EPRI | ELECTRIC POWER RESEARCH INSTITUTE

Strategic Program

Materials—Power Delivery

Technology Innovation

Advances in materials science and technology are required to improve the cost and performance of transmission and distribution system components in terms of durability, reliability, environmental compatibility, and other key areas.

STRATEGIC DRIVERS

Smart Grid

Energy Efficiency

Near-Zero Emissions

INNOVATION TARGETS

- **Mitigate key failure modes**
- **Decrease greenhouse gas emissions**

EPRI is leading the development of protective nanocoatings for composite insulators and self-healing dielectric materials for cables, as well as of substitutes for sulfur hexafluoride (SF_6), a common switchgear insulator. Several previously initiated projects are now being pursued through EPRI's Strategic Programs on Power Electronics, Energy Efficiency, and Energy Storage (see EPRI fact sheets 1023483, 1023474, and 1023475).

Strategic Value

If successful, this program will transfer advanced insulator, cable, and power flow control technologies to EPRI's Power Delivery & Utilization Sector for application-oriented development and field demonstration in collaboration with electric utilities and commercial manufacturers. Based on novel materials with improved performance characteristics, these innovations will improve reliability and reduce maintenance costs in transmission and distribution systems. For example, nanocoatings applied to guy strain insulators are expected to extend lifetime by 25% or more while increasing the purchase price by less than 3%.

Technology Gaps

Strategic work addresses the following critical capability gaps:

- Composite insulators with increased resistance to moisture penetration and photodegradation
- Longer-lasting dielectric insulation for underground cables
- Alternatives to SF_6 for high-voltage insulation and current interruption applications.

R&D Highlights

Nanocoatings for Insulators. Thin-film nanocoatings for composite insulators are being designed and tested to help address environmental aging and other degradation mechanisms affecting long-term performance. An initial coating formulation applied directly to the surface of fiberglass samples demonstrated great promise in 2009. In follow-on research, the base formulation was altered to incorporate additives that absorb ultraviolet (UV) radiation, and a two-layer nanocoating structure was created to more effectively limit radiation reaching the composite material's surface. Mechanical testing indicates that this structure does not compromise thin-film adhesion or durability. Accelerated aging studies show excellent performance under long-term exposure to UV radiation, moisture, and heat. Ongoing work involves scale-up of the nanocoating synthesis process and deposition on different types of insulator rods procured from commercial suppliers. Field exposure and environmental aging tests are being conducted at EPRI's laboratories in Charlotte, North Carolina, and Lenox, Massachusetts, and ongoing conversations with insulator

Materials innovations—such as durable, low-cost nanocoatings for fiberglass insulators—enhance the overall performance of electricity infrastructure and enable smart grid functionalities.

manufacturers focus on incorporating a coating stage in production environments. In 2012, thin-film nanocoatings are expected to be ready for field demonstration and commercial licensing.

2011-12 Milestones
- Complete initial nanocoating field tests
- Transfer technology to Power Delivery & Utilization Sector

SF_6 Alternatives. High-voltage switching equipment commonly incorporates SF_6, a stable, inert gas with high dielectric strength. As control standards for SF_6 tighten due to concern about its high global warming potential, substitutes are needed for future transmission equipment. Based on a 2009 state-of-knowledge assessment of innovative solid dielectric materials, graphite compounds are being explored as a possible quenching material and insulator in high-voltage switchgear.

2011-12 Milestones
- Complete initial evaluation of solid dielectric material
- Define development pathways and risks

Self-Healing Cables. Based on previous strategic work, nanocomposite dielectric materials are being commercialized for underground cable applications through the Power Delivery & Utilization Sector. Now, EPRI is exploring the feasibility of dielectric insulation capable of repairing itself in response to damage. Proof-of-concept work involves specialized nanoparticles embedded in a polymer composite matrix and designed to react when exposed to changes in electric fields created by nicks and scratches. Under these partial discharge conditions, the nanoparticles would release polymer precursors to form bonds within the composite and restore a damaged area's insulating properties. Laboratory studies address nanoparticle design and synthesis and in-matrix activation and evaluation, with initial tests showing that self-healing materials offer an order-of-magnitude increase in voltage endurance. If successful, long-term, high-risk research in this area could lead to underground cables with increased reliability, lower maintenance costs, and longer lifetime.

2011-12 Milestones
- Establish proof of concept for self-healing composite materials
- Define development pathways and risks

PROGRAM LEVERAGE

None at present

INNOVATION NETWORK

University
- **Rensselaer Polytechnic Institute**
- **University of Liverpool (UK)**

Public & Private Sector
- **NEI Corp.**

For more information

For more information, contact the EPRI Customer Assistance Center at 800.313.3774 (askepri@epri.com).

Contact

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EPRI employs technology readiness level (TRL) metrics to monitor the status of individual technologies as they advance through its innovation process and transition into its sector programs toward commercial application. (PDU = Power Delivery & Utilization Sector; P36 = Underground Transmission Program; P180 = Distribution Systems Program; P35 = Overhead Transmission Program; P37 = Substations Program)

Startup Conditions, End-of-Year 2011 Status and Sector Transitions

Project Area	Research and Discovery			Innovation and Development		Demonstration		Commercialization and Diffusion	
	TRL1	TRL2	TRL3	TRL4	TRL5	TRL6	TRL7	TRL8	TRL9
Nanocoatings for Fiberglass Insulators	2008					2012	PDU (P35)		
SF_6 Alternatives	2009					2014	PDU (P37)		
Dielectrics for Self-Healing Cable		2009	2011	PDU (P36, P180)					

= Anticipated Progress Through EOY11 = Anticipated Progress at Transition Point

1023480 July 2011

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