ELECTRIC POWER RESEARCH INSTITUTE

*Strategic Program*

# Energy Efficiency

Technology Innovation

*Fundamentally new materials and technologies promise to generate step-change gains in efficiency and to accelerate electrification, helping meet growing demand while managing both carbon emissions and consumer energy costs.*

**STRATEGIC DRIVERS**

**Energy Efficiency**

**Smart Grid**

**INNOVATION TARGETS**

- **Develop revolutionary end-use technologies**
- **Expand electrification**

EPRI is developing novel electrochromic window coatings with demand-response capability and phase-change wallboard materials for reducing cooling loads, and basic research and targeted proof-of-concept studies are under way to identify breakthrough lighting, motor, space conditioning, and other technologies that could be accelerated to commercialization across the next 5 to 10 years. In addition, approaches for integrating these advances with building performance, renewable generation, and smart grid technologies are being devised. This effort, which is new for 2011, incorporates projects initiated under the Strategic Materials for Power Delivery Program (see EPRI fact sheet 1023480).

## Strategic Value

If successful, this program will transfer electricity-based innovations to EPRI's Power Delivery & Utilization Sector for application-oriented development and field demonstration in collaboration with the electric sector, commercial manufacturers, and other stakeholders. New utilization technologies that enhance comfort, convenience, productivity, and performance while delivering step-change improvements in end-use efficiency will help improve quality of life, stimulate economic growth, serve demand, reduce pollutant and greenhouse gas emissions, and support electrification. This will create substantial benefits for consumers, utilities, and society.

## Technology Gaps

To leapfrog existing technologies that offer potential for only incremental efficiency gains, strategic work addresses the following critical capability gaps:

- Materials with active or passive abilities to influence needs for lighting, heating, and cooling services
- New topologies, materials, and drive systems for high-efficiency motors
- Advanced working fluids, designs, and controls for space conditioning, heat recovery, refrigeration, and other building systems
- Optimized designs for light-emitting diode (LED) systems

*Materials and design innovations—such as roll-to-roll thin-film production processes for dramatically reducing the cost of electrochromic window coatings—promise step-change efficiency gains and new demand-response capabilities for major end uses of energy.*

## R&D Highlights

**Thin-Film Electrochromic Window Coatings.** Adjusting the voltage applied to electrochromic coatings changes their energy transmittance characteristics to allow, for example, windows to be switched from being more transparent in winter to more opaque in summer. Controlling solar gain and optimizing daylighting produces energy savings of 20 to 40% in individual buildings, but current coatings must be applied directly to glass intended for new windows at a cost of $60 to $100/sq ft. In a project cosponsored by the U.S. Department of Energy's Advanced Research Projects Agency-Energy, a roll-to-roll deposition process is being developed to facilitate high-volume manufacturing of new thin-film electrochromic coatings. These nickel-based plastic coatings could be applied to both existing and new windows at costs of $3 to $5/sq ft. EPRI work focuses on modeling the performance of coated windows, testing their efficiency and durability in the laboratory, and analyzing market potential. Demand-response and other implementation strategies also are being explored to maximize the technology's value in improving efficiency and shaving peak load.

*2011-12 Milestones*

- Complete market analysis
- Model and validate coating performance
- Transfer technology to Power Delivery & Utilization Sector for field demonstration

**Phase-Change Wallboard Materials.** Incorporation of novel glycerin-based phase-change materials in wallboard is being explored as a novel strategy for adding thermal mass to buildings. By absorbing heat as they melt during the day, glycerin modules have the ability to increase latent heat storage within the building structure. This helps reduce the amount of cooling energy required to maintain indoor air temperatures at a comfortable level. At EPRI's laboratory in Knoxville, Tennessee, a test protocol has been developed for evaluating heat storage characteristics of phase-change wallboard materials and calculating potential energy savings and payback periods for different climates.

*2011-12 Milestones*

- Complete state-of-the-art assessment and laboratory testing of chosen drywall prototype
- Transfer technology to Power Delivery & Utilization Sector for field evaluation and commercialization

**Advanced End-Use Technologies.** For motors, research addresses alternatives to standard induction technology—including transverse-flux, high-temperature superconducting, and fractional-slot concentrated-winding motors—and to the rare-earth materials currently used in permanent magnet machines. In addition, two options are being studied for expanding use of adjustable speed drive (ASD) technology. Wide-bandgap semiconductors may enable low-cost, highly functional ASDs suitable for small and medium motors. The "Green Drive" may allow output from solar photovoltaic (PV) modules to be fed directly to the direct current (DC) bus of ASDs, helping power residential-scale fans and pumps while avoiding needs for separate DC-to-DC converters.

**PROGRAM LEVERAGE**

**20:1**

**INNOVATION NETWORK**

***Public & Private Sector***

- **ITN Energy Systems**
- **Southern California Edison**
- **U.S. Department of Energy Advanced Research Projects Agency (ARPA-E)**

To realize step-change efficiency gains for electricity-based heating, ventilation, and air conditioning, novel refrigerant chemistries and a magnetic cooling approach—relying on the magnetocaloric effect rather than vapor compression—are being evaluated as starting points toward development of advanced systems. Innovative approaches for recovering heat from ventilation, make-up air, cooling, and wastewater systems also are being studied.

In lighting, a systems approach is being pursued to optimize design of LED technologies for specific applications by exploiting synergies between diode efficacy, luminaire photometrics, thermal management, and power supply. This could lead to smaller, lower-cost LED systems.

*2011-12 Milestones*

- Initiate design and testing of advanced ASDs
- Identify refrigerants and heat recovery concepts meriting further development
- Develop systems approach for optimizing design of LED technologies

**Advanced Building Designs and Controls.** EPRI is exploring design strategies for optimizing the sizing and use of PV systems to serve thermal and plug loads in zero-net-energy (ZNE) buildings in multiple climates. By integrating PV with high-efficiency electricity-based technologies and other design and construction elements, the goals are to maximize lifetime energy and demand savings and alleviate first-cost barriers to ZNE construction. In addition, advanced building control systems incorporating smart grid functionalities are being designed and tested. These systems promise to facilitate widespread demand response by automating the process of minimizing energy consumption and costs within given performance constraints based on dynamic building, grid, and market conditions.

*2011-12 Milestones*

- Quantify potential energy savings in optimizing PV application for ZNE buildings
- Develop and test grid-integrated building controls

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## For more information

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

*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; P170 = End-Use Efficiency & Demand Response in a Low-Carbon Future 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 |
| **Thin-Film Electro-chromic Window Coatings** | | | 2008 | | | | 2012 | PDU (P170) | |
| **Phase-Change Wallboard Materials** | | | 2010 | | 2012 | PDU (P170) | | | |

= Anticipated Progress Through EOY11

= Anticipated Progress at Transition Point

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