

**Request for Research Funding for FY 2023-2024**

**Project Number** (Research Center Use Only): TEO-24-04

<b>Requesting Office</b>	State Traffic Engineering and Operations Office	<b>Priority</b> High	4 of 11
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**Proposed Title** Implementation of Backup Power for Traffic Cabinets during Extended Power Loss

**Current Situation**

Florida has suffered from yearly economic, social, and physical disruptions as a result of hurricane and tropical storm events. Figure 1 shows the insured property loss on the US Gulf Coast and other hurricane-prone areas, indicating that Florida has the highest overall insured property loss among all the states in hurricane-prone areas. Of particular concern is the failure of utility systems such as electricity, water, and telecommunications in the aftermath of a hurricane, as most other services rely on the integrity of these lifeline systems to function.

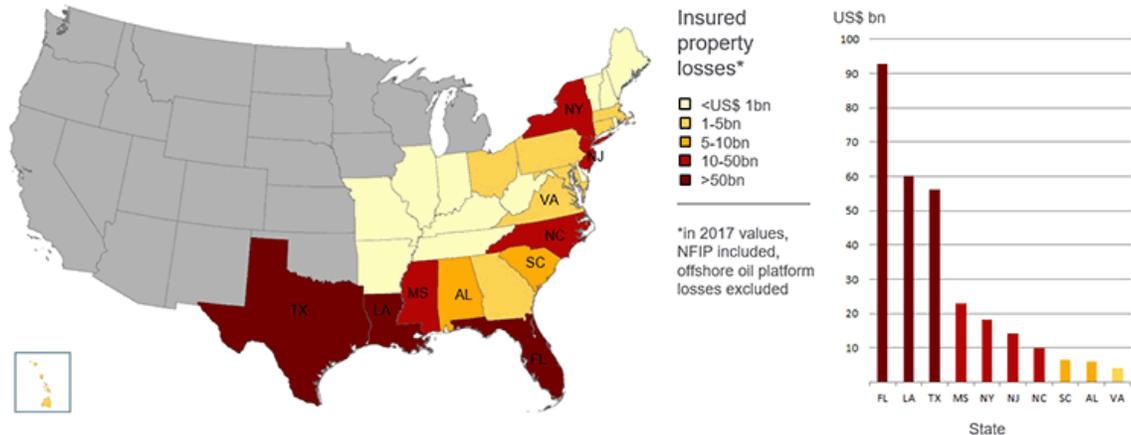


Figure 1. Insured Property Loss by State from Tropical Storms and Hurricanes, 1980–2017

**Justification**

In transportation, utility power is essential in the daily operation of traffic systems including traffic signals. Since traffic signals are critical for traffic safety and mobility, their operation has to be uninterrupted as much as possible. Currently when a traffic signal cabinet loses utility power, if it's equipped with an uninterrupted power source it can operate for up to 24 hrs depending on the power demand. The average operational duration however is 6-8 hrs. In situations of extended utility power loss due to hurricanes or other storms, the use of gas generators provides power at important intersections. Due to the cumbersome nature of upkeep, distribution, and keeping the generators working, this method is not ideal and has many failure points.

In a previous project, the Traffic Engineering and Research Lab (TERL) of the Florida Department of Transportation (FDOT) partnered with the Center for Urban Transportation research (CUTR) at the University of South Florida (USF) to conduct an investigation into different backup power systems that can provide extended power to traffic cabinets in case of power loss due to hurricanes. The research team conducted a literature review and technology search of state-of-the-art backup power systems including battery power, solar power, hydrogen, liquid propane, wind, and gas generation. The team tested a propane generator and a battery system with solar backup to power a traffic cabinet for 3 days. The tests were successful and provided insights and lessons learned for the future.

**Why the research is needed**

Even though the previous research project was successful in gathering information and showcasing the potential of two backup power systems, there is still a need for additional research on the topic of battery life cycle especially with newer chemistries like lithium-ion or lithium polymer batteries. In addition, there is a need to identify how the implementation

	<p>of solar power backup can become a reality especially with limited space at signalized intersections. At least two solutions have been identified: solar panels installed on the sidewalk and solar panels installed on mast arms or on poles. Products have become available since the completion of the previous study that warrant more research in identifying a solution that works. This research is needed to further vet all available systems and conduct a benefit cost analysis to provide FDOT with tangible evidence for the use of such system. Additionally, investigation into the new Advanced Traffic Controller (ATC) low voltage cabinets that are now available can be conducted to further identify benefits of using them over the current cabinets that are powered by AC power. Finally the team will seek to deploy a backup system at a live intersection with a local agency to further collect data on reliability, consistency and dependability of backup power systems for extended periods.</p> <p><b><i>Proposed Research Project Objectives</i></b></p> <p>Objectives and associated tasks of the proposed project are as follows:</p> <ol style="list-style-type: none"> <li>1. Expand the literature review to include additional backup systems that became available in the last 2 years,</li> <li>2. Perform additional research on the topic of battery life cycle, especially with newer chemistries like lithium-ion or lithium polymer batteries</li> <li>3. Research how solar panels adequate enough to charge a battery can be installed at a signalized intersection and provide solutions,</li> <li>4. Conduct pilot deployment of a selected backup system with a local agency,</li> <li>5. Conduct a benefit-cost analysis for selected backup systems,</li> <li>6. Research the benefits of using low power ATC cabinets instead of current NEMA-TS-2 cabinets.</li> </ol> <p><b><i>Research Effects on FDOT Mission Critical Focus Areas</i></b></p> <p>FDOT’s mission is to provide a safe transportation system that ensures the mobility of people and goods, enhances economic prosperity, and preserves the quality of Florida’s environment and communities. The mission of the FDOT Traffic Engineering and Operations office is to improve safety and mobility through the efficient application of traffic engineering principles and practices. This proposed research fully supports these missions. The proposed research will contribute to improving safety and mobility, especially mitigating safety and mobility challenges to the transportation network due to power loss after a storm. This in turn will prevent crashes from occurring due to a dark signal. The proposed research also fully supports FDOT’s vital focus to Improve Safety, Enhance Mobility, and Inspire Innovation.</p>
<b>Impact</b>	<p>The major results of this proposed research will include: (1) list of additional backup systems that can provide extended power to a traffic cabinet, (2) results of investigation into installing solar power at signalized intersections, (3) results of benefit cost analysis of backup power systems, and (4) investigation of the benefits of utilizing low voltage ATC cabinets instead of current cabinets.</p> <p>The consequences of not conducting the research include:</p> <ul style="list-style-type: none"> <li>• FDOT will not have an exhaustive and up-to-date list of backup power systems available in the market,</li> <li>• FDOT will not obtain further knowledge on topic of battery life cycle especially with newer chemistries like lithium-ion or lithium polymer batteries</li> <li>• FDOT will not have insights into the implementation of solar power at intersections,</li> <li>• FDOT will not have results from a pilot deployment of a backup power system at a live intersection,</li> <li>• FDOT will not have a benefit cost analysis of using extended backup power systems at signalized intersections,</li> <li>• FDOT will not have results of the implementation of low voltage ATC cabinets and their benefits over current cabinets.</li> </ul>
<b>Affected Offices</b>	State Traffic Engineering and Operations Office and District 7 Traffic Operations
<b>Existing Work</b>	<ol style="list-style-type: none"> <li>1. Lin, Pei-Sung; Kourtellis, Achilleas; Miao, Zhixin; Wang, Zhenyu; Zhang, Miao. Development of Low Voltage/Extended Runtime Signalized Intersection Using Backup Power after the Loss of Utility Power Due to Hurricanes. Center for Urban Transportation Research (CUTR); Florida Department of Transportation, 2021, 110p, <a href="https://trid.trb.org/view/1984651">https://trid.trb.org/view/1984651</a></li> </ol>

	<ol style="list-style-type: none"> <li>2. Qin, Nan; Brooker, R Paul; Raissi, Ali. Fuel Cell Vehicle Technologies, Infrastructure and Requirements. Electric Vehicle Transportation Center (EVTC); Research and Innovative Technology Administration, 2017, 15p. <a href="https://trid.trb.org/view/1466931">https://trid.trb.org/view/1466931</a></li> <li>3. Zhao, Mo; Sharma, Anuj; Smaglik, Edward; Overman, Tim. Traffic Signal Battery Backup Systems: Use of Event-Based Traffic Controller Logs in Performance-Based Investment Programming. Transportation Research Record: Journal of the Transportation Research Board, Issue 2488, 2015, pp 53–61, <a href="https://trid.trb.org/view/1338610">https://trid.trb.org/view/1338610</a></li> <li>4. Zhao, Mo; Sharma, Anuj; Bernt, Dave G; Meyer, Joshua A; Dickey, Benjamin; Rosenbaugh, Scott K; Jones, Elizabeth; Rilett, Laurence. Economic Analysis of Using a Renewable Wind Power System at a Signalized Intersection. Journal of Intelligent Transportation Systems, Volume 17, Issue 3, 2013, pp 210-220, <a href="https://trid.trb.org/view/1266603">https://trid.trb.org/view/1266603</a></li> <li>5. Sternberg, Steven P; Hasan, A Rashid; Mereddy, Venkatram R. A Prototype System for Chemical Hydrogen Generation and Storage for Operating ITS Devices. University of Minnesota, Duluth; Intelligent Transportation Systems Institute; Research and Innovative Technology Administration, 2013, 44p, <a href="https://trid.trb.org/view/1247381">https://trid.trb.org/view/1247381</a></li> <li>6. Mereddy, Venkatram R. Development of Novel Hydrogen-Based Power Systems for ITS Applications: Phase-I. University of Minnesota, Duluth; Intelligent Transportation Systems Institute; Research and Innovative Technology Administration, 2012, 24p, <a href="https://trid.trb.org/view/1238458">https://trid.trb.org/view/1238458</a></li> <li>7. Zhao, Mo; Appiah, Justice; Sharma, Anuj. Cost-Benefit Analysis of Providing Battery Backup at High-Speed Signalized Intersection. Transportation Research Board 91st Annual Meeting, Transportation Research Board, 2012, 14p, <a href="https://trid.trb.org/view/1130126">https://trid.trb.org/view/1130126</a></li> <li>8. Palsa, Joseph G. Power and It's Importance to Effectively Maintain Signal Control &amp; Communications for Life and Safety. ITE 2009 Technical Conference and Exhibit, Institute of Transportation Engineers (ITE), 2009, 9p, <a href="https://trid.trb.org/view/923652">https://trid.trb.org/view/923652</a></li> </ol>		
<b>Keywords Used In Existing Work Search (Cannot leave blank)</b>	Electric power generation; Lithium batteries; Low voltage; Propane generation; Solar power generation; Hydrogen generation; Traffic signals; extended power loss		
<b>Related Contracts (Give contract numbers)</b>	BE703		
<b>Funding Request</b>	\$230,000	<b>Anticipated Duration</b>	18 months
<b>Project Manager</b>	Derek Vollmer, PE	<b>Contracting Method</b>	Direct contract with Center for Urban Transportation Research (CUTR) at the University of South Florida; PI – Dr. Lin
<b>Equipment</b>	\$20K-\$25K	The team will work with the TERL to utilize existing equipment. However, additional equipment will be needed to test. This will include new backup systems not tested previously, traffic cabinets, and other equipment needed to run the systems.	
<b>Urgency</b>	Score = 1; highest, most immediate need	During the last 2 years (2020-2022), approximately 20 storms have made landfall or resulted in damage to a part of Florida causing damage and power loss. A solution to dark intersections is needed as dark intersections cause crashes, injuries, and fatalities. Power resilience is a very high priority in the state and FDOT can make its system more robust by providing an alternative to the current state of practice.	
<b>Implementability</b>	Score =1 greatest likelihood of and proximity to implementing results	This is a project that continues work conducted in the previous years. The current and future situation to traffic systems after power loss is increasing and the results of this project will directly impact the ability of FDOT to continue to provide a safe transportation system.	
<b>Project Benefits (Succinct, complete explanation)</b>			
The FDOT is in need of an implementable solution for extended power loss at signalized intersections. The significant benefits for conducting this proposed research project include the following:			
<ol style="list-style-type: none"> <li>1. FDOT will have a comprehensive list of backup power systems suitable for extended loss at signalized intersections</li> </ol>			

2. FDOT will have further knowledge on topic of battery life cycle especially with newer chemistries like lithium-ion or lithium polymer batteries
3. FDOT will have solutions for installing solar panels at signalized intersections
4. FDOT will have a benefit cost analysis of using backup power systems at signalized intersections
5. FDOT will have the opportunity to test and quantify the benefits of using low power ATC cabinets

<b>Project Benefits</b> (Select all that apply and explain)	<b>Quantifiable Benefits</b> (units, dollars, etc...if applicable)	<b>Methodology or Data Sources Used to Determine Quantifiable Benefits. If not applicable, please give justification of project benefits</b>
<input type="radio"/> Materials Enhancement		
<input type="radio"/> Materials Savings		
<input type="radio"/> Time Savings	Reduction of time needed for TERL to have a product on the APL for future use  Reduction of vehicle delays at major signalized intersections on arterial corridors	The application of this project will lead to one or more solutions to the power loss problem.  The implementation of a backup power system will lead to reduced vehicle delays and reduced need of enforcement at dark intersections after extended power loss due to a hurricane.
<input type="radio"/> Lives Saved/Injuries Prevented	Reduction of crashes and fatalities/injuries	The results of this project will lead to the implementation of a power backup system that can power dark intersections. This can prevent crashes, injuries and save lives from crashes caused by dark intersections/.
<input type="radio"/> Other (Explain)		