TRANSFORMING ELECTRICITY DELIVERY

RESEARCH AND DEVELOPMENT DIVISION

OFFICE OF ELECTRICITY DELIVERY AND ENERGY RELIABILITY

Strategic Plan

September 2007

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STRATEGIC PLAN

Research and Development (R&D) Division
Office of Electricity Delivery and Energy Reliability (OE)
U.S. Department of Energy (DOE)

Director's Message

Abundant, affordable, reliable, secure, and clean electric power is paramount for success in the global marketplace. Electricity keeps homes and offices lit, factories humming, communications flourishing, computers networking, hospitals operating, and buildings comfortable. Electricity is so fundamental that people often take it for granted. We do not. As you will see in this Strategic Plan, we are dedicated to making America's electric delivery infrastructure second to none.

To do this we are focused on the future of electric power, a future that offers both challenges and opportunities. For example:

- What will be the role of America's electricity delivery infrastructure in providing ***clean and efficient supply- and demand-side solutions*** (e.g., renewables, energy efficiency, clean coal, and nuclear power) for lower carbon emissions, reduced air pollution, and reduced dependence on foreign energy sources?
- How will the nation develop and deploy ***smart grid systems*** for interoperability, cyber security, dynamic pricing, distributed generation and storage, and demand response?
- How will system operators achieve ***real-time grid management*** for fewer blackouts and power quality disturbances, and faster restoration times when outages do occur?
- How will the electric delivery infrastructure be protected from disruptions for ***enhanced adaptability, resiliency, and response*** both to occurring and unforeseen events?
- How can we reduce congestion and increase capacity to meet ***future requirements such as plug-in hybrid electric vehicles***?

Tackling these requires technical innovation, entrepreneurship, and mechanisms for marshalling the collective resources of the electric power industry, government agencies, national laboratories, universities, and the financial community. Over the coming decades we will see billions invested in new and advanced electric transmission and distribution (T&D) equipment since many of the power lines, substations, transformers, and switchgears are aging and have been in place for forty years or more.

Our job is to work with public and private sector partners to research, develop—and help bring to market—the "next generation" of electric delivery infrastructure, technologies, tools, and techniques.

Accomplishing this involves national leadership, effective partnerships, and a shared vision for the future. Imagine the possibilities: easy delivery of a wide array of customized and cost-effective clean energy choices for consumers, automated grid operations with near-zero economic losses from outages and power quality disturbances, and flourishing markets for the world's best and cleanest electricity services—all of this from a new electricity delivery infrastructure built on smart grid systems, clean power, and advanced technologies.

While the challenges are great, the opportunities are even greater. Please join us in helping to create a more prosperous, clean, and secure electricity future for America.

Mission Statement

Our mission is to advance technology, in partnership with industry, government, and the public, to meet America's need for a reliable, efficient and resilient electric power grid

We accomplish our mission by

Designing research, development, and demonstration programs based on a future look at electric power delivery with respect to evolving societal and technological change

Developing cost-effective technology that enhances the reliability, efficiency, and resiliency of the electric grid, while enabling the effective utilization of emerging generation and demand-side management technologies and practices

Collaborating closely with industry, government, academia, and the public to ensure technological and marketplace relevance

Engaging highly-qualified, multi-disciplinary researchers to develop advanced tools and smart grid technologies

Guiding Principles

We are committed to

Fostering energy security

Making the electric grid robust, intelligent, and secure

Enabling the integration of distributed and renewable generation

Furthering fuel diversification

Decreasing production of pollutants and greenhouse gases

Increasing asset utilization

Partnering with states, utilities, industry, and academia

Collaborating with other U.S. Department of Energy (DOE) and Federal offices

Creating system level linkages between technologies

Advancing R&D to achieve market readiness

Fostering a work environment embracing teamwork and diversity

Acting with integrity and fiscal responsibility

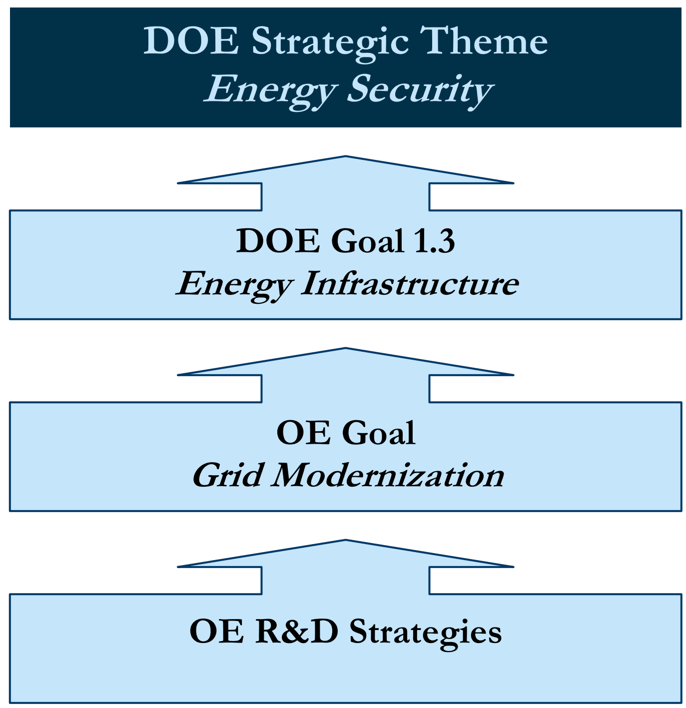
Ensuring safety in the workplace

Strategies

Supporting DOE's Energy Security Strategic Theme[1]

DOE Goal 1.3 – Energy Infrastructure[1]
Create a more flexible, more reliable, and higher capacity U.S. energy infrastructure

OE Goal
Lead national efforts to modernize the electric grid, enhance security and reliability of the energy infrastructure, and facilitate recovery from disruptions to the energy supply



OE R&D will

Develop **high temperature superconducting** and other **advanced wires and coils** to increase the capacity, efficiency, and reliability of the electricity system

Advance **real-time visualization and control tools** to improve the reliability and efficiency of the Nation's electricity delivery system by increasing the utilization of T&D assets and improving the response to disruptions

Integrate advanced technologies, including **renewables, distributed generation**, **storage**, and load management to improve the efficiency and reliability of the electricity network

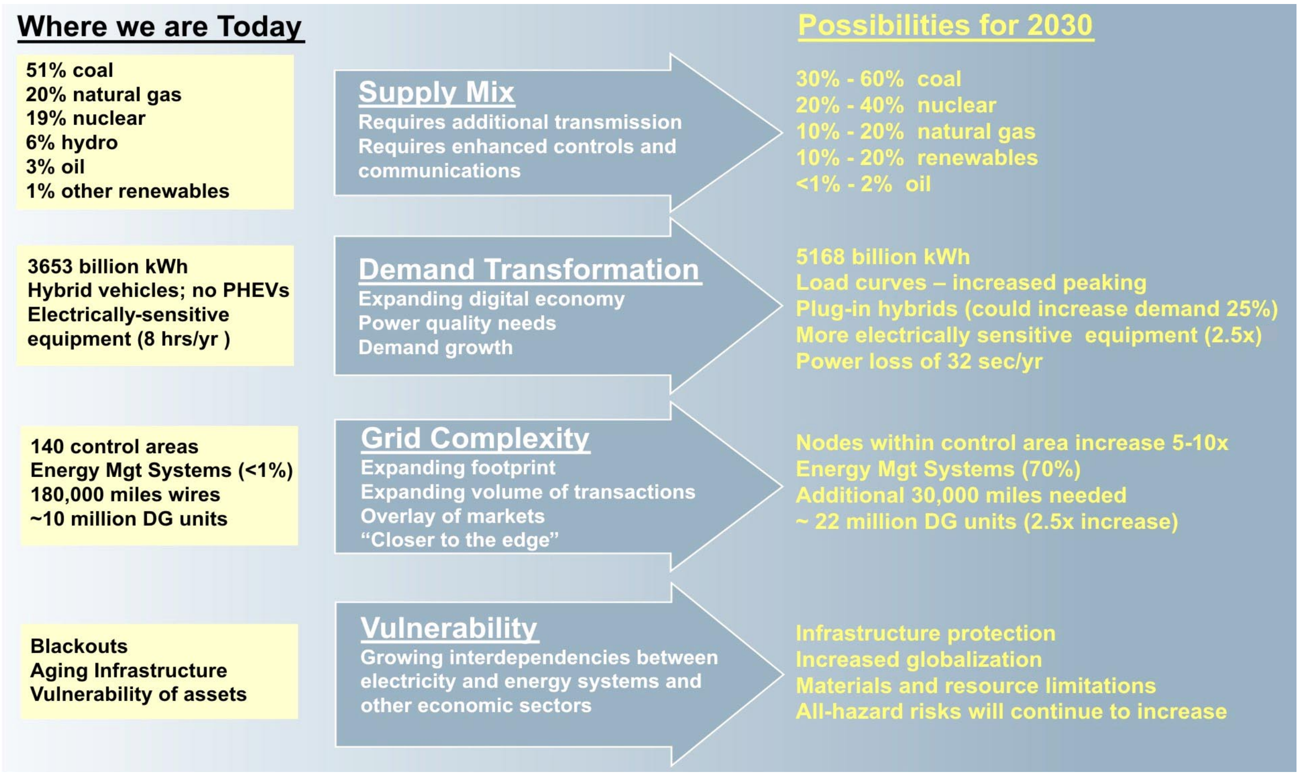
Future Conditions and Possibilities

Electric power is an essential ingredient for economic prosperity, national security, environmental protection, and public health and safety. Communities that lack electric power, even for short periods, have difficulties meeting basic needs for food, shelter, water, and law and order. In 1940 about 10% of the total energy consumed in America was used to make and deliver electric power; that fraction grew to 25% in 1970, hitting 40% today.[2]

Many trends point to a stronger and more strategically important role for electric power, electric infrastructure, and electricity end use. For example,

- Application of advanced technology to the electric infrastructure resulting in energy efficiency gains and reduced energy use could be the most important contributors to strategies aimed at overall CO_2 emissions reduction[3]
- Substantial electricity demand growth is expected, along with changes in the patterns of demand by consumers, even with greater numbers of energy efficient appliances and equipment
- More extensive diversification in the generation portfolio will be required, along with growth in electricity delivery capacity, to meet growing demand under a carbon-constrained future[4]
- Further expansion is occurring in the amount of power transactions, and in the complexity and competitiveness of power system operations, including growth in the use of distributed generation and storage, and demand response
- The energy infrastructure is becoming increasingly sensitive to disruptions, and interdependencies are deepening among electricity, natural gas, oil, transportation, communications, finance, and other critical energy and economic sectors

Electricity Delivery Faces Future Challenges[5]



Activities & Priorities

Electricity delivery systems will need to expand, evolve, and become "smarter" to meet the challenges that lie ahead. A key federal role is support of research, development, demonstration, and technology transfer for "next generation" technologies, tools, and techniques. Through extensive consultations with public and private sector partners, OE's R&D Division is pursuing four Key Activities to implement its strategies to transform electricity delivery systems in the United States and around the world. These Activities were determined as critical technology areas for Federal investments and are documented in the *Grid 2030-National Vision*[6], *National Electric Delivery Technology Roadmap*[7], and *Roadmap to Secure Control Systems in the Energy Sector*[8] documents.

Key Activities

OE R&D Key Activities are structured to effectively execute its strategies to meet future challenges and opportunities

Strategies	Key Activity	Synopsis
High temperature superconducting & other advanced wires and coils	**High Temperature Superconductivity**	Development of HTS wires and electric power equipment, such as cables, fault current limiters, and transformers
Real-time visualization and control tools	**Visualization and Controls**	Development of real-time information, analysis, and control capabilities to achieve an automated, smart, reconfigurable, and secure electric transmission and distribution network
Advanced technologies integration	**Renewable and Distributed Systems Integration**	Development of technologies, tools, and techniques for systems integration of renewables, distributed generation, and demand response to reduce peak load, broaden generation diversity, and enhance asset utilization
Advanced technologies integration; real-time control tools	**Energy Storage and Power Electronics**	Development of high-voltage, high-power, cost-effective energy storage systems Development of power electronics for high-voltage, high-power, and high-speed applications

High Temperature Superconductivity

Superconducting power equipment has the potential to become a key 21st century technology for improving the capacity, efficiency, and reliability of electric power equipment. For example, the higher capacity of superconductive power lines could provide a new approach to building transmission and distribution that will reduce the footprint and allow additional capacity to be put in place over existing rights of way. Increased energy efficiencies with reduced energy losses in transmission and distribution are an additional benefit.

OE has been leading the national efforts in this technology. Practical superconducting power equipment such as cables, fault current limiters, and transformers are now being developed and are expected to be commercially available in time to accommodate expected load growth and to replace existing equipment.

High Temperature Superconductivity Contributing to Key Performance Improvements			
Reliability	**Efficiency**	**Security**	**Environmental Impact**
Increased capacity relieves congestion and helps prevent outage	High operation efficiency conserves energy and reduces supply-side pollutants	Fewer critical nodes to secure Ability to share power between assets ensures continuity in electricity delivery and shortens recovery time from incidents	Minimizes environmental impact through oil-free operation and decreased demand for new rights of way

Goals & Metrics†

High Temperature Superconductivity

By 2020, develop prototype wire achieving 1,000,000 length-critical current (A-m) for second generation wire†

Performance of HTS wires is expressed in amperes-meters (A-m), where the critical current of 1 cm-wide wire at 77K and self-field is multiplied by the wire length. The A-m value provides a basis for the comparison of different HTS wires, and is an actual indicator of progress in wire development. HTS wires with a current capacity of 1,000 amperes and piece-length of 1,000 meters, i.e., equivalent of 1,000,000 A-m, will satisfy the requirement of most practical applications.

Demonstrate prototype 50,000 A-m critical current-length for second generation wire by FY08†

Demonstrate prototype 70,000 A-m critical current-length for second generation wire by FY10†

Demonstrate prototype 100,000 A-m critical current-length for second generation wire by FY12†

Demonstrate prototype 500,000 A-m critical current-length for second generation wire by FY14†

Demonstrate prototype 800,000 A-m critical current-length for second generation wire by FY15†

Demonstrate prototype 1,000,000 A-m critical current-length for second generation wire by FY20†

By 2014, produce high temperature superconducting coil that operates in applied magnetic fields up to 5 Tesla at 65K for HTS applications†

HTS wires used in the form of windings or coils in power equipment including fault current limiter and transformer must possess sufficient current capacity in the presence of a magnetic field at the chosen operation temperature. For most HTS power equipment, the maximum operational field is estimated to be 5 Tesla at 65K.

Demonstrate prototype superconducting coils operating in magnetic fields of 2 T at 65K by FY09†

Demonstrate prototype superconducting coils operating in magnetic fields of 3 T at 65K by FY12†

Demonstrate prototype superconducting coils operating in magnetic fields of 5 T at 65K by FY14†

† *Denotes the OE R&D Program Performance Measures, tracked by the Office of Management and Budget*[9]

By 2012, verify operating characteristics and reliability of high-capacity HTS cables for distribution level systems and gain industry acceptability

By 2012, establish design rules based on the full characterization of mechanical and electrical properties of existing and new dielectric materials at cryogenic temperatures

High-voltage dielectric insulation at cryogenic temperatures is needed for most HTS power equipment operations. Available cryogenic dielectric materials are limited and not fully characterized, especially in high-voltage AC applications with acceptable partial discharge. Also, tailor-made cryogenic dielectric materials with superior electrical and physical properties are desirable to ensure reliable and optimal performance of HTS power equipment.

Fully characterize existing materials at high voltages and cryogenic temperatures in AC applications by FY09

Establish criteria and Institute of Electrical and Electronics Engineers (IEEE) testing standards for cryogenic dielectrics at distribution and transmission voltages up to nominal 161 kV by FY10

Develop design rules based on existing materials by FY10

Fully characterize new dielectric materials at high voltages and cryogenic temperatures by FY12

Develop database of cryogenic dielectric materials and update design rules by FY12

† *Denotes the OE R&D Program Performance Measures, tracked by the Office of Management and Budget*[9]

Visualization and Controls

Visualization and Controls develops real-time visualization, monitoring, and control systems for wide-area grid system management, as well as addresses control system security. It advances situational awareness capabilities through use of time-synchronized measurements of critical system parameters, and develops planning and decision support tools that can cue operators to potential areas of concern through advanced data analysis algorithms and system modeling. With fully integrated capabilities, early detection of real and incipient disturbance events will allow timely mitigation, ultimately leading to the goal of automatic, real-time, switchable grid operation.

Control system security is aimed at reducing the risk of energy disruptions due to cyber attack on control systems. The *National Strategy to Secure Cyberspace*[10] identifies securing distributed control systems and Supervisory Control and Data Acquisition (SCADA) systems as a national priority. To implement this strategy, activities focus on developing next-generation control systems, cyber vulnerability assessments, and integrated risk analysis.

Visualization and Controls Contributing to Key Performance Improvements			
Reliability	**Efficiency**	**Security**	**Environmental Impact**
Improves the response time to system disturbances and reduces the number and spread of outages, through real-time, wide-area monitoring and management	Reduces operating margins, by allowing the system to operate closer to its loading limits by early detection and fast control capabilities	Enables control systems for critical applications to operate resiliently against an intentional cyber assault with no loss of critical function	Defers transmission upgrade, by operating transmission system with greater efficiencies

Goals & Metrics†

Visualization and Controls

By 2014, develop tools and algorithms to enable an automatic, smart, real-time switchable network for transmission and distribution system operations that enables secure and reliable grid operations for major regions of the country†

Commission an Area Interchange Error (AIE) visualization system at the North American Electric Reliability Corporation (NERC) by FY08

Develop a prototype dynamic security assessment tool to strengthen state estimation capabilities and improve analysis of system dynamics by FY09†

Develop a prototype electromechanical grid stability alarm tool enabling analysis of characteristic grid oscillations by FY10†

Develop a prototype contingency evaluation tool that enables analysis of the ability of the system to withstand contingencies by FY11

Deploy 50 distribution-level sensors as part of developing a smart, real-time switchable network by FY11†

Deploy 50 additional distribution-level sensors as part of developing a smart, real-time switchable network by FY12†

Develop operator decision support tools by FY12†

Develop common standards and protocols for interoperability among various systems and subsystems by FY14

Deploy an automatic, smart, real-time switchable network for transmission system operations in a major region of the country by FY14†

By 2012, demonstrate cost-effective security solutions with minimum host impact, and make available a scalable virtual control system environment tool to energy sector stakeholders

Complete cyber security assessments of six SCADA systems in test bed environment by FY09

Complete development of SCADA protocol security authentication technology by FY10

Demonstrate a cyber security evaluation tool that enables analysis of the impact of cyber security technologies on control systems performance by FY11†

† *Denotes the OE R&D Program Performance Measures, tracked by the Office of Management and Budget*[9]

Renewable and Distributed Systems Integration

Renewable and Distributed Systems Integration focuses on integrating renewable energy, distributed generation, energy storage, thermally activated technologies, and demand response into electric system planning and operations. The integration uses a systems approach to address technical, economic, regulatory, and institutional barriers for using renewable and distributed systems, and establishes proven value propositions under varying use scenarios for broad implementation.

Improving the ability to integrate renewables and other technologies into the distribution and transmission system will facilitate and support achieving target goals in portfolio standards for renewables and energy efficiency. In addition, the integrated system will enable "microgrid" operations, new value-added electric services such as premium power for critical loads, and new applications for electricity such as plug-in hybrid electric vehicles to meet energy diversity and climate change challenges.

Renewable and Distributed Systems Integration Contributing to Key Performance Improvements

Reliability	Efficiency	Security	Environmental Impact
Reduces peak load, thus mitigating power disturbance events Increases use of distributed systems to relieve electricity constraints	Reduces energy losses through increased use of on-site, distributed generation Increases demand response to improve economic efficiencies	Enables intentional islanding of microgrid operations to supply uninterruptible electricity to critical loads Enables use of broadly distributed systems for enhanced security	Reduces carbon emissions and emissions of other air pollutants through increased use of renewables and plug-in hybrid electric vehicles

Goals & Metrics†

Renewable and Distributed Systems Integration

By 2015, demonstrate 20% peak load reduction on distribution feeders with the implementation of Distributed Energy and Energy Management Systems†

Complete merit-based, competitive awards to demonstrate peak load reduction during FY08

Verify 5% peak load reduction achieved for a constrained feeder by FY09†

Verify 10% peak load reduction achieved for two constrained feeders by FY10†

Verify 10% peak load reduction achieved for two additional constrained feeders by FY11†

Verify 15% peak load reduction achieved for a constrained feeder by FY12†

Demonstrate data acquisition and two-way communication systems by FY12, which enables load management by both utilities and consumers to serve their respective needs

Verify 15% peak load reduction achieved for two additional constrained feeders by FY13†

Verify 15% peak load reduction achieved for two additional constrained feeders by FY14†

Verify 20% peak load reduction achieved for a constrained feeder by FY15†

By 2012, complete development of IEEE 1547 series of standards, with DG islanding applications verified and validated by 2015

Develop interconnection equipment reliability database and tools for renewable and distributed systems integration and interoperability by FY10

Initiate development of an IEEE/International Electrotechnical Commission (IEC) dual logo international standard based on IEEE 1547 by FY10

Complete IEEE P1547.4 - Standard Guide to islanding DG with the grid by FY11, with recommended design topologies, equipment for grid operational configurations

Reaffirm and revise American National Standards Institute (ANSI) IEEE 1547 - Interconnection of DER with the Electric Power System by FY12

Develop recommendations for interconnection systems improvements and cost reduction by FY12

Verify and validate the application of distributed energy systems for safe, secure, and cost-effective "islanding" operations while in compliance to 1547.4 by FY15

† *Denotes the OE R&D Program Performance Measures, tracked by the Office of Management and Budget*[9]

Energy Storage and Power Electronics

Electric energy storage is increasingly being recognized as a key element in improving grid reliability and stability in the future electricity delivery system. Advances in battery technology and large-scale storage systems, the introduction of electrochemical "SuperCapacitors" and high-capacity flywheels into the grid will enable energy storage benefits across the power system.

Advanced Power Electronics systems have the potential to significantly improve grid operations. Advanced Power Electronics systems are being developed to allow greater control over power flow, reduce response time and automate grid reaction during unusual events, and replace existing analog components allowing digital control.

Energy Storage and Power Electronics Contributing to Key Performance Improvements			
Reliability	**Efficiency**	**Security**	**Environmental Impact**
Improves power quality Reduces congestion Limits spread of cascading outages	Improves asset utilization and capacity factor Shifts peak loads	Improves system control Enables microgrids	Facilitates integration of renewables

Goals & Metrics†

Energy Storage and Power Electronics

By 2020, develop prototype battery/super-capacitor systems with three-fold increase in stored energy and super-capacitors with operating voltages two-to-three times greater than today's systems

Test three electrolytes with potential for doubling the energy and increasing the power by 50% for capacitors or doubling the lifetime and improving safety of rechargeable nonaqueous batteries by FY08

Increase energy density in battery or electrochemical capacitor systems by 10% by FY10

Increase energy density in battery or electrochemical capacitor systems by 50% by FY13

Increase energy density in battery or electrochemical capacitor systems by a factor of two by FY16

By 2025, demonstrate a prototype solid state breaker (switch) with less than 1 millisecond response time†

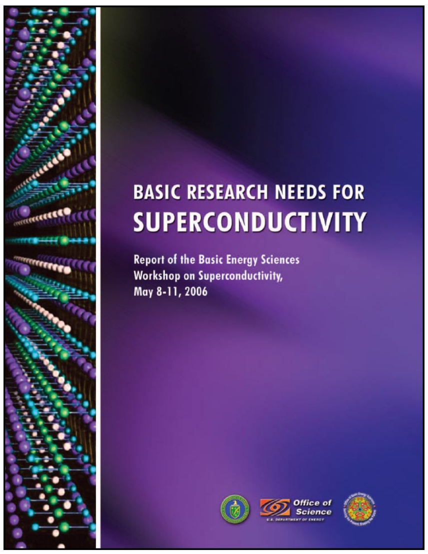
Initiate OE Power Electronics program to develop utility scale power electronic devices at both transmission and distribution levels by FY08

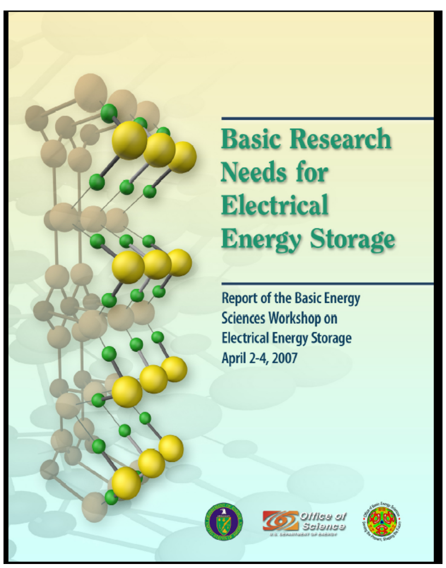
Develop switching systems (power electronics) at 10,000 volts/10 amps with a switching speed of 4 ms by FY12†

Develop switching systems (power electronics) at 20,000 volts and 100 amps by FY18 operating effectively at 250°C†

† *Denotes the OE R&D Program Performance Measures, tracked by the Office of Management and Budget*[9]

Research Integration





Breakthrough developments in **electric energy storage** and **superconductivity** have potential for paradigm-shifting impact on the energy future. DOE's Office of Science (SC) has targeted these two areas[11, 12] as science grand challenges for discovery research and user-inspired basic research to gain new knowledge and understanding to solve real-world material problems.

Other basic research pursued by the SC, Department of Defense (DoD), and National Science Foundation (NSF) could also have a direct impact on OE R&D, including:

- *materials science research* in wide band gap material such as silicon carbide, gallium nitride, and diamond for improved performance and energy efficiency of power electronics and controls
- *computational science and computer/network science* for improved real-time simulation, modeling, and controls of electric infrastructure
- *nanoscale materials science* for enabling new designs and building blocks for devices in the electric system

Turning scientific discoveries from these basic research areas into new and better electricity delivery devices is a major challenge in transforming the electric grid. Also needed for this transformation is close integration of applied research and development efforts on:

- *renewable energy and other clean energy systems* conducted by the DOE Offices of Energy Efficiency and Renewable Energy (EERE), Fossil Energy (FE), and Nuclear Energy (NE)
- *control systems security, cyber security development, and high temperature superconductivity* conducted by the Department of Homeland Security (DHS)

OE R&D will continue to work with State energy research organizations, electric utilities, equipment manufacturers, universities, national laboratories, and other stakeholders, through workshops and other multi-party mechanisms, to jointly implement an integrated planning process for research integration.

Metrics

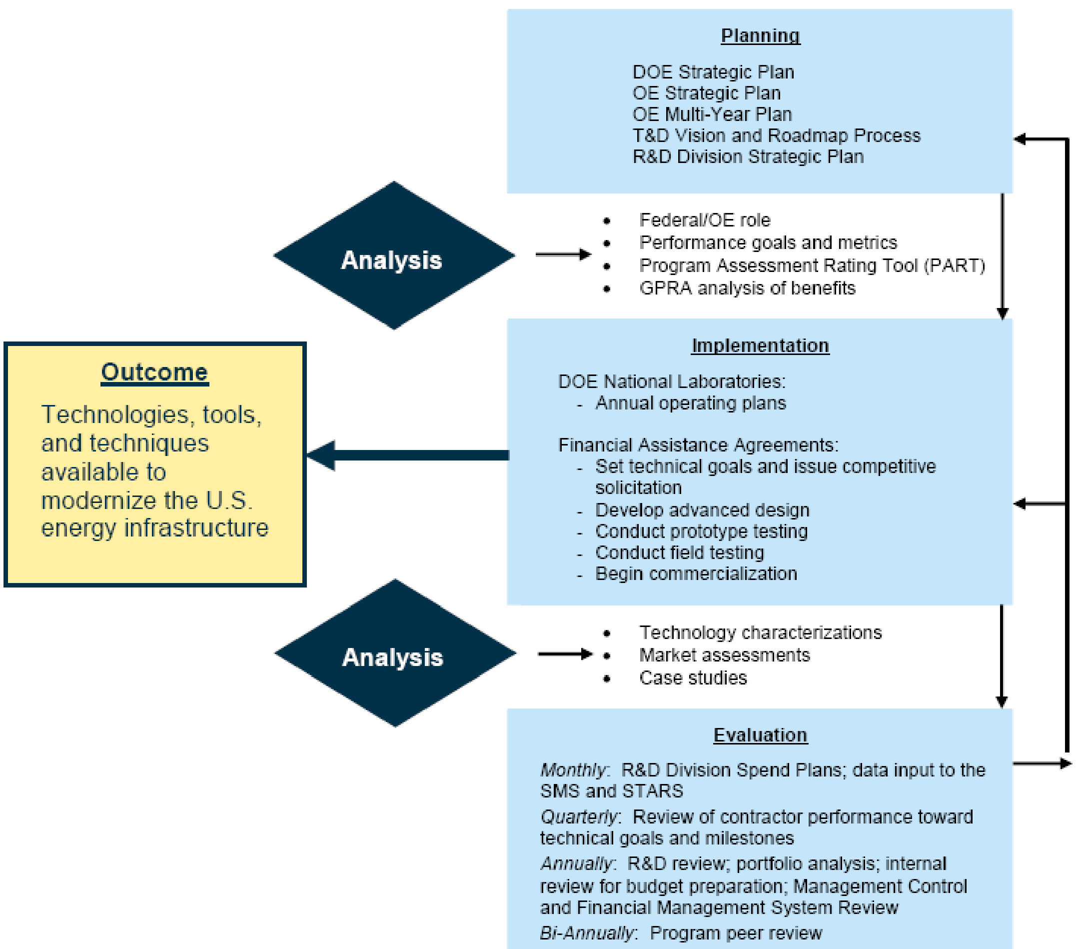
OE R&D contributing to achieving DOE Goal 3.3 – Research Integration[1]

Integrate basic and applied research to accelerate innovation and to create transformational solutions for energy and other U.S. needs

- **Engage SC and other Federal research agencies (DoD, NSF, DHS, if appropriate) to**
  - Identify technology issues, challenges, and impediments when developing each OE R&D program plan and roadmap
  - Develop solicitation topic areas to address the identified R&D areas
  - Review technical merits of proposals received and ongoing projects during peer reviews
- **Ensure continuous information flow from basic research through integrated management of research activities with SC and other Federal research agencies**
- **Strengthen strategic partnership with EERE, State energy organizations, and electric utilities to jointly advance grid integration of renewable and energy efficient systems, by leveraging the combined resources for integration activities**

Management Excellence

OE R&D has developed and implemented its management and analysis process[13] depicted in the chart below. This iterative process begins with planning and continues through implementation and evaluation. Analysis and evaluation results are fed back to planning and implementation to ensure continuous improvements and proper alignment between R&D priorities and industry needs. Portfolio adjustments, including implementation of risk mitigation measures, termination of unproductive R&D pathways, and development of new R&D projects and initiatives, are critical management responsibilities.



Metrics

***OE R&D contributing to achieving DOE Goal 5.1 – Integrated Management*[1]**

Institute an integrated business management approach throughout DOE with clear roles and responsibilities and accountabilities to include effective line management oversight by both Federal and contractor organizations

- Submit timely updates of the Performance Assessment Rating Tool (PART) to Office of Management and Budget
- Use competitive solicitations to select the majority of OE R&D projects and services
- Achieve small business contracting annual goals in accordance with DOE requirements
- Annually align OE R&D employee performance standards with the goals and metrics of the OE R&D Division
- R&D program funding request will maintain a program direction percentage of less than 12%
- Conduct reviews and evaluations
  - Ongoing: Utilize the Corporate Planning System (CPS) to track project/program funding and milestones
  - Monthly: Utilize the Strategic Management System (SMS) to inform planning and budgeting decisions in compliance with the President's Management Agenda; submit financial data to DOE's Standard Accounting and Reporting System (STARS); conduct review of R&D spend plans to further financial accountability, efficiency, and progress against milestones
  - Quarterly: Track progress, via the Joule system, toward program goals and milestones, with development of action plans for corrective actions if necessary
  - Annually: Review R&D work performed on contracts (including national laboratories) and grants for cost, schedule, and performance results and take corrective actions; conduct portfolio and risk analysis reviews to balance resource allocations against priorities and adapt to changing external factors; submit a Management Control and Financial Management System Review, in accordance with the Federal Managers' Financial Integrity Act (FMFIA); assess program benefits in accordance to the Government Performance Results Act (GPRA) requirements
  - Bi-Annually: Conduct peer reviews to identify less productive projects and redirect resources toward the most promising technology pathways

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Appendix Strategic Opportunities

Technologies, policies, and markets for electricity delivery infrastructure are highly dynamic and subject to significant uncertainties about future conditions and possibilities. Numerous factors and trends could create new research, development, and demonstration (RD&D) needs for the Division to address; for example, these include:

- New state and federal policies that encourage reductions in carbon emissions such as taxes or tradable credits
- New state and federal policies to promote energy efficiency and renewable energy such as portfolio standards or expanded efficiency standards
- New standards from the recently established Electricity Reliability Organization (ERO)
- New efforts to promote protection of critical infrastructure

The following opportunities are identified as strategic to OE R&D Division; new RD&D needs are being uncovered and will continue to evolve in each opportunity area.

Smart Grid

A smart grid enables two-way communication and digital control throughout the electricity delivery infrastructure. Areas for potential smart grid activities include:

- Further definition of smart grid as a unifying theme that connects emerging development at both ends of the grid, i.e., renewable and other alternative generation sources on one end, with plug-in hybrid electric vehicle (PHEV) technology and responsive loads on the other
- Development of smart grid roadmap(s) or guidebook(s), and demonstration of smart grid concepts in utilities, states, and regions
- Development of measurement and verification protocols for evaluating customer efficiency gains and corresponding reductions in carbon emissions, from leveraging smart grid infrastructure
- Investigation of "technology" options for "quick" recovery from disruptions

Climate Change

Growing national interest in climate change drives toward broad adoption of renewable portfolio standards and energy efficiency portfolio standards, as well as toward the practice of carbon cap and trade. Areas for potential climate change technology development and integration activities include:

- Development of technologies and policies to position the electric grid as a strategic asset to deliver efficiency, renewables, nuclear and clean coal generation, and carbon reduction
- Integration of wind farms with the grid by addressing technical integration (storage, effects on overall grid generation resources and reliability), electricity market integration, and regulatory policy challenges to maximize wind production while minimizing production costs
- Enhancement of current efforts in integrating and promoting use of clean distributed generation and combined heat and power to address efficiency, reliability, and security of the grid

Modeling and Analysis

With the advent of smart grid, modeling and analysis of new and emerging operational scenarios are needed with respect to meeting future system demands and requirements, along with analyzing their sensitivity to changes in technical, market, regulatory, and policy aspects. Areas for potential modeling and analysis activities include:

- Comprehensive scenario analysis of future conditions and possibilities such as electrifying transportation, broad implementation of intelligent devices, competitive retail markets, disruptive technologies (e.g., wireless electricity), and wide adoption of HTS
- Evaluation and validation of system level impacts from PHEV penetration and associated new technologies and policies

R&D Partnerships

Close collaboration with industry stakeholders and regulatory entities is critical to the success of smart grid development and implementation, as is their acceptance of its values and rewards. Areas for potential R&D partnership activities include:

- Expansion of collaborations with regulating bodies (e.g., Federal Energy Regulatory Commission [FERC], NERC, ERO, public utility commissions) and international partnerships (e.g., International Energy Agency, European Union, Canada, China, and Japan)
- Education programs for state regulators and T&D planners about "upcoming" technology options for grid modernization

Pursuit of Strategic Opportunities

Through annual budget processes, OE R&D incorporates newly identified strategic opportunities into its planned scope as part of its portfolio adjustments practices. When new opportunities cannot be adequately supported under planning budgets, they are included in over-target budget justifications. In the FY09 budget development, specific "Smart Grid" technologies that enable carbon emissions reduction contributing to climate change strategic goals[3] have been identified in need of focused research, development, demonstration, and integration into the electric system. Acceleration of these R&D efforts is viewed as essential for the electric infrastructure to supplement and enable other parallel development (such as PHEV, commercial readiness of superconducting power equipment and energy storage for utility-scale applications, power electronics for interconnection and control of renewables) in addressing climate change and energy diversity. Along with the over-target justifications, associated key performance metrics have also been developed under each Key Activity as listed below.

Over-Target Metrics

High Temperature Superconductivity

Complete laboratory testing at full current and voltage of a single phase high temperature superconductor fault current limiter for use at high voltage (above 110 kV) by FY11

Complete engineering design of a prototype three phase high temperature superconductor fault current limiter for use at high voltage (above 110 kV) in a utility grid by FY12

Complete build of a prototype three phase high temperature superconductor fault current limiter for use at high voltage (above 110 kV) in a utility grid by FY13

Visualization and Controls

Demonstrate Electromechanical Grid Stability Prototype Alarm Tool in selected RTO, ISO, and transmission operator control centers by FY11

Demonstrate the use of phasor data for adaptive protective relays by FY12

Develop and demonstrate a prototype market monitor tool by FY13

Renewable and Distributed Systems Integration

Complete collection and analysis of field performance data of smart charger controllers in PHEV fleet vehicles for readiness to commercialization by FY11

Initiate large-scale smart grid systems integration projects to meet the performance targets defined by the industry metrics task force by FY12

Develop cost-effective, advanced power electronics for Vehicle-to-Grid (V2G) applications by FY13

Energy Storage and Power Electronics

Complete construction of two Utility energy storage demonstration projects by FY10

Commission and test two Utility demonstration projects and initiate third project, by FY11

Commission third utility demonstration project and prototype advanced high energy density, energy storage system, by FY12

Test advanced high energy density, energy storage system in utility environment by FY13

Commission and test ETO STATCOM and prototype and test high power (>10kV, 100A) SiC switch, by FY10

Prototype mobile STATCOM system with Energy Storage by FY11

Demonstrate Energy Storage FACTS device on distribution system by FY12

Prototype integrated, high density SiC based inverter system by FY13