Eliminating Hurricane-Induced Storm Surge Damage to Electric Utilities via In-Place Elevation of Substation Structures and Equipment

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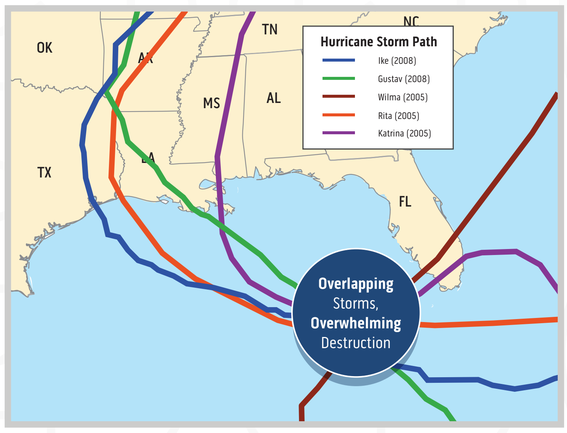
When coastal communities suffer the consequences of multiple "hundred year" tropical storms within the span of just a few years, with property damages measured in the billions, electric utilities must take action to increase the resistive strength of their system's operating assets to the destructive forces of these storms. Otherwise, they risk:

- Prolonged power outages
- Dangerous Working Conditions
- Costly, often irreparable property damage
- Regulatory concerns
- Negative public perception of utility provider service



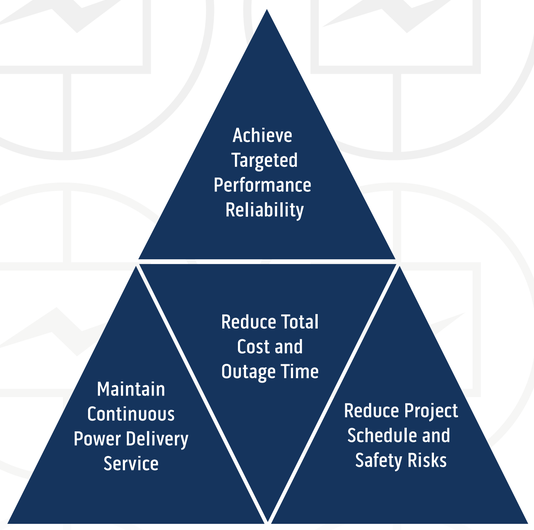
As these high-magnitude storms hit coastal regions with increasing frequency and storm surges that range from 10 to 30 feet in height, the devastation caused is monumental.

The immense Impact of Hurricanes on U.S. Gulf Electric Infrastructure, 2005 vs. 2008

Infrastructure Impacted	2005		2008	
	Katrina	Rita	Gustav	Ike
Utility Poles Destroyed	72,447	14,817	11,478	10,300
Transformers Damaged	8,821	3,580	4,349	2,900
Transmission Structures Damaged	1,515	3,550	241	238
Substations Off-line	300	508	368	383
Customer Outages (weeks)	~ 4	~ 4.5	~ 1.5	~ 2.5
Infrastructure Impacted	72,447	14,817	11,478	10,300

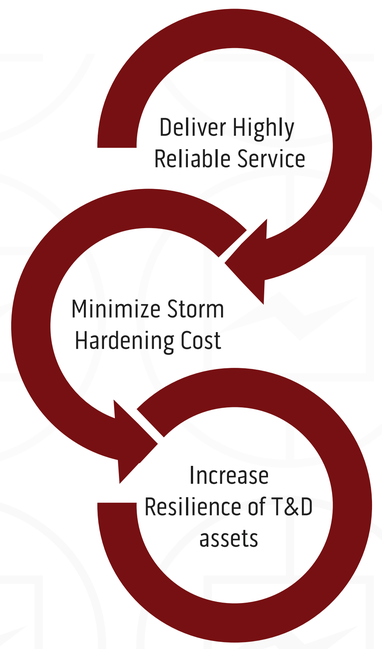
In-place structural elevation provides optimal results to storm-harden existing substation equipment sensitive to storm surge flooding by elevating structures in-place to 13 feet above sea level (5 feet above the highest flood point and 2 feet above FEMA and insurance recommendations).

The successful completion of this approach primarily resides in the coupling of clear expected outcomes with a thorough project planning process and a stakeholder-focused iterative design process with ample design review and comment opportunities.



Coastal electric utilities have been challenged with balancing competing responsibilities.

However, not all solutions offer equal value when considering the technical challenges and costs. Upon closer examination, in-place structural elevation is a solution that rises above the rest.



Evaluation of Storm-Hardening Solutions

	LEVEE (FLOODWALL)	RELOCATION	STRUCTURAL ELEVATION
Description	A protective berm with electric pumping equipment to remove entrapped water.	Relocate the substation onto higher ground by building up the entire substation site pad.	Raise sensitive substation equipment utilizing existing structures.
Illustration			
Cost Criterion	**SATISFACTORY** Avoids costs associated with demolition and new site construction.	**PROHIBITIVE** High site development costs escalate dramatically, lose 'embedded' assets.	**SATISFACTORY** Avoids cost associated with new site acquisition and construction, loss of assets.
Schedule Criterion	**SATISFACTORY** Minimal construction duration, abundance of qualified contractors.	**PROHIBITIVE** Land acquisition and site pad development time are significant.	**SATISFACTORY** Minimal construction duration, ability to meet schedule deadlines.
Potential for Service Disruption	**MINOR RISK** Construction of floodwall unlikely to disturb operations.	**SIGNIFICANT RISK** Circuits could be minimally protected and overloaded during relocation.	**SOME RISK** Though solution *has* been successfully implemented with *no* disruption.
Performance Criterion	**SIGNIFICANT RISK** Requires additional equipment monitoring and maintenance, while a breach could result in total operational failure.	**SATISFACTORY** The substation should adequately resist the effects of storm surge, once relocated to the new elevated site pad.	**SATISFACTORY** No change at all in performance risk, with only moderate increases in operation and maintenance risk.

CASE STUDY: 115-24.5kV Outdoor Open-Air Substation

Description	**After experiencing substation damage due to storm surge flooding in 2005 during Hurricane Rita and again in 2008 with Hurricane Ike**, one coastal utility opted to elevate in-place existing 115-24.5kV outdoor open-air substation flood-sensitive equipment to a point of 5 feet above the previous hurricane-induced storm surge high water mark, or 13 feet above mean sea level. This effort included but was not limited to: 1. Elevating in-place four (4) existing 115kV circuit switcher electronic control cabinets 2. Elevating in-place two (2) existing 33MVA 115-25kV power transformers 3. Elevating in-place one (1) existing control building 4. Elevating in-place two (2) existing 25kV distribution substation structures and associated circuit breakers
Specifications	**The project criterion additionally stipulated the following conditions:** 1. No change in power station performance or system reliability permitted 2. No appreciable change in operational and maintenance practices permitted 3. No service disruption throughout the life of the project permitted 4. No increase in construction safety risk permitted 5. Total installed cost cannot exceed authorized budget 6. Solution must be delivered on schedule
Process	**The electric utility retained power throughout the process literally and figuratively:** DIS-TRAN substation structure engineers engaged closely with the utility's O&M management and technicians during an iterative design process to provide opportunities(1) to develop clear expected outcomes and (2) to ensure that the final system of interconnected elevated platforms would adequately account for the space required to safely operate the equipment as if done at grade level. 1. Assess the structural condition of the existing substation to be hoisted 2. Assess the structural condition of the existing foundations to be subjected to increased loadings 3. Establish design criteria 4. Design the column extensions 5. Design platform for operations and maintenance 6. Design lifting plan to accommodate existing equipment and site constraints
Outcomes	• **Project completed within the established budget** • **Project completed within the allotted time frame** • **No power loss to customers** • **No unusual maintenance requirements after completion** • **Final measure 13 feet above sea level**

Note that not all sites are ideally suited for in-place elevation. For more information, ask a DIS-TRAN specialist or visit www.distransubstations.com.