report describes the workshop held in Gainesville, Florida that formed the basis for determining the initial scope of research conducted pursuant to the MOU. Sections III and IV describe the research being conducted in three main topic areas chosen by the Steering Committee subsequent to the workshop, namely undergrounding of overhead infrastructure, granular wind data collection, and vegetation management. Each section describes the purpose of the research, its scope and objective, the research methods, data inputs, expected costs and benefits as well as the costs and benefits achieved, sources of funding, schedule, and findings to date. The budgeted dollars shown for each project are being allocated on a percentage basis to each of the Project Sponsors as outlined in the MOU. The last section 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. Initial Workshop**

The initial step in this Project was a workshop held in June 2006 in Gainesville, Florida. The purpose of this workshop was to provide a forum at which utility managers and hazard research professionals could discuss means to prepare Florida's electric infrastructure to better withstand and recover from hurricanes. The workshop included presentations by five utility managers and six researchers and research organizations. The presentations and a workshop report are on the PURC web site located at [www.purc.ufl.edu](http://www.purc.ufl.edu). 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.

The workshop began with presentations by industry infrastructure managers who described their experiences with outages, damage, and recovery during recent hurricanes. Presentations were made by:

- J. R. "Pepe" Diaz, Reliability Engineering Manager, Power Systems – Distribution, FPL
- Jason Cutliffe, Manager, Distribution Asset Performance, Progress Energy Florida
- Alan McDaniel, Project Services Manager, Gulf Power Company
- T.J. Szelistowski, Director, Transmission and Distribution Operations, TECO
- Jorge Puentes, Electric Operations Manager, Florida Public Utilities Company

Following a Q&A, researchers from Florida and other states discussed their work and the capabilities of their universities, centers, or consulting firms. The

researchers who presented were selected by an industry steering committee. Presentations were made by:

- Dr. Kurt Gurley, University of Florida
- Dr. Steinar J. Dale, Florida State University
- Dr. Alex Domijan, Jr., University of South Florida
- Calvin Stewart, Davies Consulting, Maryland
- Dr. Francis M. Lavelle, Applied Research Associates, N. Carolina
- Dr. Seth Guikema, Texas A&M; and Dr. Rachel Davidson, Cornell University

The workshop provided a valuable educational opportunity for both industry and researchers, and provided an important exchange of ideas on how Florida utilities might improve its approach to hardening their infrastructure. In their presentations and discussion, the utilities emphasized the need for practical research, advanced analytical techniques, and increased data availability and testing. Utility representatives demonstrated interest in the following research topics:

- Wind research, such as might be provided by the hurricane wind simulation lab (i.e., the Wall of Wind) and wind measurement devices;
- Materials development and analysis that could provide, for example, poles that are cheaper and easier to install during storm recovery efforts;
- Cost-effectiveness of possible hardening solutions, including undergrounding and vegetation management; and
- How joint use loads affect storm damage and recovery

Subsequent to the workshop, the utility sponsors' Steering Committee refined the areas of interest into four topics for further research: the economics of undergrounding, granular analysis and modeling of hurricane winds, vegetation management, and improved materials. The Steering Committee decided that materials vendors should be encouraged to perform the materials research because they are the ones who would subsequently profit from selling the new equipment and facilities. The Steering Committee has launched efforts on each of the other three topics. Each is described below.

### **III. 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 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.

While there are numerous studies on undergrounding electric infrastructure, missing from this work are a comprehensive survey of what is known and what is not yet known, current analyses of Florida cases where overhead facilities have been moved underground, and a methodology that can be used to consistently quantify the costs and benefits of specific undergrounding proposals in Florida. This project will seek to fill these gaps by summarizing the body of knowledge on the costs and benefits of undergrounding, analyzing recent undergrounding cases in Florida, and developing a methodology for identifying and evaluating before a project is undertaken, the costs and benefits of undergrounding a specific area of existing electricity distribution infrastructure in Florida. This methodology is referred to as an *ex ante* methodology. Possible benefits to be considered include reliability impacts, reduced outages and changes in restoration times, reduced O&M costs, and reduced vegetation management costs, as well as an attempt to capture non-utility benefits, such as aesthetic benefits.

The project is divided into three phases. Phase I is a meta-analysis of existing research, reports, methodologies, and case studies. Phase II examines specific undergrounding project case studies in Florida and may include relevant case studies from other hurricane prone states and other parts of the world. Phase III develops and tests an *ex ante* methodology to identify and evaluate the costs and benefits of undergrounding specific facilities in Florida. Each phase of the project includes tasks of data collection, analysis, and reporting. Although the primary focus is the impact of undergrounding on hurricane performance, this study will also consider benefits and drawbacks of undergrounding during non-hurricane conditions.

The Steering Committee issued a request for proposal (RFP) for this project in November 2006. Based on its knowledge of power delivery systems, expertise in risk management and reliability issues, and proven ability to analyze the complex utility issues, InfraSource Technology (InfraSource) was selected as the vendor by the Steering Committee.

Once the vendor was retained, work on this project began in mid December. The vendor's Phase I meta-analysis is to be completed by February 28 and available for the submission of this report to the FPSC. The Steering Committee has decided that Florida-specific case studies are needed and that an appropriate *ex ante* methodology does not already exist, so it has directed InfraSource to begin work on Phases II and III. Case studies for inclusion in Phase II have been submitted; they are available for review on the PURC web site.

The budget for Phase I of this project is \$40,000. The budget for Phases II and III is \$220,000.

#### **IV. 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 are addressing the first requirement by contracting with the University of Florida's Department of Civil & Coastal Engineering (Department) to establish a granular wind observation network will be established to address the first requirement. This network of devices will capture the behavior of the dynamic wind field upon hurricane landfall. 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.

The spatial resolution should be such that performance of varying power distribution infrastructure designs can be evaluated and compared to an accurate assessment of their respective wind loads. The influence of local terrain features as well as proximity to the coast will be incorporated within the resultant description of the wind field. Existing portable weather stations already deployed by the research team will continue to provide ground level wind observations. This portable network now consists of five portable stations; it may be extended to up to twelve portable stations.

The Steering Committee has approved funding for this project for a one-year period, with the option to expand the program in future years to bring more deployment stations on line. This one-year pilot-level program will fund development of the portable instrument package, the development of the fixed deployment station details, the production of several portable units and perhaps a dozen deployment stations. This pilot program will serve as a proof-of-concept, with possible additional follow-up investments expanding the pilot program to produce more portable units and more stations if chosen by the Steering Committee.

To monitor hurricane weather conditions, the researchers are developing a hardened compact package (wind reading instrument, data-logger, power supply) that is designed for deployment where needed as a storm approaches. Stations will be set up across Florida to receive the portable instrument package. As a storm approaches, the portable instrument packages will be deployed to selected stations within the path of the oncoming storm. This arrangement produces a close spatial resolution of observation points in the impacted area. The instrument packages would be stored and maintained by the researchers, assuring quality control. A mobile, centrally controlled stockpile of units to be

placed as the storm path dictates is effective in terms of cost efficiency and quality control.

Presently, the Steering Committee has presented potential site locations for the researchers' review. Twelve wind device stations will be established on the sponsoring utilities' properties. Site visits for the final locations will take place during February and March 2007. The sites are expected to be completed and ready prior to the beginning of the 2007 hurricane season. Funding for the researchers has been established on a yearly basis; there is an option to increase the number of stations in subsequent years. The one-year budget for constructing three portable units and twelve deployment sites, and to deploy units in two storms, is estimated to be \$196,250. More precise cost estimates will be developed after locations are selected.

## **V. Vegetation Management**

The goal of this project is 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 project will review existing research and studies on vegetation management as it relates to outage reductions and cost-effectiveness, survey current vegetation management practices and compare these to any existing research, and conduct a one-and-one-half day workshop on March 5-6 that will include vegetation management experts and utility arborists. The topics to be discussed in the workshop include:

- Utilities' clearance specifications
- Inspection program for hazardous trees
- Review of participating utilities' storm preparedness and planning, and vegetation management programs
- How vegetation management teams are organized and managed to maximize effectiveness
- Trimming observations from past hurricanes
- Cycle trimming vs. reliability-based approach to trimming
- Increasing public awareness
- Working with the Florida Department of Transportation and County Road Departments
- Working with county and city governments to ease restrictions on tree ordinances
- Success stories to avoid/reduce the amount of vegetation management damage by pro-active vegetation management programs
- Developing/communicating a VM storm restoration best practices manual for foreign crews
- Approaches to deal with customer refusals best practices
- Pro-active storm management

- Strategies to managing vegetation management resources to stay ahead of line crews' needs and restoration activities
- Distribution: Removals - targeting certain species

The initial outcome will be a greater pool of shared knowledge on the part of utilities, vendors and PURC regarding the utilities' needs for improved vegetation management practices. The Steering Committee will determine whether further work is needed in this area after the workshop. The budget for this workshop is attached as Appendix C.

## **VI. Conclusion**

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. The initial step in this project was a workshop held in June 2006 in Gainesville, Florida. The workshop provided a forum for utility managers and hazard research professionals to discuss means to prepare Florida's electric infrastructure to better withstand and recover from hurricanes. The presentations and a workshop report are on the PURC web site located at [www.purc.ufl.edu](http://www.purc.ufl.edu).

The research and study areas under consideration were extracted from information provided by the utilities and other stakeholder groups, including the universities. The work of the group is guided by the utilities sponsoring the research. Implementation includes a coordination effort and organization of workshops to examine ongoing studies and research, and the development of a formal research agenda.

The second step in this coordination effort was the organization of meetings and conference calls to examine ongoing studies and research, and to discuss the potential need, for a formal research agenda. PURC worked with the Steering Committee, which decided to pursue work on undergrounding, wind data collection and analysis, and vegetation management as described above.

Costs have been incurred according to the funding schedule set by the Steering Committee. Thus far, costs have included the initial workshop, PURC's coordinating work, Phase I of the undergrounding research, and seed money for the granular wind research. These costs are detailed above. Funds have been designated for Phases II and III of the undergrounding research and for wind measurement also as described above. The Steering Committee has also approved plans for the vegetation management workshop in March. Registration fees for this workshop will cover the workshop costs.

The benefits of the scope of work realized at the time of this report include increased collaboration and discussion between members of the Steering

Committee, greater shared knowledge of experiences with hurricane preparation and recovery, clearly defined research needs, and a meta-analysis of the economics of undergrounding existing overhead facilities.



## Appendix A

### PURC's Budget for Research Coordination March – July, 2006

<u>Items</u>	<u>Amounts</u>
Personnel	
Engineering Faculty (2 weeks)	\$ 5,432.00
PURC Faculty (2 weeks)	\$ 6,858.00
Admin. Assist. (2 weeks)	\$ 2,467.00
	\$ 14,757.00
Workshop (June 9, 2006)	
Registration Fee	\$ (5,125.00)
Facility Rental, AV & Food	\$ 2,900.00
Speaker Travel	\$ 1,000.00
Materials & Supplies	\$ 200.00
	\$ (1,025.00)
Travel	
Related Workshops & Conferences	\$ 1,472.00
Trips to Tallahassee	\$ 270.00
	\$ 1,742.00
Subtotal	\$ 15,474.00
University Overhead (25%)	\$ 5,158.00
Total	\$ 20,632.00

#### Payment Amounts

<u>Sponsor</u>	<u>Percent of Total</u>	<u>Amount due PURC</u>
Florida Power & Light	47.61%	\$ 9,822.90
Florida Public Utilities Company	0.34%	\$ 70.15
Gulf Power Company	4.54%	\$ 936.69
Progress Energy Florida	17.20%	\$ 3,548.70
Tampa Electric Company	7.06%	\$ 1,456.62
Florida Electric Cooperatives Association	8.55%	\$ 1,764.04
Florida Municipal Electric Association	14.69%	\$ 3,030.84
Total	100.00%	\$ 20,629.94

#### PURC Faculty Activities

Organizing workshop

- Identifying speakers
- Preparing agenda
- Managing content

Developing workshop report

Developing plans with project sponsors

Participation in meetings and conference calls

Working on Memorandum of Understanding for research coordination

Preparing plans for research coordination

**PURC Administrative Activities**

Managing workshop

Developing budgets

Proofreading all materials

Taking minutes on conference calls

Organizing conference calls and meetings

Developing all administrative documents, such as contact lists and invoices

## Appendix B

### PURC's Budget for Research Coordination August – December, 2006

<u>Items</u>	<u>Amounts</u>
Personnel	
PURC Faculty (4 weeks)	\$ 11,200.00
Grad Student (5 weeks)	\$ 3,300.00
Administrative (4 weeks)	<u>\$ 5,600.00</u>
	\$ 20,100.00
Travel	
Steering Committee meetings (3)	<u>\$ 390.00</u>
	\$ 390.00
Subtotal	\$ 20,490.00
University Overhead (25%)	<u>\$ 6,830.00</u>
Total	<u>\$ 27,320.00</u>

#### Payment Amounts

<u>Sponsor</u>	<u>Percent of Total</u>	<u>Amount due PURC</u>
FPL	46.71%	\$ 12,761.17
FPUC	0.33%	\$ 90.16
Gulf	4.46%	\$ 1,218.47
Progress	16.88%	\$ 4,611.62
TECO	6.93%	\$ 1,893.28
FECA	8.39%	\$ 2,292.15
FMEA	14.41%	\$ 3,936.81
LCEC	1.89%	<u>\$ 516.35</u>
	100.00%	\$ 27,320.00

#### PURC Faculty Activities

Drafting work plans for undergrounding, vegetation management, and materials  
 Drafting RFP for undergrounding  
 Compiling consultant list for undergrounding  
 Organizing and managing weekly conference calls  
 Attending meeting with FPSC staff  
 Managing PURC staff working on project  
 Compiling literature to be reviewed by undergrounding consultant  
 Organizing undergrounding consultant selection

#### PURC Graduate Student Activities

Researching templates for RFPs  
 Editing RFP for undergrounding  
 Compiling consultant list for undergrounding  
 Participating in and taking minutes for weekly conference calls  
 Developing PURC work plan for overseeing projects  
 Compiling literature to be reviewed by undergrounding consultant  
 Organizing undergrounding consultant selection  
     Distributing notices to consultants  
     Providing content for web site

**PURC Administrative Activities**

Developing budgets

Proofreading all materials

Taking minutes on conference calls

Overseeing web site development

Organizing conference calls and meetings

Developing and updating web site

Developing all administrative documents, such as contact lists and invoices

## Appendix C

### Budget for Vegetation Management Workshop

<u>Items</u>	<u>Amounts</u>
Food	
Monday Lunch @\$25	\$ 1,175.00
Afternoon/morning breaks	\$ 1,410.00
Breakfast Tuesday morning	\$ 940.00
Tuesday Lunch	\$ 1,410.00
	<u>\$ 4,935.00</u>
Facilities	
Misc. room charges and fees	\$ 400.00
Audio visual set up and screen	\$ 200.00
	<u>\$ 600.00</u>
Total	<u>\$ 5535.00</u>
 <b><u>Payment Amounts</u></b>	
Registration Fee: 35* @ \$125	\$ 5,875.00*
*Projected	

## Appendix D

### PURC's Projected Budget for Research Coordination January – June, 2007

<u>Items</u>	<u>Amounts</u>
Personnel	
PURC Faculty (5 weeks)	\$ 25,200.00
Grad Student (5 weeks)	\$ 6,600.00
Administrative (2 weeks)	\$ 9,800.00
	\$ 41,600.00
Travel	
Vegetation Management Workshop	\$ 797.19
Steering Committee meetings (1)	\$ 130.00
	\$ 927.19
Miscellaneous	
Global Crossing Conference Calls	\$ 1,320.00
	\$ 1,320.00
Subtotal	\$ 43,847.19
University Overhead (25%)	\$ 14,615.73
Total	\$ 58,462.92

#### Payment Amounts

<u>Sponsor</u>	<u>Percent of Total</u>	<u>Amount due PURC</u>
FPL	46.71%	\$ 27,308.03
FPUC	0.33%	\$ 192.93
Gulf	4.46%	\$ 2,607.45
Progress	16.88%	\$ 9,868.54
TECO	6.93%	\$ 4,051.48
FECA	8.39%	\$ 4,905.04
FMEA	14.41%	\$ 8,424.51
LCEC	1.89%	\$ 1,104.95
	100.00%	\$ 58,462.92

#### PURC Faculty Activities

Managing work plans for wind study and vegetation management  
 Managing RFP and invoicing for wind study  
 Drafting report from vegetation management workshop  
 Reviewing undergrounding research reports  
 Drafting regulatory report for Sponsors  
 Organizing and managing weekly conference calls  
 Attending meetings with Sponsors, FPSC staff, and others  
 Managing PURC staff working on project

#### PURC Graduate Student Activities

Editing RFP for wind study  
 Participating in and taking minutes for weekly conference calls  
 Maintaining PURC work plan for overseeing projects  
 Serve as scribe for vegetation management workshop  
 Drafting report from vegetation management workshop  
 Managing conference call agendas

PURC Administrative Activities

Developing budgets

Proofreading all materials

Taking minutes on conference calls

Organizing conference calls and meetings

Developing all administrative documents, such as contact lists and invoices